Post-Graduate School

Indian Agricultural Research Institute, New Delhi
Supervision and Guidance

Dr. H.S. Gupta  
*Director*

Dr. H.S. Gaur  
*Dean & Joint Director (Education)*

Sh. B.N. Rao  
*Registrar*

Editorial Board

Dr. V.C. Mathur  
*Professor, Agricultural Economics*

Dr. R.D. Gautam  
*Professor, Entomology*

Dr. V.P. Singh  
*Professor, Plant Physiology*

Dr. Anil Sirohi  
*Principal Scientist, Division of Nematology*

Dr. K. M. Manjaiah  
*Officer Incharge (Academic Implementation and Monitoring Cell), PG School*

PG School Team

Sh. A. K. Tyagi  
*Technical Officer*

Sh. Ashwani Kumar  
*Assistant Administrative Officer*

Sh. Ashok Kumar  
*T-2 (Computer)*
The Indian Agricultural Research Institute, since its inception in 1905, has been playing a flagship role in the field of agricultural research, education and human resource development. Initially, the Institute helped in training the senior officers of the Department of Agriculture through informal training courses. A formal course leading to a two year diploma, ‘Associateship of IARI’ in various fields of agriculture was started in 1923 which was awarded to 903 graduates upto 1957. During 1958, IARI was granted the “deemed university” status by University Grants Commission and thus became the fore-runner of the agricultural university system in India. The unique feature of education in IARI, which is based on the model of course credit system of universities in USA, is that research, teaching and extension are fully integrated. This has helped to make the post-graduate education not only more relevant to solve the farmers’ problems but also made it competitive at national and international levels.

Post Graduate School of IARI provides national and international leadership in Human Resource Development. The IARI is well poised to find solution to some of the problems that have surfaced in the post Green Revolution era, such as environmental and land degradation, water shortage, climate change, emerging of pest and diseases, and loss of biodiversity. In addition to India’s population surge, the GATT, GATS, IPR, PVR&FR, Kyoto protocol, CBD, Bio-safety guidelines and several environmental acts will have both direct and hidden effects on Agricultural research and education. Even though India has achieved an enormous amount of success in agricultural development, we have to continually feed more than one billion people in the coming years from finite land area.

Keeping the tradition of the glorious past, the PG School is trying to scale newer heights in agricultural research, education and extension through change in course curriculum and adopting innovative teaching methodologies. In this context, I am happy to note that the Institute is bringing out this new edition of the important publication, Post Graduate School Calendar containing the revised PG course curricula and syllabus and updated rules and regulations approved during 2006-07 till date. This exercise done after a gap of six years is expected to provide greater professionalism to the PG School of IARI. I thank the entire faculty, Professors, students for their contribution in preparing this document. Our special thanks are due to the resource persons viz., Dr. Sudhir Kumar Sopory, Vice Chancellor, JNU, Delhi, Dr. M. Mahadevappa, Director, JSS Rural Development Foundation, Mysore, Dr. S. Edison, former Director, CTCRI, Trivandrum, Dr. I.P. Abrol, Director, CASA, New Delhi and Dr. P.C. Chengappa, Former Vice Chancellor, UAS, Bengaluru for their scholarly inputs during the PG course curricula revision process. The PG School is thankful to the untiring efforts made by Dr. H.S. Gaur, Dean & Jt. Director (Edn.) and members of the Editorial Committee. My appreciation is also for the whole team of the Post Graduate School.

Date: 1-2-2011
Place: New Delhi

(H.S. Gupta)
Chairman, Academic Council &
Director, IARI (Deemed University)
New Delhi
Preface

The Indian Agricultural Research Institute (IARI) is India’s largest and foremost Institute in the field of research and higher education and training in agricultural sciences. The Green Revolution was born in the fields of IARI and our graduates constitute the core of the quality human resource in India’s agricultural research and education. There has been improvement in the agricultural education and training from time to time through the innovations of new research and technical advances. The Post Graduate School of Indian Agricultural Research Institute which was first established as a part of the Deemed University in 1958 has been engaged in providing high quality agricultural education at the post-graduate level in the country as a lead centre. From 1923 till 1958, the IARI extended agricultural education leading to ‘Associateship of IARI’ equivalent to M.Sc., which was awarded to 903 scholars. In 1958, there were only six disciplines for admission to PG courses, which have now increased to 23 for M.Sc., one for M.Tech. and 22 for Ph.D. So far, 3138 M.Sc. and 4077 Ph.D. students have been awarded including 287 international students. The Post Graduate School, IARI has made significant contributions by producing M.Sc. and Ph.D. degree holders who are occupying key positions at the national as well as international level, besides the best crop varieties and production and protection technologies.

The Post Graduate School Calendar contains all relevant rules and regulations and laws and by-laws right from admission to the eligibility of the qualified student to receive the degree and a thorough listing of course curricula of various disciplines which have been updated in the light of the amendments approved by the Academic Council. The course-curricula have been revised as per the pattern developed by the ICAR which included deletion of obsolete courses, addition of new courses, merger of courses and listing of some courses across the disciplines, keeping in pace with the latest developments taking place in agricultural education and research. This revised volume will prove worthy of providing relevant information to the students as well as to the faculty members and motivate young research scholars pursuing their studies especially in agricultural sciences to strive towards excellence.

I am highly indebted to all the resource persons, Professors, faculty members and the Committee comprising Dr. V.C. Mathur, Dr. R.D. Gautam, Dr. V.P. Singh, Dr. Anil Sirohi, and Dr. K. M. Manjaiah for their support in bringing out this updated volume. My thanks are also due to the entire staff of the Post Graduate School.

(H.S. Gaur)
Dean & Joint Director (Edn.)
IARI, New Delhi

Date: 1-2-2011
Place: New Delhi
Dr. R.W. Cummings (1958-60)
1st Dean of IARI Post Graduate School

Dr. A.B. Joshi (1960-66)
1st Indian Dean of IARI Post Graduate School
Lay-out Plan of the Indian Agricultural Research Institute
New Delhi - 110 012

1. Library
2. P.G. School
3. Soil Science and Agricultural Chemistry
4. Plant Pathology
5. Entomology
6. Auditorium
7. Genetics
8. Seed Science and Technology
9. Horticulture
10. Nuclear Research Laboratory, Environmental Sciences, Agricultural Physics
11. Plant Physiology, Biochemistry
12. Microbiology
13. Agricultural Extension
14. Agricultural Economics
15. Water Technology Centre
16. Agronomy
17. Agricultural Engineering
18. Sharad Hostel
19. Shishir Hostel
20. Vasant and Hemant Hostels
21. Varsha Hostel
22. Lal Bahadur Shastri Centre for Biotechnology and Plant Protection, Nematology, Agricultural Chemicals, NCIPM
23. Dispensary
24. Faculty Club, Shopping Complex
25. Reception
26. Post Office
27. Cummings Lab, DMR/Cereal Lab.
28. National Phytotron Facility
29. Rituraj Hostel
30. Grishm Hostel
31. Kaveri Trainees Hostel
## Contents

**PART I (RULES AND REGULATIONS)**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Chapter</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Institute</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Emblem and Invocation</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Administration and Faculty</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Academic Session and Term Calendar</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Disciplines and Major Fields of Specialisation</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>Admission of Students</td>
<td>27</td>
</tr>
<tr>
<td>7</td>
<td>Fees and Other Charges</td>
<td>43</td>
</tr>
<tr>
<td>8</td>
<td>Academic Requirements for Course and Research Work</td>
<td>46</td>
</tr>
<tr>
<td>9</td>
<td>Examination System</td>
<td>58</td>
</tr>
<tr>
<td>10</td>
<td>Seminars</td>
<td>69</td>
</tr>
<tr>
<td>11</td>
<td>Relief from the Post Graduate School</td>
<td>71</td>
</tr>
<tr>
<td>12</td>
<td>Convocation and Award of Degrees</td>
<td>73</td>
</tr>
<tr>
<td>13</td>
<td>Medals</td>
<td>75</td>
</tr>
<tr>
<td>14</td>
<td>Awards</td>
<td>78</td>
</tr>
<tr>
<td>15</td>
<td>Scholarship/Fellowship</td>
<td>87</td>
</tr>
<tr>
<td>16</td>
<td>Utilisation of the Contingent Grant</td>
<td>90</td>
</tr>
<tr>
<td>17</td>
<td>The Institute Library</td>
<td>94</td>
</tr>
<tr>
<td>18</td>
<td>The Students’ Hostel</td>
<td>99</td>
</tr>
<tr>
<td>19</td>
<td>The Post Graduate School Students’ Union</td>
<td>109</td>
</tr>
<tr>
<td>20</td>
<td>The Students’ Welfare Fund</td>
<td>114</td>
</tr>
<tr>
<td>21</td>
<td>Co-curricular and Extra-curricular Activities</td>
<td>116</td>
</tr>
<tr>
<td>22</td>
<td>Short-term Training Courses</td>
<td>117</td>
</tr>
</tbody>
</table>
## PART II (COURSE CURRICULA)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Chapter</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Agricultural Chemicals</td>
<td>123</td>
</tr>
<tr>
<td>2.</td>
<td>Agricultural Economics</td>
<td>139</td>
</tr>
<tr>
<td>3.</td>
<td>Agricultural Engineering</td>
<td>166</td>
</tr>
<tr>
<td>4.</td>
<td>Agricultural Extension</td>
<td>199</td>
</tr>
<tr>
<td>5.</td>
<td>Agricultural Physics</td>
<td>231</td>
</tr>
<tr>
<td>6.</td>
<td>Agricultural Statistics</td>
<td>260</td>
</tr>
<tr>
<td>7.</td>
<td>Agronomy</td>
<td>302</td>
</tr>
<tr>
<td>8.</td>
<td>Biochemistry</td>
<td>329</td>
</tr>
<tr>
<td>9.</td>
<td>Bioinformatics</td>
<td>342</td>
</tr>
<tr>
<td>10.</td>
<td>Computer Application</td>
<td>359</td>
</tr>
<tr>
<td>11.</td>
<td>Entomology</td>
<td>391</td>
</tr>
<tr>
<td>12.</td>
<td>Environmental Sciences</td>
<td>415</td>
</tr>
<tr>
<td>13.</td>
<td>Genetics</td>
<td>439</td>
</tr>
<tr>
<td>14.</td>
<td>Horticulture</td>
<td>466</td>
</tr>
<tr>
<td>15.</td>
<td>Microbiology</td>
<td>505</td>
</tr>
<tr>
<td>16.</td>
<td>Molecular Biology and Biotechnology</td>
<td>526</td>
</tr>
<tr>
<td>17.</td>
<td>Nematology</td>
<td>540</td>
</tr>
<tr>
<td>18.</td>
<td>Plant Genetic Resources</td>
<td>558</td>
</tr>
<tr>
<td>19.</td>
<td>Plant Pathology</td>
<td>583</td>
</tr>
<tr>
<td>20.</td>
<td>Plant Physiology</td>
<td>613</td>
</tr>
<tr>
<td>21.</td>
<td>Post Harvest Technology</td>
<td>633</td>
</tr>
<tr>
<td>22.</td>
<td>Seed Science and Technology</td>
<td>655</td>
</tr>
<tr>
<td>23.</td>
<td>Soil Science and Agricultural Chemistry</td>
<td>677</td>
</tr>
<tr>
<td>24.</td>
<td>Water Science and Technology</td>
<td>704</td>
</tr>
<tr>
<td>25.</td>
<td>Other Compulsory Courses</td>
<td>724</td>
</tr>
<tr>
<td></td>
<td>ANNEXURES</td>
<td>731</td>
</tr>
</tbody>
</table>
PART-I
RULES AND REGULATIONS
1 The Institute

1.1 Functions

1.1.1 The Indian Agricultural Research Institute (IARI) is India’s premier institution for agricultural research and education including extension education. Since 1958, it holds the status of a Deemed University under the University Grants Commission Act of 1956 and is authorized to award post-graduate degrees of Master of Science and Doctor of Philosophy in agricultural sciences and their related basic disciplines vide Govt. of India Notification No. F.24-44/58-U-S dated 22nd August, 1958 (reproduced below):

Government of India,
Ministry of Education,
New Delhi 1, the 22nd August, 1958/31 Sravana, 1880 Saka
No. F. 24-44/58-U-S.

Notification

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956), the Central Government, on the advice of the University Grants Commission, hereby declares that the Indian Agricultural Research Institute, New Delhi which is an institution of higher education, shall be deemed to be a University for the purpose of the said act.

Sd/-
N.S. Junankar
Deputy Education Adviser

1.1.2 The primary functions of the Institute are: 
(i) To conduct basic and strategic research with a view to understanding the processes, in all their complexity, and to undertake need based research, that lead to crop improvement and sustained agricultural productivity in harmony with the environment, (ii) To serve as a center for academic excellence in the area of post-graduate and human resources development in agricultural sciences, (iii) To provide national leadership in agricultural research, extension, and technology assessment and transfer by developing new concepts and approaches and serving as a national referral point for quality and standards, and (iv) To develop an information system, add value to information, share the information nationally and internationally, and serve as a national agricultural library and database.

1.2 Origin, Growth and Development

1.2.1 The Institute was originally established as Agricultural Research Institute and College by the Government of India in 1905 at a village called Pusa in North Bihar. The establishment was greatly helped by an American philanthropist Mr. Henry Phipps, after whom the main building in Pusa was named. After the devastating earthquake of Bihar in 1934, the Institute was shifted to its present site in New Delhi in 1936. This is why it is also popularly known as the “Pusa Institute”. The Institute has inherited a great tradition of agricultural research and training at the post-graduate level. Since its early days at Pusa, the Institute has done pioneering work in the various fields of agricultural sciences. In 1923, it started a two-year formal training course leading to the Diploma in Associateship of IARI, which was recognized equivalent to the M.Sc. degree of the Indian universities vide O.M. No. F. 17-13/49- T dated 8th October, 1949 [(received under the Ministry of Agriculture letter No. 1147 Institute/ 49 dated 14th November, 1949 [copy placed at Annexure-I)]. Till 1955, the Institute awarded 903 Associateships in different disciplines. In 1958 the Institute was accorded the status of a Deemed to be University. At that time students were admitted only in six disciplines. Gradually more disciplines
were introduced and presently IARI admits M.Sc. students in 23 disciplines, M.Tech. in one discipline and Ph.D. in 22 disciplines.

Many pathbreaking contributions were made by the Institute during the pre-independence era.

Special mention may be made of the outstanding wheat varieties bred by Albert Howard and his wife Gabrielle which became famous as the “Pusa Wheats” both in India and abroad. Howard and later F.J.F. Shaw were responsible for the evolution of improved varieties of many other crops. The contributions of E.J. Butler in the field of fungi and fungal diseases of crops, and of H.M. Lefroy and T.B. Fletcher in Entomology were most outstanding. So were the contributions of J.W. Leather in Agricultural Chemistry. The famous “CO” varieties of sugarcane, which helped in revolutionising the sugar industry in India, were developed by C.A. Barber and T.S. Venkataraman at the Sugarcane Breeding Station (now Sugarcane Breeding Institute) at Coimbatore, which until 1950 was a part of this Institute.

1.2.2 In independent India, the Institute has expanded in scope, activities, research facilities and scientific personnel. The Institute has eight regional stations located at Indore, Kalimpong, Karnal, Katrain, Pune, Pusa, Shimla and Wellington, two regional centres at Aduthurai and Dharwad, and a KVK at Shikohpur.

The teaching disciplines at IARI have been broadly classified and structured in five schools. The principal research themes of various Schools are as follows:

**School of crop improvement**

**Genetics**

The Division of Genetics, which was known as the Division of Botany until 1966, contributed significantly to the development of a highly competent and trained manpower base of the country through its post-graduate programme. The advanced training programme intensified with the setting up of the Post Graduate School at IARI in 1958, which confers M.Sc. and Ph.D. degrees.

The post-graduate students’ research constitutes an integral part of the overall research output of the Division and many of the contributions emanating from students’ research have been valuable in terms of quality and practical utility. Genetic improvement of various crops, methodologies for efficient selection, genetic basis of the traits of economic importance and genetics in the model organism Drosophila are some of the major themes of research. In addition, molecular approaches, especially the use of molecular markers in crop improvement and diversity analysis are being employed in the Division.

**Horticulture**

The Division of Horticulture was constituted in the year 1956 for more intensive research on fruits and vegetables by strengthening the groups which existed on these crops in the Division of Botany. The Division of Horticulture in the consequent years saw a further expansion with the formation of the follow up three Divisions:

**Fruits and Horticultural Technology:** Involved in the development of improved varieties of fruits through introduction and breeding, and in evolving improved techniques of propagation and cultivation of some of the major fruits in the sub-tropical region particularly mango, citrus, grapes and guava.

**Floriculture and Landscaping:** The Division has been a centre for evolution of improved varieties of roses and ornamental plants like gladioli, marigold, etc.

**Vegetable Science:** The Division has seen the development of a wide array of improved varieties in cauliflower, cabbage, turnip, radish, carrot, garden peas, French bean, cowpea, tomato, brinjal, onion, cucumber, musk melon, water melon, bottlegourd, bittergourd, spinach, and *methi*. These vegetable varieties are today cultivated not only in India but also in countries like Australia.

For teaching purpose, however, there is only one discipline of Horticulture spread over these three divisions, in which, M.Sc. and Ph.D. degrees are awarded.
Post Harvest Technology

Initially, the Division of Post Harvest Technology started as a Fruit and Vegetable Preservation Section of the Division of Horticulture. With the splitting of the Division of Horticulture in 1970, it became a Unit of the Division of Fruits and Horticultural Technology. The Division of Fruits and Horticultural Technology was divided and a new Division of Post Harvest Technology (PHT) with a multidisciplinary approach was established on 5th February, 2002 during the IX Plan period. The mandate of the Division comprises post harvest loss reduction, value addition and export promotion of horticultural crops, cereals, pulses and oilseeds.

PHT has emerged as one of the frontier areas of research having multidisciplinary approach in which studies are conducted on the major thrust areas, namely, production, post harvest handling, processing and marketing of horticultural and arable crops. The Division also imparts postgraduate education and training for human resource development, and provides advisory and consultancy services on handling, packaging, storage and processing technology in addition to dissemination of information for transfer of technologies developed in the Division.

Seed Science and Technology

With the release of maize hybrids in India during early 1960s, a Seed Testing Section was established in the Division of Genetics which blossomed into the Division of Seed Technology in the year 1968.

The Division was renamed as the Division of Seed Science and Technology in 1984. The Division and IARI Regional Station, Karnal are closely associated in post-graduate teaching and research in the area of seed science and technology.

The Division started a P.G. Diploma course for in-service candidates in 1978 which was terminated in 1980. The regular M.Sc. course in Seed Science and Technology was started in 1983 on the persistent demand from the industry. The Ph.D. course was started in 1994.

School of resource management

Agricultural Engineering

The Division of Agricultural Engineering was established in 1945 with an objective to improve and devise efficient and affordable tools for various farm operations. The degree programmes in the discipline of Agricultural Engineering were initiated in 1967. The course contents were designed with a view to equipping the students with the knowledge of a wide array of topics ranging from pure mathematics, electronics and physics to soil science and agriculture, and are periodically updated.

Agricultural Physics

The Division of Agricultural Physics was created in 1962 by separating it from the Division of Soil Science and Agricultural Chemistry. The teaching activities were also initiated in the same year in the discipline of Agricultural Physics.

Research work at post-graduate level in the discipline of Agricultural Physics has been carried out on application of remote sensing in agriculture, soil physical conditions in relation to plant growth, agrometeorology and in biophysical processes. The courses in the discipline have been developed comprehensively to give basic concepts as well as advanced knowledge to the students.

Agronomy

Initially, this Division was set up in the form of a Farm Office in 1936. With the efforts of workers like Dr. C.H. Parr, it was established as a full-fledged Division in 1945. There are two major thrust areas of research, viz., crop husbandry and resource management. Within these two major fields, the main research areas are: cropping system, fertilizer management, water management, weed science, dryland farming and conservation agriculture. The Division has ample facilities for field and laboratory research.

The students’ research is being carried out within the mandate of the Division. The significant achievements of the students’ research include relay cropping on multiple cropping concepts, use of slow release nitrogenous fertilizers, nitrogen
economy through legumes, agronomy of dwarf wheats, improved techniques of dryland farming, water and weed management in different crops and cropping systems, conservation agriculture, etc.

**Environmental Sciences**

The Division of Environmental Sciences was established on 1st January, 1993. M.Sc. degree programme in Environmental Sciences started from 1992 with the help of the teaching faculty drawn from other related disciplines. Ph.D. programme commenced from 1994. The Division has a mandate to conduct applied and strategic research on resource management with sustainable agricultural productivity and environment.

**Microbiology**

The Division of Microbiology was established in 1961 with a view to exploring alternative sources of soil fertility build-up depending more on renewable sources rather than non-renewable sources.

The initial work was related to organic matter decomposition and recycling of organic wastes, phosphate solubilisation by bacteria and fungi, symbiotic nitrogen fixation by *Rhizobium* and asymbiotic nitrogen fixation by *Azotobacter*, *Azospirillium* and blue-green algae. Currently, advanced tools and biotechnological applications are incorporated into precision based resource management for improving crop production.

Teaching programmes were initiated in 1963. The course contents encompass the basic aspects of soil microbiology, algology and agricultural bacteriology.

**Soil Science and Agricultural Chemistry**

The Division of Soil Science and Agricultural Chemistry is one of the original five sections of the then Agricultural Research Institute and College established at Pusa, Bihar. The Division was established with the main objective of carrying out re-search on basic and applied aspects of the physical, chemical and biological properties of soils, fertiliz-ers and manures, interactions with soil and plant, improvement in soil fertility, and advice to the farm-ers on fertilizer recommendations based on soil tests. Laboratories of this Division are adequately equipped with modern scientific instruments.

**Water Technology Centre**

The year 1970 saw the development of the Water Technology Centre (WTC) as the major response to the challenges of reducing water resources. It conducts research leading to more efficient management of irrigation water. The Institute received valuable grants from the Ford Foundation for the establishment of this Centre.

An M.Sc. degree programme in Water Science and Technology based at WTC was started in 1996. From the academic session 2003-2004, a Ph.D. degree programme was also started. The faculty of the discipline has been drawn from other related fields like Agricultural Engineering, Soil Science, Agronomy, Plant Physiology and Agricultural Physics.

**School of crop protection**

**Agricultural Chemicals**

It was realised in 1960s that in order to increase the production of food, Indian agriculture would have to receive increasing support from a wide group of chemicals encompassing not only fertilizers but also pesticides of various kinds for the control of diseases, insects and pests. IARI responded to this challenge by creating a separate Division of Agricultural Chemicals in November 1966 with the major responsibility for the synthesis of pesticides, synergists and chemical formulations. The research in this Division has particularly paid attention to the development of new agricultural chemicals. A comprehensive syllabus and expert guidance by the faculty have led to major research contributions by the students, some of which have been patented and commercially exploited.

The Division has produced some pioneering re-search work on neem extracts which has been ac-claimed widely.

**Entomology**

Entomology was one of the first disciplines to be organised at the Institute with its setting up at
Pusa, Bihar in 1905. From the very first days of its establishment, the Division of Entomology has been concerned with the investigations, which would help to reduce the losses caused by a wide range of insect pests to Indian agriculture. The Division started with the building up of an exhaustive collection of the insect fauna of the country both for the purpose of identification and the study of their biology. The Division has been awarding post-graduate degrees in the discipline since 1960s.

**Nematology**

IARI's research programme on parasitic nematodes was initiated in 1962 and it was decided to intensify it by setting up a separate Division in November, 1966.

The Division has been concerned with basic and applied research on parasitic nematodes of agricultural interest with special emphasis on the occurrence and distribution of important nematode species, their host range, bionomics and pathogenicity, identification of disease complexes and above all their control.

The Institute has been a major centre for systematic studies on economically important groups of plant parasitic nematodes. The faculty members specialise in nematode biosystematics and physiological studies and use of safe bioagents for nematode management. The Division also has a national nematode collection, which has been recognised as the world’s major collection of its kind.

**Plant Pathology**

IARI’s contributions have laid a strong foundation for plant pathological research in the country. India has been able to protect the genetic potential for high yields created in the recent years only because of the excellent support provided by the plant pathologists by way of incorporating a high degree of disease resistance in the improved varieties. The Division of Plant Pathology has its origin in the section of Mycology in 1905.

The main objective of the Division is to generate data pertaining to the identification/detection of plant pathogens (fungi, bacteria, mycoplasma, viruses, viroids) and their management. The programme includes diseases of economically important agricultural/horticultural crops and emphasises the areas of molecular characterization of plant pathogens, distribution of races/virulences/genotypes, resistant sources, epidemiology, disease forecasting, assessment of losses, apoplastic/symplastic movement of chemicals, interaction amongst chemicals, resistant mutants, development of detection kits for plant pathogens with the use of ELISA, dot blot, etc., cloning of pathogenic species specific genes, transfer useful genes to host plants, tissue culture, physiology of host-pathogen interaction and taxonomy of plant pathogens.

The Division started its teaching programme in 1958 when IARI became a Deemed University.

**School of social sciences**

**Agricultural Economics**

In order to develop more intensive research programmes in Agricultural Economics, the Division was created in 1960 by transferring the units which earlier formed a part of the Division of Agronomy. Since its inception the Division is actively engaged in activities which have interested not only the agricultural economists but also the policy makers and administrators. The teaching activities were also initiated since its creation. The students of the Division go through a rigorous course work to equip themselves with the basic as well as the advanced concepts of agricultural economics to undertake the research work.

The present scenario has changed with a different set of problems and challenges in agricultural economics, globalisation, liberalisation, emergence of new trade relations and trade blocks and increasing role of private sectors. Environmental concerns have been incorporated in the educational programme. This has caused reorientation of the programme in Agricultural Economics.

**Agricultural Extension**

The Division of Agricultural Extension offers teaching programmes leading to M.Sc. and Ph.D.
in Agricultural Extension since 1960. Since its inception the Division has played a leadership role for different agricultural universities and research institutes located not only in India but also in Asia. The Division has a strong and well trained faculty and modern facilities for undertaking teaching and research functions. The students are trained to take up professional positions in extension education, communication and management in public and private institutions. Facilities are available in the specialised areas of agricultural management and agricultural communication.

School of basic sciences

Biochemistry

The Division of Biochemistry has its roots in the Division of Soil Science and Agricultural Chemistry. It was created in the year 1966 to carry out research in biochemical science. The teaching programmes in the discipline of Biochemistry started in 1967. The students are trained in the areas of plant biochemistry, nutritional biochemistry and plant molecular biology. The students are also provided training in advanced molecular and biochemical techniques.

Molecular Biology and Biotechnology

The National Research Centre on Plant Biotechnology established in 1985, is playing an important role since its inception in the development of human resources. The NRC on Plant Biotechnology has excellent facilities for carrying out advanced research in plant biotechnology.

The Centre is well equipped to carry out advanced research in the field of molecular biology and biotechnology. Following are the facilities which are usually used by graduate students for their research work: ultracentrifuges, high pressure liquid chromatography, PCR machine, biolistic gun, DNA sequencing apparatus, nucleic acid hybridization sonicator and monitor for radioisotopes, separate common facility labs for radio-isotopes work and DNA sequencing, tissue culture and genetic transformation.

Plant Physiology

In 1940, one of the two posts of Assistant Economic Botanist was earmarked for a Plant Physiologist. In 1966, the Division of Plant Physiology was established at IARI. Prior to this, plant physiology had a modest infrastructure. Nevertheless, during this period significant research outputs, especially in the areas of stress physiology nitrogen metabolism, post harvest physiology and aspects of physiological basis of crop productivity, were generated which are internationally recognized and have relevance to crop improvement programme even in the present times. At present, the Division is equipped with all the modern instruments, and research work is being carried out on physiological and molecular aspects of source-sink relationship, abiotic stress, post harvest physiology and global climate change.

The following teaching programmes have been developed in association with the other sister institutes of ICAR located in the IARI Campus:

Agricultural Statistics

Since October 1964, courses leading to M.Sc. and Ph.D. degrees in Agricultural Statistics were started at the Post Graduate School of IARI in collaboration with the neighbouring Indian Agricultural Statistics Research Institute (IASRI). Earlier certificate courses in statistics were awarded by IASRI.

Computer Application

Identifying the growing importance and application of computers, the post-graduate course (M.Sc.) in the discipline of Computer Application in Agriculture was started in September 1985 in association with the Indian Agricultural Statistics Research Institute. The course was later renamed as Computer Application.

The course contents of the discipline are comprehensively designed to cater to the present and future needs.

The IASRI offers all the modern computing facilities (more than 100), Internet, E-mail, etc. to the students. Besides these, the Institute has software packages like SAS, SPSS, STATISTICA,
Bioinformatics

M.Sc. degree programme introduced from the Academic Session 2011-12.

Bioinformatics is conceptualizing biology in terms of molecules (in the sense of Physical Chemistry) and applying “informatics techniques” (derived from disciplines such as applied mathematics, computer science and statistics) to understand and organize the information associated with these molecules, on a large scale. It integrates the advances in the areas of Computer Science, Information Technology and Biology to unravel complex biological phenomena. Bioinformatics is used for the creation and advancement of databases, algorithms, computational and statistical techniques to solve problems arising from the management and analysis of large scale biological data.

AIMS of Bioinformatics

- To organize data in a way that allows researches to access existing information and to submit new entries as they are produced.
- To develop tools and resources that aid in the analysis of data. Development of such resources dictates expertise in computational theory, as well as thorough understanding of biology.
- To use computational tools to analyze the data and interpret the results in a biologically meaningful manner.

Plant Genetic Resources

The possibilities of genetic improvement of various crop plants through systematic evaluation and upgrading of the germplasm resources of the country were clearly brought out by students’ research; and some of the basic studies, besides proposing and testing newer concepts, have provided support for the development of improved technologies for crop improvement. Keeping this in view, a new M.Sc. degree programme was started in Plant Genetic Resources in the academic year 1997-98 and a Ph.D. degree programme in the academic year 2004-2005 at the National Bureau of Plant Genetic Resources (NBPR) located in the IARI campus. These courses have been based on a similar degree programme being offered by Birmingham University in U.K. The courses of PGR include the components of genetics, statistics, horticulture and other related disciplines. This programme has evoked a good initial response.

Laboratories

Along with general divisional laboratory facilities, the Institute takes pride in having developed sophisticated specialised laboratories to undertake research in all the areas of agricultural sciences.

Nuclear Research Laboratory

The Nuclear Research Laboratory (NRL) was established in 1969. Development of management practices for optimising the use of fertilizers, micronutrients, water and pesticides, development of ground water resources, soil-plant-nutrient system analysis, radionuclide transfer from soils to crops, studies on clay-organic complexes, characterisation of ultra structures of biological materials, development of techniques for non-destructive determination of oil in oilseeds, analysis of biotic and abiotic stresses, and preservation and disinfestation of food products are the main areas of work undertaken at NRL.

Water Technology Centre

The Institute established the Water Technology Centre (WTC) in 1970. At this Centre, excellent infrastructure has been provided for research on all aspects dealing with water technology. The laboratory is equipped to design appropriate structures for farm irrigation, water conveyance and control, develop suitable techniques for use of saline water for irrigation, computer-based procedure for calculation of water balance in crop root zone, conduct studies on agricultural land drainage, and analyse physiological basis of drought resistance in crops and irrigation management.
Phytotron Facility

The Institute has established the National Phytotron Facility (NPF) with the assistance of the Department of Science and Technology, Indian Council of Agricultural Research, FAO and United Nations Development Programme. The facility provides a battery of plant growth chambers with environmental controls which are proving useful in developing our understanding of the complicated interactions of physico-chemical environments and living systems, specially the plants and their pathogens. This is the first facility of its kind in the country to study the life responses under controlled conditions and the possible impact of climate change and greenhouse gases. These studies will help in developing varieties of crops suitable for different agroclimatic zones. Ten glasshouses with computerised controls are attached with the facility. These growth chambers have more than 250 permutations and combinations of photoperiod, temperature, lighting, humidity and carbon dioxide concentrations.

Advanced Centre for Plant Virology

In 1988, the Institute created an Advanced Centre for Plant Virology with the assistance of Indian Council of Agricultural Research, United Nations Development Programme, and FAO for generating basic knowledge on economically important plant viruses and virus like pathogens to help in their effective management and also to train young scientists in various areas of advanced virology. The Centre is identified as a lead centre for plant virology, not only in the country, but also in the region. It plays an important role in identifying viruses, supplying diagnostic reagents and training. The Centre has well equipped laboratories for work on electron microscopy, purification, production of polyclonal and monoclonal antibodies, cloning of viral genomes, use of radioactive and non-radioactive probes, electrophoresis, sequencing, use of PCR in disease diagnosis, tissue culture and plant transformation.

Microbial and Insect Conservation Facilities

The Institute realised the importance of diversity of biological forms and their importance in maintaining the ecological balance right from its inception when it established Herbarium Cryptogamae Indae Orientalis in 1905. Since then the Institute has developed a National Culture Collection of fungi, a National Insect Collection which has more than 4 lakh insect collections, a National Collection of Nematodes, and a National Facility of Blue Green Algae and Azolla.

Central Seed Testing Laboratory (CSTL)

The Seed Testing Laboratory of the Institute has got the status of CSTL under the Ministry of Agriculture, and serves as the Referral Laboratory for all the 96 seed testing labs located in different parts of the country. Regular training courses for the personnel of the State Seed Testing Labs are being organised.

Quality Seed Facility

A Japan Grant Aid Project has been launched at IARI to upgrade the facilities for seed research, processing and storage through infrastructure development, highly sophisticated equipment and state of the art technology in Seed Science and Technology. This National Facility is envisaged to provide medium term storage for 4.5 tonnes of authentic seed samples of all released varieties (approx. 3500) from the National Agricultural Research System. Storage facilities for 160 tonnes of Nucleus and Breeder seed will be availed by IARI, SAUs and ICAR institutes for need-based buffer stocking which will help avert high seed insecurity in the country and in the South Asia region. The facilities also help in developing a ‘Centre of Excellence in Seed Science and Technology’ to meet the challenges of emerging research requirements and development of human resources in this critical sector. In addition, the Centre is expected to act as a catalyst in fostering scientific linkages among the developing countries.

Other Laboratories and Instrumentation Facilities

The Institute has also developed specialised laboratories for work on agricultural chemicals, nematology, fungal pathology, insect pathology and physiology, post-harvest technology, etc.
The Institute is equipped with sophisticated instrumentation facilities such as: X-ray Diffraction, NMR Spectrometer, Amino Acid Analyzers, Ultracentrifuges, Electron Microscopes, Gamma Ray Spectrometer, Infrared Spectrometer, $^{15}$N Emission Analyser, Electrophoretic Apparatuses, Walk-in-Growth Chambers, PCRs, Bioreactors, Biolistic Particle Delivery System, Differential Thermal Analysers, GCMS, Gas Chromatograph, Auto-Nitrogen Analysers, Scintillation and GM Counters, Atomic Absorption Spectrophotometers, UV Spectrometer, Tritium Enrichment Plant, Gamma Irradiation Chamber, HPLCs, Refrigerated Shakers, Electroporator, and MICROVAX II Computers.

**Experimental Farm**

IARI has an area of 500 ha, out of which 280 ha are cultivated and 220 ha are under roads and buildings of the IARI estate. Nearly 85 per cent of the total area is irrigated and the rest is available for rainfed dryland research on different crops. About 15 ha area of the land has been given over to the National Agricultural Sciences Centre of ICAR and to three other adjoining ICAR setups. Thus, there is a pressure for land resource for field experiments of nearly 500 scientists working in the Institute. Excellent facilities for field experimentation exist and are managed by the Farm Operation and Service Unit (FOSU) of the Institute.

**Protected Agriculture**

To meet the research and technology development needs of protected agriculture, specially horticulture, vegetable seed production and nursery production, about 10 ha area of the farm is being put under veritable types of temperature, humidity and fertigation controlled glass and plastic houses. An IARI-Israel cooperative programme on protected agriculture has been started to complete and further strengthen these facilities.

**Coordinated Research**

The concept of Coordinated Research Project started from IARI. The Institute also serves as the headquarters of a number of All India Coordinated Research Projects. The All India Soil and Land Use Survey and the Division of Plant Introduction, which were part of the Institute, have now been set up as independent institutions under the Indian Council of Agricultural Research. The Directorate of Wheat Research, Karnal, Directorate of Maize Research, New Delhi and Directorate of Floriculture Research, New Delhi have also emerged out of IARI.

1.3 **Post-Graduate Education**

1.3.1 Since its early years, the Institute has flourished as a centre for imparting post-graduate training to officers of the State Departments of Agriculture as also other candidates, so as to equip them for manning important positions in the fields of research, teaching, and extension. In 1923, the training programme was placed on an organised footing and two-year courses of specialised post-graduate training leading to the Associateship of the Institute (Assoc. IARI) were organised in different major fields of agricultural science. This programme was reviewed comprehensively in 1945 and a regular programme of instruction and examination, including lectures, practical work and field investigation was introduced. These diploma courses were replaced by post-graduate courses leading to the M.Sc. and Ph.D. degrees of the Institute in 1958 when it was given the status of a “Deemed University” under the University Grants Commission Act of 1956. With regard to educational standards and quality, the Institute ranks among the best institutions of post-graduate education in the world. A unique feature of the system of instruction at the Institute, which is largely modeled on the course-credit system obtaining in many universities of the USA, is that research, teaching and extension are fully integrated and the programme of instruction is broad-based so as to give the student a mastery not only in his/her major field of specialisation but also in the supporting minor fields. Currently, instruction leading to the post-graduate degrees of the Institute is organised in 24 disciplines, viz. Agricultural Chemicals, Agricultural Economics, Agricultural Engineering, Agricultural Extension, Agricultural Physics, Agricultural Statistics,
Agronomy, Biochemistry, Bioinformatics, Computer Application, Entomology, Environmental Sciences, Genetics, Horticulture, Microbiology, Molecular Biology and Biotechnology, Nematology, Plant Genetic Resources, Plant Pathology, Plant Physiology, Post Harvest Technology, Soil Science and Agricultural Chemistry, Seed Science and Technology, and Water Science and Technology. The education programmes in the field of Agricultural Statistics and Computer Application are organised in collaboration with IASRI while Plant Genetic Resources with NBPR (both of the Indian Council of Agricultural Research). The Institute played a notable role in the development and upgradation of the faculty in the newly set up Agricultural Universities when it collaborated with the USAID. Under this programme, selected members of faculty from Agricultural Universities did their course work in universities of the USA and completed their research work and degree requirements at IARI. A fruitful phase of bilateral cooperation was also completed in collaboration with the International Rice Research Institute, Philippines whereby both Indian and foreign students completed their course work at IARI and the research work at IRRI for the award of the IARI degree. 

1.3.2 Till the 48th Convocation of the PG School held on 13th February, 2010, 4077 Ph.D. and 3138 M.Sc. degrees had been awarded to students. The post-graduate students (presently numbering about 770 including a number of female students) come from all over India and from several foreign countries such as Afghanistan, United Arab Emirates, Republic of Egypt, Bangladesh, Cyprus, Ethiopia, Indonesia, Guyana, Iraq, Jordan, People’s Democratic Republic of Yemen, Kenya, Malaysia, Malawi, Mauritius, Myanmar, Nepal, Nigeria, Sierra Leone, Philippines, Singapore, Sri Lanka, Syria, Thailand, Trinidad, USA, Vietnam, etc. There are seven large hostels, complete with spacious dining and common rooms, separately for male and female students and for married students, a gymnasium and a play field. Alumni of the Institute are now occupying positions of responsibility in the various agricultural universities and other offices of high esteem in the country as well as abroad.

1.4 Location and Campus

1.4.1 The Institute is located about 23 km north of the Indira Gandhi International Airport and 5 and 8 km, respectively, west of the New Delhi and the Old Delhi railway stations on a self-contained 500 hectares campus of its own, at a latitude of 28.04° N and longitude of 77.12° E, and at an elevation of 228 meters (750 ft.) above mean sea level. The climate of Delhi is semi-arid, sub-tropical with hot summers and cool winters. The mean monthly maximum and minimum temperatures during the year range from 21.3°C to 40.5°C and 7.3°C to 28.7°C, respectively. The annual normal rainfall is 708 mm, of which, on an average, 597 mm (84%) is received from June to September and 85 mm (12%) during the winter months, i.e., November to March.

1.4.2 In addition to the library, laboratories and the offices, residential accommodation is also provided on the campus. The amenities on the campus include a medical dispensary, a shopping complex, two government higher secondary schools (one for boys and another for girls), a nursery school run by the Nehru Experimental Centre, provisions store, a Post Office and a nationalised bank. The Indian Agricultural Statistics Research Institute (IASRI), National Bureau of Plant Genetic Resources (NBPR), National Research Centre on Plant Biotechnology (NRCPB), National Research Centre for Integrated Pest Management (NCIPM), Directorate of Floricultural Research (DFR), Directorate of Maize Research (DMR), National Centre for Agricultural Economics and Policy Research (NCAP), National Agricultural Sciences Centre (NASC) of the Indian Council of Agricultural Research (ICAR), National Physical Laboratory (NPL) under the Council of Scientific and Industrial Research (CSIR), Institute of Hotel Management, Catering and Nutrition, and National Seeds Corporation are located adjacent to the Institute.
2 Emblem and Invocation

2.1 Emblem

The Post Graduate School emblem is in the form of leaf representing the plant kingdom which is basic to agriculture. It bears three colours: Red, Blue and Gold.

The EAR of wheat represents agriculture and plant sciences.

The MICROSCOPE signifies modern research.

The BOOK represents knowledge, including science basic to agriculture.

The Motto is:

जीव जीवनं कृषि:

“Agriculture is the supporter of life”.

2.2 Invocation

Invocation song

The invocation song, sung at the annual convocation and other functions of the Post Graduate School, is reproduced below:

विज्ञानं ब्रह्माति ब्रह्मानालं।
विज्ञानं धन्यं क्षित्मानं भूतानि जागन्ते।।
विज्ञानं जातानि जीवन्ति।
विज्ञानं प्रच्छन्नमिति विश्वास्ति।।
विज्ञानं यदं तुमुः। कर्माणि तुमुःदंपि च।
विज्ञानं देवा सर्वं। ब्रह्माण्येकं मुखपासि।।
तस्माचेतन प्रमादग्नि।
शरीरं पाप्मो दितवा सर्वंकामानं समस्मुन्ते।
क्षेत्रविभिन्तं क्षेत्रविभिन्दं ह्यप्राप्त।
सप्रगतं क्षेत्रविदानुस्तिः।
एतदेशं भद्रं अनुशासनं च।
उत्सुतं विन्द्यज्ञज्ञज्ञीनाम्।।
कृषि ह्यूहनावलु। सह नी भुनक्तु।
सह कृषि कल्यावलु। तेजस्विनाकपीतमस्व। मा विद्विषाण हैं।।
ऊं शाति: शाति: शाति:।।
May the ploughshares till our land properly;
May the ploughmen go happily with the oxen;
May the Rain God send us sweet showers at appropriate times;
May Suna and Sira grant us prosperity.

Understand knowledge as Brahman;

Because it is by knowledge alone that all these living being are born;

Having been born, by the knowledge they live;

And having departed, into knowledge again they enter.

Knowledge is the fountain-head of sacrifice;
It stimulates all our actions; All Gods worship knowledge as *Brahman*, the highest;
If man does not swerve from the path of knowledge. He attains all desires, having abandoned his sins in the body,
One ignorant of the land asks him who knows about it;
And advised by the teacher who knows, one (the pupil) goes forward.

This, verily, is the blessing of instruction;
One finds the path that leads straight forward (by oneself).
May He protect us. May He cause us to enjoy together;
May we exert together.
May learning make us radiant;
May we not hate one another.
Om, Peace, Peace, Peace!!!
3 Administration and Faculty

3.1 The Institute is a constituent unit of the Indian Council of Agricultural Research, which is a Society registered under the Societies Registration Act (Act XXI of 1860). The Director is the principal executive officer of the Institute. The Dean and Joint Director (Education) is responsible for the overall supervision of the programme of post-graduate education and training at the Institute.

3.2 The Institute has five main bodies, which are responsible for broad policy matters and decision making in the field of research, post-graduate education and training, extension education and administration. These are:

(i) Board of Management

(ii) Research Council

(iii) Academic Council

(iv) Extension Council

(v) Executive Council

The highest policy making body of the Institute is the Board of Management. The Research Council is responsible for the formulation of research projects and monitoring their progress and application. All the matters relating to post-graduate education and training are decided by the Academic Council, which is supported by Board of Studies in each discipline and four Standing Committees. The Extension Council is responsible to formulate the extension education and transfer of technology programme and to monitor the progress of extension education. All the administrative matters and policy decisions are implemented by the Executive Council.

The Composition of Academic Council

(i) Director Chairman

(ii) Dean & Joint Director (Education) Vice-Chairman

(iii) All Project Directors Member

(iv) Joint Director (Research) Member

(v) Joint Director (Extension) Member

(vi) Deputy Director-General (Education), ICAR Member

(vii) Four eminent scientists/educationists from outside the IARI distinguished in the field of education including agricultural education (for the period of two years) Member

(viii) All Professors of teaching disciplines, (or where there is no Professor, the Head of the Division) Member

(ix) Director, Indian Agricultural Statistics Research Institute, New Delhi Member

(x) Director, National Bureau of Plant Genetic Resources, New Delhi Member

(xi) Director, National Research Centre on Plant Biotechnology, New Delhi Member

(xii) Director, Directorate of Floricultural Research, New Delhi Member
Membership and Functions of Academic Council

3.3 Four eminent scientists/educationists will be nominated by the Chairman of the Academic Council on the recommendation of the Dean. The tenure of their membership is two years, the first two of them retiring through draw of lots at the end of the first year.

3.4 Two representatives from the post-graduate faculty are elected through an annual election by secret ballot by the faculty members. The following rules and procedures will be observed for election of the two faculty members to the Academic Council.

(i) All faculty members, other than those designated as ex-officio member or either the Board of Management or the Academic Council, will be eligible to be elected.

(ii) Members will normally be elected for a term of two years such that one vacancy is filled every year. A sitting member may only be re-elected for a second time in direct sequence but not for the third term.

(iii) In case a vacancy is created on account of an elected member's ineligibility or inability to complete his/her term, election to fill the vacancy will be held in the prescribed manner for the remaining period of the term provided that the remaining period is not less than one year.

(iv) Nominations will be invited from faculty members for each vacancy. Each faculty member will be permitted to nominate one person and forward the nomination duly seconded, direct to the Dean or any other duly authorised officer of the Post Graduate School by name in a closed cover.

(v) The election will be by a secret, single non-transferable vote to be cast at the specified place on the specified date provided that the faculty members located at Regional Stations shall be permitted to cast their vote by post. The detailed instructions in this regard will be laid down by the Dean with the approval of the Chairman of the Academic Council and notified to all Faculty Members at least a month in advance of the date fixed for polling.

(vi) A candidate receiving the highest number of votes shall be declared elected.

(vii) In case of a tie between two candidates, the issue will be settled by toss of coin after getting the agreement of both the candidates.

3.5 The two students' representatives will be appointed in the following manner:

(i) The President, Post Graduate School Students' Union (PGSSU), IARI will be an ex-officio student representative in the Academic Council.

(ii) The second student representative will be elected every year by secret ballot by the members of the PGSSU through the same election process adopted for electing the Executive of the Post Graduate School Students’ Union.

(iii) The tenure of the student representative shall be one year.

(iv) In case of resignation of the student representative to the Academic Council, the vacancy would be filled by holding a re-election.
3.6 Any item suggested for inclusion in the agenda should reach the Post Graduate School Office at least 15 days in advance of the proposed date of the meeting of the Academic Council.

3.7 Agenda note for the meeting of the Academic Council shall normally be made available to the members at least one week in advance of the meeting. If a member has to make some clarifications on the agenda items, this may be made at the time of the meeting; in case the member is not in a position to attend the meeting, a written note expressing his/her views may be sent to the Chairman for consideration.

3.8 Members of the Academic Council who are not in a position to attend the meeting of the Council for unavoidable and exceptional reasons should formally seek prior leave of absence from the Chairman of the Academic Council.

3.9 The membership of the Academic Council is personal as the Academic Council discharges certain statutory functions. A member cannot depute his nominee to attend meetings of Academic Council on his behalf.

3.10 Membership of the Academic Council shall stand terminated on the happening of any of the following events:

(i) Upon the expiry of the period of membership for which nominated.
(ii) Death, resignation, lunacy or conviction for a criminal offence involving moral turpitude.
(iii) When the member declines to serve on the Academic Council or the member's employer refuses to grant permission to serve on the Academic Council.
(iv) When a member does not attend three consecutive meetings of the Academic Council without informing the Academic Council.

3.11 The Academic Council shall meet as often as necessary and in any event at least once in each trimester of the year, the year for this purpose being the academic year commencing from August and ending in July.

3.12 The Academic Council meeting shall be held on such date, time and place as may be determined by the Chairman.

3.13 All meetings of the Academic Council shall be called by notice in writing by and under signature of the Member-Secretary.

3.14 Every notice calling for the meeting of the Academic Council shall state the date, time and place of the meeting and shall be served upon every member of the Academic Council not less than 10 clear days before the day appointed for the meeting. However, in case of an emergency the Academic Council meeting can be convened at a short notice giving clear 48 hours for the members to attend the meeting.

3.15 Any inadvertent omission to give notice, or non-receipt or late receipt of notice by any member shall not invalidate the proceedings of the meeting.

3.16 The draft proceedings of the meeting of the Academic Council will be circulated to all the members of the Academic Council for comments which should be communicated to the Post Graduate School office within a period of 10 days of such circulation. The comments, if any, will be placed for discussion at the next meeting of the Academic Council.

3.17 Proceedings of the meeting of the Academic Council shall also be circulated to Project Directors, Heads of Divisions and Regional Stations.

3.18 The proceedings of the meetings of the Academic Council shall be placed in the very next meeting of the Board of Management for information.

3.19 It is the responsibility of each of the representative of the various Divisions to interact regularly with the Head of the Division and with post-graduate faculty of the Division, to keep them informed of actions of the Academic Council and matters under discussion by the Academic Council. They are expected to bring to the attention of the Academic Council important views of the Divisions with respect to matters under discussion.

3.20 The powers and functions of the Academic Council shall be:

(i) to be the main consultative, deliberative and task implementing body in the fields of education and training.
(ii) to be responsible for broad policy matters on academic issues without dealing with individual cases.

(iii) to have control and general regulatory powers on matters relating to education and training.

(iv) The Academic Council shall be responsible for the maintenance of standards of instruction, education and examination within the Post Graduate School and to exercise such other powers and duties as are conferred on it.

(v) The Academic Council shall be responsible for the determination of equivalence of degrees of candidates applying for admission from other universities and shall be the final authority to make selection among the applicants for admission.

(vi) The Academic Council shall perform, in relation to academic matters, all such duties, as may be necessary, for the proper conduct of the programmes of post-graduate education.

3.21 Standing Committees

3.21.1 The Academic Council has four Standing Committees for examining the issues relating to education and training. The Standing Committees shall dispose of individual cases if these are within the frame-work of the rules and regulations in force. Cases of policy nature and which involve financial/administrative implications, shall be recommended and put up to the Academic Council with specific suggestions after examination from the financial and administrative angles. The recommendations of the Standing Committees shall be reported to the Academic Council for consideration. The tenure of these committees is 2 years.

3.21.2 The composition and functions of the Standing Committees as approved by the Board of Management are as under:

(i) Standing Committee on Courses, Curricula and Academic Affairs

Chairman: A Professor or a Project Director/Head of the Division who is a member of the Academic Council

Members: Three Professors, an elected faculty representative in the Academic Council, the elected student representative in the Academic Council, and an officer of the Post Graduate School (Member-Secretary).

Functions
(a) Review of academic standards including syllabus, examination etc.
(b) Matters regarding admissions to M.Sc. and Ph.D. courses.
(c) Matters relating to examination, evaluation, teaching technique, etc.
(d) Criteria for formulation of new courses and recommendation of new courses for the approval of the Academic Council.
(e) Academic work-load of faculty members.
(f) Matters regarding major field of specialisation and subject on which a degree has to be awarded.
(g) Rules regarding the award of degree, IARI merit medals, etc.

(ii) Standing Committee on Faculty and Discipline

Chairman: A Professor or a Project Director/Head of the Division who is a member of the Academic Council.

Members: Three Professors, Second elected Faculty Representative in Academic Council, and an officer of PG School (Member-Secretary).

Functions
(a) Formulation of guidelines regarding admission of faculty members, their duties obligations and other related faculty matters.
(b) Guidelines regarding the composition and function of the Board of Studies and Faculty in each discipline.
(c) To deal with representations from individual faculty member regarding allotment of students, constitution of Advisory Committees, teaching of course, representation in Board of Studies, grant of laboratory and other facilities.
(d) Consideration of requests from the Scientists / Faculty members of different disciplines for their induction as member / research guide in PG school faculty as the case may be.

(iii) Standing Committee on Scholarships, Financial Assistance and Academic Progress

Chairman: A Professor or a Project Director/ Head of the Division who is a member of the Academic Council.

Members: Three Professors, President, PGSSU, the elected Student Representative in Academic Council and an officer of the Post Graduate School (Member-Secretary).

Functions

(a) Procedure for reviewing the academic progress of students.
(b) Individual cases of students regarding extension of time limit for submission of thesis and also cases of poor academic performance.
(c) Formulation of terms and conditions for the award of various scholarships and fellowships.
(d) Award of scholarships.
(e) Procedure for assistance from Students’ Welfare Fund.

(iv) Standing Committee on Students Problems and Discipline, Welfare Board and Residences

Chairman: A Professor or a Project Director/Head of the Division who is a member of the Academic Council.

Members: Three Professors, Master of Halls of Residences, Registrar & Joint Director (Administration), President, PGSSU, the elected Student Representative in Academic Council and an officer of the Post Graduate School (Member-Secretary).

Functions

(a) Representation from students regarding the constitution of Advisory Committee, dropping/adding of courses, relief from Post Graduate School, maximum period of absence on leave, and removal of names from the rolls of Post Graduate School etc.
(b) Use of Institute’s facilities in terms of equipment, chemicals etc. by the students.
(c) Cases relating to students’ discipline.
(d) Review of amenities in the hostel including food services.
(e) Organisation of co-curricular and extra-curricular activities.
(f) Rules regarding hostels including guests, overstay, etc.
(g) Placement of students for employment.
(h) Medical attendance.

3.21.3 The members of various Standing Committees shall be nominated by the Chairman, Academic Council and the nominations are placed before the Academic Council for approval at the time of reconstitution of the Committees once in two years. The Chairman is empowered to fill-up casual vacancies occurring during the life of these Committees.

3.22 Post Graduate School Faculty

The Post Graduate School Faculty consists of the following:

(i) Dean, Post Graduate School (Chairman, ex-officio)
(ii) Director, IARI (Member, ex-officio)
(iii) All Project Directors and Heads of the Division (Member, ex-officio)
(iv) All Professors (Member, ex-officio)
(v) Other officers of the Institute who are specifically approved for inclusion in the Post Graduate Faculty as per norms prescribed in this regard (Member)
(vi) Registrar (Member-Secretary, ex-officio)

(a) The Post Graduate Faculty may consider or report on any matter referred to it by the
Academic Council /Board of Management/ members of the Faculty.

(b) The meetings of the Post Graduate Faculty are generally held 3 to 4 times in a year or as often as necessary.

(c) All visiting Professors will automatically be recognised as members of the faculty provided their curriculum vitae is forwarded to the Dean sufficiently in advance of the date of arrival.

(d) The Academic Council may in special cases, induct distinguished scientists to the Post Graduate faculty.

3.22.1 Induction into the Post Graduate Faculty

(i) All IARI (including Regional Stations) / IASRI / NBPG / DMR / DFR / NRCPB / NCIPM / NCAP scientists holding Ph.D. degree are eligible to be inducted automatically as Faculty Members on the intimation of his/her Joining by Chairman, BOS of the discipline.

On the joining of Director/JDs (Edn., Res., Extn.)/PD/PC/HOD at IARI / IASRI / NBPG / NRCPB / DMR / NCIPM / NCAP / DFR shall automatically be admitted to the PG faculty and research guide in their respective discipline.

A scientist ceases to be faculty member when he/she leaves IARI/IASRI/NBPGR / DMR / DFR / NRCPB / NCIPM / NCAP on transfer/retirement.

(ii) Until a faculty member becomes eligible for research guidance, he/she can serve as a member of the Advisory Committee of the students representing the respective major or minor field as the case may be, but will not be eligible to function as Chairperson/Co-Chairperson of the Advisory Committee of the student.

(iii) The request of the faculty members transferred from IARI to other Institutes located in the IARI campus for continuation of their faculty membership of the Post Graduate School, can be considered for honorary faculty membership for delivering lectures on the topics of their field of specialization only. They can also be allowed to become additional members in the Advisory Committees of the students.

(iv) The National Professor(s) working at IARI may continue as faculty of the Post Graduate School on their request, if they were faculty members before taking up the National Professorship. The National Professors working at IARI who are not faculty members however, may be inducted into the faculty of Post Graduate School as per the recommendations of the Board of Studies upon the request of the National Professor(s) concerned.

(v) Emeritus Scientists working at IARI may serve as honorary faculty of the PG School if they were faculty members before joining as Emeritus Scientists. Those who were not faculty, may be inducted as honorary faculty as per recommendations of the Board of Studies. The Emeritus Scientists may deliver lectures/practicals in the field of their specialization. They can also be allowed to become additional members in the Advisory Committee of the students.

(vi) Recognition of faculty of other Institutes: The Dean may on the recommendation of the Board of Studies and approval of the Chairman, Academic Council, induct scientists located in other Institutes of ICAR or reputed research organizations, faculty members of the Post Graduate School, in disciplines where such additional faculty members in specific specializations are required, provided they meet the other eligibility conditions for being a faculty member of the PG School. Such external faculty members can be called to deliver lecture/practical classes on short visits and can serve as Co-chairperson or Member in the Advisory Committee of students who may be sent to carry out whole or part of the research work for their thesis at the Institute where such external faculty member is normally located. In such cases, the credit for research work including authorship and any other intellectual property rights shall be
shared as per the MoU (Annexure XX) between the Institutes and faculty with the concerned student as the senior author.

(vii) Notified Adjunct and Guest Faculty: The Dean may consider the recommendation of Board of Studies with the approval of the Chairman, Academic Council, to recognize and notify certain reputed scientists, retired or working, who have made significant contributions in research and teaching in their field of specialization and may be available to take active part in teaching; as Adjunct Faculty or Guest Faculty. Such faculty members will be required to deliver at least 10 lectures in a year to cover a part of a regular course. They shall be paid remuneration for not more than 25 lectures at approved rates prevailing at the relevant time. The Dean with the approval of Chairman, Academic Council may denotify an Adjunct/Guest Faculty in case he/she is unable to meet the minimum teaching requirements.

3.22.2 Recognition as Research Guide

The faculty members who fulfill the following requirements shall apply in the prescribed proforma (Annexure IIb) for becoming eligible for research guidance.

(i) A faculty member should have put in a minimum 3 years of teaching experience as Course Leader or Course Associate and should have published at least 3 papers in sole or senior authorship in professional journals of repute with NAAS rating in the concerned discipline for M.Sc. guidance.

(ii) A faculty member should have put in at least 5 years of teaching experience as Course Leader or Course Associate and should have published 5 papers in professional Journals of repute in the concerned discipline in sole or senior authorship with experience of guiding 2 M.Sc. students to be eligible for guiding a Ph.D. student.

(iii) Those with Ph.D. degree will be eligible to guide Ph.D. students only after they have guided 2 M.Sc. students. However, the Dean may permit a faculty member, who has not guided 2 M.Sc. students, to guide Ph.D. students in relaxation of existing guidelines.

(iv) Scientists / Staff members who have guided students in other Universities prior to their appointment in IARI are eligible to apply for research guide.

(v) A faculty member should have teaching experience of at least 24 lectures in an academic year. Teaching for at least one trimester in an year will be taken as one year experience.

(vi) Board of Studies will justify and recommend whether applicant’s induction to the faculty will add to the efficiency of the teaching programme in the discipline.

(vii) The requirement of publishing research papers as sole or senior author may be relaxed for senior scientists who are already faculty members (as credit is often shared equally by authors) while consider requests for becoming research guides.

3.22.3 Guidelines for Induction of non-Ph.D. Scientists into faculty

(i) Scientists with Masters Degree in the discipline concerned with minimum 2nd class or equivalent grade and similar grade in bachelor's degree.

(ii) Three years post M.Sc. research / teaching / extension experience in the relevant field of specialisation as Scientist.

(iii) Those with only Master's Degree will be eligible to guide only M.Sc. students.

(iv) Those with Master's Degree by course work alone will not be eligible to guide any student until they acquire a Ph.D. degree.

3.22.4 Qualifications for Library Staff for Induction as Faculty Members

(i) A Master's Degree in Library Science with minimum second class or equivalent grade and also a similar grade in the bachelor's
degree.

(ii) Six years experience as Librarian with 5 publications in journals of library science or 8 years experience as Librarian (in lieu of publications).

(iii) Library staff with exceptional experience who may not fulfill the above qualifications can also be considered for induction into faculty provided they have a Master’s Degree in science and a diploma in library science.

3.22.5 If any faculty member is admitted as a departmental student of the Post Graduate School or is registered for a higher degree with an outside university, his/her faculty membership shall stand automatically discontinued. During his/her studentship he/she will not be eligible to teach courses or guide students either as Chairperson or member of the Advisory Committee. A member of faculty who applies for registration for “Higher Degree” with an outside university, will cease to be a faculty member on expiry of 6 months from the date on which his/her application is forwarded by the Dean, Post Graduate School or from the date he/she is actually registered with the outside university, whichever is earlier. It would be the responsibility of the faculty member concerned to inform the Professor and Dean immediately on receipt of intimation of his/her registration with an outside university. The provision of this rule would not be applicable to a member of faculty registered with an outside university for a post-doctoral degree.

3.22.6 A staff member had been a student of the Post Graduate School and his/her name had been struck off for not maintaining the minimum required O.G.P.A., he/she will not be eligible for faculty membership. If the staff member had also a faculty membership before his/her admission to the Post Graduate School and his/her name is struck off for not maintaining the required O.G.P.A., his/her faculty membership shall not be revived.

3.22.7 A faculty member shall ordinarily function as the Chairperson of the Advisory Committee of not more than 4 students and in any case of not more than 5 students.

3.22.8 A faculty member shall function as a member of the Advisory Committee of not more than 10 students. However, this limit can be extended up to 20 students for disciplines lacking adequate faculty on recommendation of the Board of Studies. This shall be in addition to the limit of 5 students mentioned in Para 3.22.7.

3.22.9 No faculty/staff member shall function as a guide for any candidate registered with another university. However, faculty members located at Regional Stations of IARI are allowed to guide students registered as full time students at a local agricultural university, provided that:

(i) The Faculty Member certifies that he/she can undertake the guidance work without prejudice, in any way, to his/her approved research programme at the Regional Station,

(ii) Prior permission of the Director, IARI, through the Post Graduate School before communicating his/her consent is required for undertaking guidance of any such student, and,

(iii) The student concerned undertakes to acknowledge the facilities extended by the IARI in his/her thesis.

3.22.10 A faculty member will be Course Leader for a maximum of two courses in an academic year. In exceptional cases, a faculty member may be appointed Leader of three courses with the permission of the Dean. Ad-hoc teaching responsibility may be granted to a scientist who is not a faculty member on an annual basis, but should not be appointed as Course Leader.

3.22.11 Guidelines for Charge of Professor

In each discipline one of the Principal Scientists will be nominated as Professor to supervise teaching and HRD activities of the discipline, as per the following criteria:

i) Seniority of Principal Scientists in particular discipline with Ph.D. may be considered as the prime criterion and normally the senior most person should be considered for charge of Professor, provided other conditions are fulfilled.
ii) The scientist should be a faculty member of the PG School and should have at least 5 years teaching experience having taught at least 18 lectures in a year in the relevant field and experience of guiding at least 2 M.Sc. or 1 Ph.D. student.

iii) The scientist should have at least 5 research publications during the last 5 years of service in journals of National and International repute with an average rating of 2.5 out of 10 as per NAAS score.

Note:

(i) The crop varieties released by a faculty shall be taken into account in case of deficiency in lacking the requirement of publication of required number of research papers in the journal of repute with prescribed rating for consideration for the charge of Professor in the respective discipline.

(ii) Publication of a technical bulletin as a sole or senior author may also be considered as a publication. The rating of release of crop varieties, Technical bulletins to be considered equivalent to the publication of research papers may be done by the Dean & Joint Director (Edn.).

3.23 Faculty Guidelines

3.23.1 The following guidelines have been prescribed to ensure smooth and uninterrupted teaching and guidance programme of post-graduate students at a high level:

(i) As research and post-graduate teaching functions are integrated at IARI, all the faculty members shall give equal importance to teaching, guidance and research work of post-graduate students.

(ii) The Head of the Division/Project Director/Project Coordinator should carefully examine, in consultation with the Professor, the commitments of the faculty member with regard to the guiding of students and teaching of courses before sanctioning tour programme, leave, deputation abroad or relieving him/her for accepting other jobs etc. The permission of the Dean may be sought for any absence of faculty exceeding three months. While seeking the permission, the commitments involved and the alternative arrangements made should be indicated.

(iii) The members of the Advisory Committees of the students should refrain from going on long tours during the period when the students are expected to finalize their thesis, if such tours are likely to delay the finalization of the thesis. Short unavoidable tours may be undertaken in such a way that the submission of thesis is not delayed.

(iv) Except for minor adjustments, a Course Leader should not drop or suspend any class as per the approved time-table on account of meetings, workshops, selection committees, etc. in IARI, ICAR or outside. Such invitations/engagements may be declined, if these interfere with the commitments of the faculty members.

(v) Every Course Leader shall submit the result of examination online at the end of the trimester within 7 days of the date of holding the final examination. The reason for delay, if any, should be clearly explained.

(vi) A faculty member leaving the Institute and taking up another temporary assignment elsewhere should take prior approval of the Dean for temporarily discontinuing the faculty membership. The faculty member, on return from his/her assignment, should send a formal intimation to the Professor and the Dean, and would be automatically included in the faculty list.

3.23.2 The following guidelines have been prescribed in regard to teaching and guidance of the post-graduate students by faculty members located outside the Division relating to their parent discipline:

(i) The faculty members, irrespective of their location, shall belong to their parent discipline.

(ii) They shall be eligible to teach courses/become Chairperson/Member of the Advisory Committee or members of the Board of Studies of the discipline. There shall be no distinction for any purpose between a
faculty member located outside the Division and a faculty member located inside the Division in respect of post-graduate education and teaching.

(iii) They shall be eligible for teaching a course including designation as Course Leader.

(iv) Matters such as courses to be taught by the faculty members shall be decided by Board of Studies in each discipline well in advance. The Professor of the parent discipline (or the Head of the Division concerned where there is no Professor) may ascertain from the Head of the establishment where the faculty member is located, the commitments of the particular faculty member. If such a faculty member is not in a position to teach courses or guide students during a particular period, this shall be intimated sufficiently in advance to the Professor/Head of the Division relating to the parent discipline. Details regarding the background of the faculty member and of the courses previously taught by him/her shall be kept in view by the faculty while allotting the courses to such a faculty member.

(v) In order to ensure that the faculty members are fully committed to the responsibility of post-graduate education and teaching in a particular discipline, the Professor of the parent discipline or the concerned Head of the Division where there is no Professor, shall assess annually the performance of each faculty member so far as his/her work relating to teaching of courses and guiding of students are concerned and submit a report to the Dean. The assessment in respect of work other than teaching of courses and guiding of students shall be made by the immediate supervisory officer of the Unit/Division/Centre where the faculty members are working. However, in respect of faculty members in whose case the assessment for research work is done directly by the Director, the assessment for work relating to teaching of courses and guiding students shall also be done directly by the Director.

(vi) In case, the assessment done as per para (v) above shows that a faculty member is not taking active part in teaching and research guidance, as applicable, or his/her performance is found unsatisfactory, the Dean may take corrective measures or refer the matter to the Standing Committee. The Standing Committee can recommend cancellation of faculty membership. The Dean, with the approval of Chairman, Academic Council, may cancel membership of the faculty.

3.24 Issue of Directions, Clarifications etc. in Special Circumstances on Behalf of the Academic Council

(i) If a situation arises in which it is expedient to issue authoritative clarifications or directions on behalf of the Academic Council with a view to ensuring smooth and uninterrupted conduct of academic activity at the Institute and it is not practicable to convene its meeting immediately, the Chairman of the Academic Council may, in consultation with the Chairman of the Post Graduate Faculty of the Institute and the Chairman of the Standing Committee(s) concerned, issue necessary clarifications or directions, and these shall have effect as if made by the Academic Council and shall continue to be in force until revoked or modified by the Academic Council after consideration at its meeting later.

(ii) All such clarifications or directions shall as far as practicable, be reported to the Academic Council for ratification at its next regular meeting (including a postponed meeting) or a meeting specially convened, inter alia for this purpose.

3.25 Board of Studies

3.25.1 Each discipline shall have a Board of Studies. It shall be constituted and shall function in the manner herein specified:

(i) The members of the Board of Studies will be nominated by the Dean at the commencement of each academic year in
consultation with the Professor and the Head(s) of the Division(s) concerned. While making nominations, the Dean will strive to provide representation to the scientists belonging to the various grades of scientists having regard to their seniority. The Dean may nominate a relatively junior scientist of a grade, keeping in view the academic interests, the advice of the Professor/Head(s) concerned and also the need for providing representation to all the areas of specialisation covered by the discipline. The decision of the Dean in the matter shall be final. Subject to these stipulations, each Board will consist of the following members:

(a) Professor Chairman (ex-Officio)
(b) Head of the Division Member (ex-Officio)
(c) Three scientists representing different categories, such as Scientist, Scientist (SG), Senior Scientist, and Principal Scientist Members
(d) One student representative Member

(ii) Only the scientists who are faculty members of the concerned discipline, shall be eligible to be included in the Board of Studies. The faculty members posted at the Regional Stations, i.e. outside Delhi, shall not be nominated to the Board of Studies as it will be generally difficult for them to attend the meetings of the Board of Studies.

(iii) One of the non-permanent scientist members of the Board of Studies shall be nominated as Member-Secretary by the Chairman.

(iv) The students’ representative should preferably be a Ph.D. student in the third year of his/her studies and will be nominated normally on the advice of the Student’s club/society of the discipline concerned. The Dean may, however, nominate any other student at his/her discretion if he/she is of the opinion that the student representative suggested by the Students’ club/ society is not likely to make/

is not making any useful contributions to the deliberations at the meetings of the Board of Studies concerned in an orderly manner.

(v) The Board of Studies may co-opt an additional member or decide to specially invite any scientist of the discipline to help it in its deliberations. Such co-opted members(s)/ invitee(s) shall have no right of vote.

(vi) The non-permanent members shall retire every year. The Dean, however, will have the power to renominate a retiring member.

(vii) Where there is no other scientist belonging to a category in a faculty except the one already included in the Board of Studies, such scientist shall continue to be included in the Board of Studies despite the expiry of his/her term.

(viii) Dean may nominate alternate members in the Boards of Studies in place of existing ones if in opinion of the Dean, the member is not taking adequate interest in the proceedings of the Boards of Studies or the member's conduct at the meeting of the Board of Studies is such as to hinder the smooth functioning of the Board of Studies concerned.

(ix) As far as practicable, the Professor shall decide the date, time and place for holding the meeting of the Board of Studies in consultation with the Head of the Division concerned, and but for exceptional reasons a notice of 7 clear days shall be given for holding of meeting of the Board of Studies. While the quorum for holding of the meeting of the Board of Studies shall be 75% of the total membership of the Board, no quorum will be needed for holding an adjourned meeting provided due notice has been given of the date and time for holding the adjourned meeting.

(x) Each Board of Studies shall be re-constituted by the end of the academic year preceding the commencement of the new academic year.
3.25.2 The Board of Studies shall have the responsibility of reviewing the instructional programme of the discipline concerned in respect of each trimester, preparing recommendations for revision, addition or deletion of courses, organisation of the teaching of courses in each trimester in the discipline concerned and considering all matters relating to improvement and conduct of Post Graduate School. The executive responsibility for implementation will be that of the Professor and the Head of the Division concerned.

3.25.3 The Board of Studies shall meet as often as necessary, but at least once at the end of each trimester to review progress of students, conduct of courses in the previous trimester and other academic matters.

3.26 Post Graduate School Administration
1. Director
2. Dean and Joint Director (Edn.)
3. Registrar
4. Officer Incharge (Academic Implementation and Monitoring Cell)
5. Technical Officer (Statistical Cell)
6. Technical Officer (IT Cell)
7. Asstt. Administrative Officer (Academic)
8. Asstt. Administrative Officer (Scholarship)
9. Master of Halls of Residences
10. Head, Library Services
11. Incharge, Central Photo Lab
12. Medical Officer Incharge
13. Associate Wardens
14. International Students’ Advisor
15. Lady Students’ Advisor
4 Academic Session and Term Calendar

4.1 The academic year of the Post Graduate School is organised in terms of three trimesters in a year, each approximately of 12 weeks duration. The academic session will commence in August of each year.

4.2 The exact dates of each trimester in a particular academic year shall be decided by the Academic Council from time to time. The broad time schedule of the three trimesters is given below:

I Trimester : August to November
II Trimester : December to April
III Trimester : May to July

4.3 There is a provision for a summer vacation of approximately one month duration during April and May, for which the dates are specified by the Academic Council. In addition to summer vacation, there is a provision for winter break of approximately three weeks and a break of about one week at the end of the academic year on dates to be specified by the Academic Council. Thus, the number of teaching days in an academic year are kept about 220 following the UGC guidelines of minimum 180 teaching days in a year.

4.4 The main activities undertaken in the term calendar and deadlines for various important activities are briefly mentioned below:

— Written Test for admission to Ph.D. programmes
— Declaration of result of Written Test for admission
— Interview for admission to Ph.D. courses in the respective disciplines
— Announcement of final result of selection for admission
— Registration of newly admitted students
— Orientation programme
— Newly admitted students to be addressed by the Dean and the Director
— Registration for continuing students
— Commencement of class work after registration of every trimester
— Last date for adding/dropping of courses
— Final examination of each trimester
— Last date for receipt of mark sheet of final examination
— Winter break
— Holding final *viva-voce* examination for consideration for award of IARI Merit Medals
— Holding final *viva-voce* examination for award of degrees in the Annual Convocation
— Convocation programme
— Lal Bahadur Shastri Memorial Lecture
— Annual Sports Meet
5 Disciplines and Major Fields of Specialisation

5.1 The main subjects of study and the major areas of activity /specialisation within each main subject in which instruction is offered at the Post Graduate School, leading to the M.Sc., M.Tech. (Agricultural Engineering only) and Ph.D. degrees, are as follows:

(i) AGRICULTURAL CHEMICALS: Agricultural Chemicals.

(ii) AGRICULTURAL ECONOMICS: Agricultural Marketing and Trade; Agricultural Finance and Project Analysis; Agricultural Development and Policy; Farm Management and Resource Economics; and Agri-business Management.

(iii) AGRICULTURAL ENGINEERING: Agricultural Processing and Structures; Farm Power and Equipment; and Soil and Water Conservation Engineering.

(iv) AGRICULTURAL EXTENSION: Agricultural Communication; Agricultural Extension; and Agricultural Management.

(v) AGRICULTURAL PHYSICS: Agricultural Physics.

(vi) AGRICULTURAL STATISTICS: Agricultural Statistics.

(vii) AGRONOMY: Crop Husbandry; and Resource Management.

(viii) BIOCHEMISTRY: Biochemistry; and Nutrition.

(ix) BIOINFORMATICS: Bioinformatics (for M.Sc. only).

(x) COMPUTER APPLICATION: Computer Application (for M.Sc. only).

(xi) ENTOMOLOGY: Insect Biosystematics; Insect Physiology; Insect-Pest Management; and Insect Toxicology.

(xii) ENVIRONMENTAL SCIENCES: Environmental Sciences.

(xiii) GENETICS: Genetics; and Plant Breeding.

(xiv) HORTICULTURE: Floriculture and Landscape Architecture (FLA); Fruit Science (FSC); and Vegetable Science (VSC).

(xv) MICROBIOLOGY: Environmental and Evolutionary Microbiology; Plant Microbe Interactions; and Industrial Microbiology.

(xvi) MOLECULAR BIOLOGY AND BIOTECHNOLOGY: Molecular Biology and Biotechnology.

(xvii) NEMATOLOGY: Nematology.

(xviii) PLANT GENETIC RESOURCES: Plant Genetic Resources.

(xix) PLANT PATHOLOGY: Fungal Pathology; Mycology; Plant Bacteriology; and Plant Virology.

(xx) PLANT PHYSIOLOGY: Plant Physiology.

(xxi) POST HARVEST TECHNOLOGY: Post Harvest Technology of Horticultural Crops; and Post Harvest Engineering and Technology.

(xxii) SEED SCIENCE AND TECHNOLOGY: Seed Science and Technology.

(xxiii) SOIL SCIENCE AND AGRICULTURAL CHEMISTRY: Soil Science; and Agricultural Chemistry.

(xxiv) WATER SCIENCE AND TECHNOLOGY: Water Science and Technology.

5.2 The main subjects and the major fields of specialisation within each main subject in which admissions are to be made in a particular year are subject to review by the Academic Council on the basis of availability of facilities in each discipline in terms of faculty members, laboratory, land, etc., and the same will be announced in the ‘Information Bulletin’ for admission to Post Graduate School.
6 Admission of Students

6.1 The Institute admits students to the Post Graduate School under five separate streams as indicated below:

A. Open competition
B. Faculty Upgradation Scheme (FUS)
C. Departmental stream (Scientific and Technical)
D. ICAR in-service nominees
E. International students

The admission policies and procedures have been prescribed by the Academic Council keeping in view the distinct needs and requirements of candidates coming from each stream. The details of these policies and procedures are as follows:

A. OPEN COMPETITION

6.2 System of Admission

(i) M.Sc. and M.Tech. degree courses: Entrance examination for admission to M.Sc. and M.Tech. degree courses is undertaken by the Education Division of ICAR and on the basis of merit, the ICAR finalizes the admission for 23 M.Sc. and one M.Tech. degree courses at IARI.

(ii) Ph.D. degree courses: Admission to the Ph.D. courses in 22 disciplines is based on performance of candidates in the written entrance examination (70% weightage) + academic score (20% weightage) + interview (10% weightage).

Entrance examination to be conducted by the IARI will consist of one paper of three parts: Part I (General Agriculture) and Part II & III (Subject Paper). Academic score shall be calculated on the basis of percentage of marks obtained in various examinations from matric (X standard) onwards.

6.3 Advertisement for Ph.D. admission

6.3.1 Applications for admission shall be through an advertisement in newspapers and the website of IARI (http://www.iari.res.in) every year around the first/second week of March. The last date for receipt of applications shall generally be last week of April every year or a date as may be specified from time to time.

6.3.2 The applications from employees of Universities (including institutions deemed to be Universities), Central or State Govt. Departments/Undertakings, Statutory Organisations and other Public Institutions, shall be entertained upto the last date prescribed for receipt of marks sheets (vide Para 6.9.7) provided the application is complete in all respects and has been submitted to the applicant’s employer before the last date prescribed for receipt of applications, and has been forwarded by such employer officially.

Note:

(i) The last date of receipt of applications from candidates from Andaman & Nicobar Islands, Lakshadweep, State/Union Territories in the North-Eastern Region, Ladakh Division of J&K State, Sikkim, and Pangri Sub-division of Chamba, Lahaul & Spiti district of Himachal Pradesh shall generally be 15 days later than for those from all other parts of the country.

(ii) Only the applications/mark sheets, received by post in the first morning dak in the Post Graduate School Office on the working day immediately following the last date prescribed for receipt of such applications/mark sheets will be entertained in relaxation of the prescribed last date as a matter of grace.
6.4 Number of Seats

The number of seats earmarked for an academic year for admission to the various disciplines/specialisations, both for M.Sc./M.Tech. and Ph.D., shall be decided each year by the Academic Council. The number of seats shall be published in the Information Bulletin for the concerned year.

6.5 Reservation for Scheduled Castes/ Tribes/Other Backward Classes and Physically Challenged / Differentially abled candidates

6.5.1 Fifteen per cent of the total available seats shall be reserved for Scheduled Castes (SC), seven and a half per cent for Scheduled Tribes (ST) and upto twenty seven per cent (as may be decided by the Academic Council) for Other Backward Classes (OBC) candidates subject to their being otherwise suitable. At the time of finalization of allocation of seats, the seats to be reserved for Scheduled Castes/Scheduled Tribes/Other Backward Classes shall be identified and earmarked discipline-wise and sub-discipline-wise, if any and shall be notified in the Information Bulletin. The seats earmarked for Scheduled Castes shall be filled as per the distribution decided by the Academic Council for the year. However, in the event of there being no eligible suitable Scheduled Caste candidates in the earmarked discipline such unfilled seats shall be transferred to other disciplines, where eligible suitable Scheduled Caste candidates are available for filling these seats. An identical procedure as above will be followed in the case of Scheduled Tribe reservations also. After these two exercises, if any seat(s) still remain(s) unfilled in the Scheduled Caste and Scheduled Tribe categories respectively, such unfilled Scheduled Caste/Scheduled Tribe seat(s) shall be transferred to Scheduled Tribe/Scheduled Caste category and filled-up by the available eligible candidate(s) in the concerned category. Under no circumstances, the Scheduled Caste and Scheduled Tribe seats shall be transferable from M.Sc./M.Tech. to Ph.D. programme and vice-versa. The Scheduled Caste/Tribe candidates who are selected for admission on the basis of merit may not be counted against the reserved quota and there is no maximum limit on the admission of the candidates belonging to the two-categories.

6.5.2 If Scheduled Caste/Tribe candidates have been called and have appeared for written test and interview, the seats reserved for the two categories as per the particular year’s Information Bulletin shall be kept vacant and not dereserved, even if none of the Scheduled Caste/Tribe candidates qualify for admission in that academic year.

6.5.3 Three per cent of the total number of seats in each scheme of admission open to Indian nationals, namely, General (Open competition), Departmental, Faculty Upgradation Scheme and ICAR In-Service Nominees Scheme are reserved for Physically Challenged (PC) candidates subject to their being otherwise suitable on the basis of merit irrespective of the categories. In case, no physically handicapped candidates are available, these seats will be filled-up from among general category candidates. The extent of reservation for physically challenged candidates will be as per the Government of India guidelines in the year of admission.

6.6 Eligibility for M.Sc./M.Tech./Ph.D. Courses

For the M.Sc./M.Tech. (Agricultural Engineering only) Courses:

As prescribed by the ICAR.

6.6.1 Only those candidates who had their Bachelor’s Degree Programmes under 10+2+4 OR 10+2+3 OR 10+1+4 system (OR awarded B.Sc. degree under 10+2+2 system prior to 1985) and fulfill the qualifications as prescribed in the Information Bulletin are eligible to apply for admission.

6.6.2 The eligibility requirements and other allied matters relating to admission to the Post Graduate School shall be decided by the Academic Council from time to time. The eligibility requirements are subject to change. Normally these are considered and approved by the Academic Council while finalising the admission policy prior to conducting the entrance examination for each academic session. The details are given in the Information Bulletin while inviting applications for each academic session.
6.6.3 (i) The candidates must satisfy one of the qualifications as indicated against the relevant course of M.Sc./M.Tech. degree programme and discipline to which admission is sought.

**Qualification for admission to M.Sc./M.Tech. degree programme**

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agricultural Chemicals</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>3. Agricultural Engineering</td>
<td>B.Sc. in Agricultural Engineering / B.Tech. / B.E.</td>
</tr>
<tr>
<td>5. Agricultural Physics</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture.</td>
</tr>
<tr>
<td>6. Agricultural Statistics</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry / Agroforestry / Sericulture / Agricultural Market.</td>
</tr>
<tr>
<td>7. Agronomy</td>
<td>B.Sc. in Agriculture.</td>
</tr>
<tr>
<td>8. Biochemistry</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture.</td>
</tr>
<tr>
<td>9. Bioinformatics</td>
<td>B.Sc. in any discipline of Science.</td>
</tr>
<tr>
<td>11. Entomology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry / Agroforestry / Sericulture.</td>
</tr>
<tr>
<td>12. Environmental Sciences</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry / Agricultural Engineering.</td>
</tr>
<tr>
<td>13. Genetics</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>15. Microbiology</td>
<td>B.Sc. or B.Sc. in Agriculture/ Microbiology / Horticulture.</td>
</tr>
<tr>
<td>16. Molecular Biology and Biotechnology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry / Sericulture / Biotechnology.</td>
</tr>
<tr>
<td>17. Nematology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>18. Plant Genetic Resources</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>19. Plant Pathology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>20. Plant Physiology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture.</td>
</tr>
<tr>
<td>21. Post Harvest Technology</td>
<td>B.Sc. in Agriculture / Horticulture / Food Science / Food Science and Technology / B. Tech. / B.E. in Agricultural Engineering / Food Engineering / Biochemical Engineering / Chemical Engineering.</td>
</tr>
<tr>
<td>22. Seed Science and Technology</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture / Forestry.</td>
</tr>
<tr>
<td>23. Soil Science and Agricultural Chemistry</td>
<td>B.Sc. or B.Sc. in Agriculture / Horticulture.</td>
</tr>
</tbody>
</table>
For the Ph.D. Courses:

Candidates must have obtained at least 60% marks OR an Overall Grade Point Average (OGPA) of 7.50 out of 10.00 OR 3.75 out of 5.00 OR 3.00 out of 4.00 OR 2.25 out of 3.00 (For SC/ST/PC candidates: 55% marks OR OGPA of 7.00 out of 10.00 OR 3.50 out of 5.00 OR 2.80 out of 4.00 OR 2.10 out of 3.00) in M.Sc. / M.Tech. degree programme. In no case conversion of OGPA in to percentage will be considered for calculation of marks where the OGPA is awarded.

6.6.4 The candidates must satisfy one of the qualifications as indicated against the relevant course of Ph.D. degree programme and discipline to which admission is sought.

### Qualification for admission to Ph.D. degree programme

<table>
<thead>
<tr>
<th>Discipline</th>
<th>M.Sc./M.Sc.(Agri.)/M.Tech./M.E. in</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Agricultural Engineering</td>
<td>Agricultural Engineering / Dairy Engineering / Water Science and Technology; M.Sc. in Dairy Engineering are eligible for Ph.D. in Agricultural Processing and Structures (Pre-requisite: B.Sc./B.Tech./BE in Agricultural Engineering.</td>
</tr>
<tr>
<td>9. Entomology</td>
<td>Entomology / Agricultural Entomology / Zoology or Plant Protection with Entomology as specialization / Life Sciences.</td>
</tr>
<tr>
<td>10. Environmental Sciences</td>
<td>Environmental Sciences / Physical Sciences / Biological Sciences / Chemistry / any branch of Agricultural Sciences / Life Sciences.</td>
</tr>
<tr>
<td>11. Genetics</td>
<td>Genetics and/OR Plant Breeding / Plant Genetic Resources / any other branch of Plant Sciences with Genetics and/OR Plant Breeding as a subject.</td>
</tr>
<tr>
<td>12. Horticulture</td>
<td>Horticulture or Agriculture with major in Fruit Science / Vegetable Science / Floriculture and Landscape Architecture/ Post Harvest Technology of Horticultural Crops / Food Science and/OR Technology / Genetics and/OR Plant Breeding / Plant Genetic Resources / Plant Physiology / Crop Physiology with specialization in any of above sub-discipline of Horticulture / Physiology/ Water Science and Technology.</td>
</tr>
</tbody>
</table>
13. Microbiology
Microbiology / Agricultural Microbiology / Soil Science and/OR Agricultural Chemistry / Genetics / Botany / Agricultural Botany / Molecular Biology and/OR Biotechnology / Life Sciences / Biochemistry with Microbiology as a special subject.

14. Molecular Biology and Biotechnology
Molecular Biology and/OR Biotechnology / Biochemistry / Agricultural Biochemistry / Botany / Agricultural Botany / Genetics and/OR Plant Breeding / Life Sciences /Microbiology / Agricultural Microbiology / Plant Genetic Resources.

15. Nematology
Nematology / Entomology / Zoology / Botany /Mycology and/OR Plant Pathology / Life Sciences / Molecular Biology and / OR Biotechnology / Plant Protection with Nematology as specialization.

16. Plant Genetic Resources
Plant Genetic Resources/ Plant Breeding / Agricultural Botany / Horticulture/ Plant Biotechnology/ Seed Science and Technology / Plant Physiology / any other branch of Biological Sciences with specialization in these subjects and/OR Plant Taxonomy / Economic Botany.

17. Plant Pathology
Mycology and/OR Plant Pathology / Botany /Agricultural Botany / Molecular Biology and/OR Biotechnology / Genetics / Microbiology / Seed Science and Technology / Biochemistry / Plant Genetic Resources / Plant Protection / Life Sciences with Mycology and Plant Pathology as specialization.

18. Plant Physiology
Plant Physiology / Crop Physiology / Botany /Agricultural Botany / Biochemistry / Life Sciences /Molecular Biology and/OR Biotechnology / Plant Genetic Resources.

19. Post Harvest Technology
a) For Post Harvest Technology of Horticultural Crops Horticulture/ Post Harvest Technology/Food Science and Technology b) For Post Harvest Engineering and Technology Agricultural Processing and Structures / Food Engineering / Post Harvest Engineering / Biochemical Engineering.

20. Seed Science and Technology
Seed Science and Technology / Genetics and/OR Plant Breeding / Plant Physiology / Crop Physiology /Mycology and/OR Plant Pathology / Entomology / Nematology / Botany / Agricultural Botany / Plant Genetic Resources.

21. Soil Science and Agricultural Chemistry
Soil Science and/OR Agricultural Chemistry /Chemistry / Agricultural Physics with specialization in Soil Physics / Environmental Sciences with specialization in Soil Science.

22. Water Science and Technology
Water Science and Technology / Agricultural Physics / Physics / Chemistry / Mathematics (with Physical Sciences at Bachelor Degree level) / M. Tech. in Agricultural Engineering / Civil Engineering.

6.6.5 A good knowledge of English is essential.

6.6.6 All non-agricultural graduates will have to complete prescribed course of 36 credits in Introductory Agriculture before they are permitted to take regular courses and qualify for the degree.

The candidates, who do not possess B.Sc. (Agriculture), B.Sc. (Horticulture) or B.Sc./B.Tech. in Agricultural Engineering shall have to successfully complete the prescribed courses of 36 credits on Introductory Agriculture in the first
year of the three year programme of M.Sc. / M.Tech. Similarly the candidates, who have not been exposed to subjects of agriculture in their Master’s degree programme shall have to take prescribed courses on Introductory Agriculture (of 36 credits) in the first year of their Ph.D. programme.

6.7 Recognition of Universities Degrees

Degrees of all statutory universities and institutions deemed to be universities shall be recognised by the Institute for purpose of admission to higher courses of study at this Institute on a reciprocal basis.

6.8 Age Limit

The minimum age limit for admission to Ph.D. shall be 21 years. The age shall be reckoned as on 31st July of the year of admission and no further relaxation will be given to the candidates.

6.9 Procedure for Application

6.9.1 Applications for admission shall be made in the prescribed form and Information Bulletin can be obtained:

(i) By sending a crossed Demand Draft for ₹ 575/- drawn in favour of the Registrar, Post Graduate School, Indian Agricultural Research Institute, New Delhi 110 012, along with a written request for the application form and the Information Bulletin clearly indicating the full and legible address of the candidate.

(ii) In person from Syndicate Bank, Pusa Campus by making a payment of ₹ 500/- (₹ 250/- for SC/ST/PC candidates plus the charges prescribed by the Bank).

(iii) Candidates may download the Information Bulletin, Admit Cards, Application Form and Acknowledgement Card from the Institute website: http://www.iari.res.in. In this case, a Demand Draft of ₹ 500/- (for General/OBC category) and ₹ 250/- (for SC/ST/PC category) is required to be enclosed along with the Application Form.

The charges mentioned above are subject to review and change from time to time.

6.9.2 A candidate can apply for admission to one subject (discipline) only.

6.9.3 The candidate must in his/her own interest fill-up the Application Form most carefully and accurately. Incomplete application shall not be considered and may be rejected outright.

6.9.4 All correspondence for admission should be addressed to the Registrar, Post Graduate School, Indian Agricultural Research Institute, New Delhi 110 012. Each application form shall bear a serial number. This number and also the programme (M.Sc./M.Tech./Ph.D.) and the discipline to which the admission is sought must be quoted in all correspondences regarding admission to this School.

6.9.5 Candidates who are in employment must submit their applications through proper channel. No advance copies shall be considered.

6.9.6 Sponsorship: An employee is considered as a sponsored candidate, if he/she is sponsored for admission at this Institute under the terms of deputation leave, study leave, extraordinary leave or under grant of a scholarship/stipend/any other financial assistance and is bound under the terms of the sponsorship to return to the sponsoring Institution after the training. An employee permitted by the employer to pursue post-graduate studies at this School at his/her own expenses on the understanding that he/she, if admitted, would have to resign the employment, shall not be treated as sponsored candidate.

6.9.7 All applications as also the acknowledgement cards (duly stamped) filled in legibly and correctly in applicant’s own handwriting should be forwarded, along with the accompanying set of documents completed in all respects so as to reach the Registrar, Post Graduate School, Indian Agricultural Research Institute, New Delhi 110 012 on or before the last date notified. Postal delay shall not be accepted as a plea to entertain applications after the last date.

6.9.8 In case a candidate has appeared for the degree examination and the result has not been announced in time for submission of the application by the last date prescribed, the application may still be completed in all respects,
except the academic record, and submitted so as to reach the Registrar by the due date. Information with regard to the academic record shall then be furnished as soon as it becomes available in duplicate. However, this information must reach the Registrar by the date to be notified each year. Postal delay cannot be accepted as a plea to entertain this information beyond this date.

6.9.9 Application of candidates from an University that follows the course-credit system, shall be considered even if the final viva-voce is yet to be completed. A full transcript showing the grade point average should be enclosed along with a Course Completion Certificate issued by the Registrar / Head of the College, Dean/Associate Dean of multi-campus Universities is mandatory. The certificate issued in this regard by the Head of Department or issued by any other officer will not be entertained. However, at the time of interview a certificate shall have to be produced from the Registrar of the University/Head of the College, Dean/Associate Dean of the campus of multi-campus Universities stating clearly that the candidate has passed the last degree examination, failing which the candidate shall not be interviewed.

6.9.10 Notwithstanding anything contained in Para 6.9.9, candidates pursuing M.Sc./M.Tech. while applying for admission to Ph.D. are eligible to appear in the Ph.D. entrance examination and interview subject to completion of final viva-voce examination, completion of all course work and submission of his/her thesis. Such a candidate, if included in the regular Merit /Waiting List, may be conditionally granted admission to Ph.D. during the validity period of the Merit/Waiting list with the approval of the Chairman of the Academic Council upon completion of the viva-voce. Where the final viva-voce examination is held after the commencement of the new academic session and the student may be admitted only if:

(i) the student thesis was submitted by the date specifically prescribed for the purpose, and

(ii) the delay in the holding of the final viva-voce examination is not attributable in any way to candidate concerned.

6.9.11 At the time of interview, it is mandatory for the candidate to produce the following certificates in original along with the attested copies:

(a) Proof of date of birth.

(b) Matriculation (10th) or equivalent certificate and mark sheet.

(c) Higher Secondary examination certificate mark sheet, if applicable.

(d) Intermediate (12th) examination certificate and mark sheet, if applicable.

(e) Bachelor's degree certificate and mark sheet.

(f) Master's degree certificate and mark sheet.

(g) Course Completion Certificate is required for candidates from a university following the course-credit system. This certificate should be issued by the Registrar/ Principal of the College, Dean/Associate Dean (Certificate from officials other than those four mentioned above shall not be entertained).

(h) Scheduled Caste, Scheduled Tribe, Other Backward Classes and Physically Handicapped certificates (whichever is applicable) in the proforma (as given in the Information Bulletin) from District Magistrate or the authorities empowered to issue such certificate of verification should be issued not more than six months before the date of application.

(i) If employed, documentary evidence of continuous employment from employer(s).

(j) One recent passport size photograph to be affixed in the space provided on the application form and another on the Reference Card.

6.9.12 Production of original certificates and mark sheets at the time of interview and enrolment is an essential requirement and is not relaxable in any case under any circumstance.

6.9.13 If any document submitted by the candidate is found to be false at any stage during his/her study at IARI, his/her admission shall be cancelled.
6.10 Scrutiny of Applications

6.10.1 The application forms of Ph.D. candidates shall be entered in the computer database on the day of receipt.

6.10.2 The application shall be scrutinised by the Professor of the respective discipline for eligibility and prescribed qualifications. Ineligible applications shall be rejected.

6.11 Entrance Examination

Ph.D. degree courses: Admission to the Ph.D. courses shall be based on performance in the entrance examination that has a weightage of 70%.

6.11.1 Written Examination

(a) Candidates to be called for the written examination shall have a minimum qualification prescribed for the purpose.

(b) Eligible candidates will be informed of the date, time and venue of written test through Admit Card under certificate of posting duly-signed by and bearing the official stamp of the Registrar of the Post Graduate School of this Institute.

(c) In case there is any change in the date of examination due to any unforeseen reasons, the final date will be indicated in the written test call letter.

(d) The entrance examination will consist of one paper of three parts: Part-I (General Agriculture) and Parts II & III (Subject Paper). The minimum qualifying mark is 50% for General / OBC (45% for SC/ST/PC candidates). Total marks would be considered for the preparation of merit. The weightage for entrance examination is 70%.

(e) The written examination papers will be evaluated in the manner decided by the Dean. The score of the written test will be determined according to the weightage assigned to the entrance examination.

6.11.2 Academic attainments (Record): Weightage for academic attainments [High School (10th standard) to terminal degree] is 20%.

6.11.3 Interview of candidates

(i) A discipline-wise merit list shall be prepared based on the candidate’s performance in the written test. For reserved category candidates, the merit list shall be prepared separately for each discipline. Candidates, in order of merit in the written test in each discipline, shall be called for interview in the ratio limited to 1:4 (No. of seats: No. of students called for interview). The weightage of interview is 10%.

(ii) The candidate called for interview shall have to appear before an Interview Board constituted by the Chairman of the Academic Council for each discipline. The interview will be held in the respective Divisions at IARI, IASRI, NBGPR and NRCPB, New Delhi. Each candidate shall be interviewed separately.

The Interview Board shall consist of the concerned Head of the Divisions; the concerned Professor; and 3 faculty members including two from outside the concerned discipline. The Dean & Joint Director (Education) with the approval of the Director, IARI shall nominate the members of the respective Interview Boards.

(iii) No candidate shall be interviewed unless the original certificates, mark sheets, etc. are checked by the Post Graduate School office at least one day before the interview date. However, in cases where the original mark sheet indicates clearly that the candidate has passed the concerned examination, the candidate can be interviewed even if the original degree certificate has not been produced. In case a candidate has already submitted an attested copy of mark sheet of the qualifying examination issued by the Registrar of the University concerned but is unable to produce the original at the interview on the plea that the mark sheet had been submitted to another university, he/she may be allowed to appear in the interview but, if selected, his/her admission would be subject to production of original certificate by his/her. No other relaxation can be given by the Interview Board. There can be no appeal to any authority, if the candidate fails to produce the original documents prescribed except to the extent indicated herein above.
The final Thesis *viva-voce* examination must be cleared before the date of commencement of the first academic session.

**6.11.4** Candidates appearing for the entrance examination as well as for interview will have to come at their own expense and make their own stay arrangements.

**6.11.5** Invitations to the entrance examination and interview are no guarantee of admission to the Post Graduate School.

**6.11.6** The Dean will decide the manner of conducting the entrance examination and interview including all the relevant details.

**6.11.7** The academic score shall be calculated as per the ready reckoner given below:

Let $Y$ be the total academic score based on the performance of the candidate in his/her earlier classes. We may take the academic score as a linear function of the performance of the candidates in earlier examinations. This can be given for Ph.D. candidates as:

$$Y = X_1 + 0.60 X_2 + 0.25 X_3 + 0.15 X_4$$

where $Y =$ Total academic score

$X_1 =$ Percentage of marks in M.Sc./M.Tech. examination.

$X_2 =$ Percentage of marks in B.Sc. examination

$X_3 =$ Percentage of marks in I.Sc. examination

$X_4 =$ Percentage of marks in Matric or High School examination

If a candidate has done M.Sc./M.Tech., B.Sc. and Higher Secondary ($X_1$, $X_2$, $X_3$), his/her academic score will be obtained as:

$$Y = X_1 + 0.60 X_2 + 0.40 X_3$$

where $X_1$ and $X_2$ are as above, $X_3 =$ Percentage of marks in Higher Secondary examination

If a candidate has got percentage of marks in some examination and OGPA in others, his/her score may also be obtained by suitably combining the two formulae by converting OGPA into percentage. OGPA of 4.00/4.00, 5.00/5.00 and 10.00/10.00 etc. is taken equivalent to 90% for calculation of academic score. In the percentage mark system, maximum marks will be taken as 90% in the above formulae.

**6.11.8** The marks in the entrance examination of the candidates shall be kept confidential in the Post Graduate School office. The marks obtained in entrance examination, academic score and interview shall be totalled in the Dean’s Office / Post Graduate School. On the basis of the total marks obtained by each candidate, a merit list in descending order shall be prepared in respect of all the candidates called for interview. The SC/ST/OBC/PC candidates will be shown as a distinct category and their merit shall also be shown separately.

**6.12 Announcement of Results**

**6.12.1** The marks obtained by the candidates in the final selection shall be worked out up to the second decimal place, the decimal fractions of 0.05 or above occurring at the third decimal place being rounded off upwards and those of 0.04 or below being ignored. In the case of tie, admission will be given to the candidate whose written test marks are the highest. If there is a tie in this respect also, the marks obtained by them may be extended to the third or fourth digit and admission given to the student who obtained higher marks.

**6.12.2** The minimum percentage of marks for qualifying in the entrance examination for admission shall be fifty (50%) in respect of general/OBC candidates and forty five (45%) for SC/ST/PC candidates.

**6.12.3** The final list of candidates to be admitted to the Post Graduate School on the basis of the seats allotted to each discipline shall be approved by the Academic Council and the results will be notified thereafter. The notification shall be displayed on the IARI Website and Notice Boards. Successful candidates would also be informed of their result by post.

**6.12.4** The notification announcing the names of the selected candidates for each discipline shall consist of two parts, *viz.* (a) regular list and (b) waiting list. The seats will first be offered to the qualified candidates in the order of merit up to the number of seats available in each discipline. The names of the remaining qualified candidates in the
merit list shall be kept in the waiting list in the order of merit.

6.12.5 The seats reserved for SC/ST/OBC/PC candidates shall be offered to only SC/ST/OBC/PC candidates in the order of merit.

6.12.6 If SC/ST/OBC/PC candidates secure a seat on their own merit in competition with general candidates, they shall not be counted against the reserved quota.

6.12.7 The selected candidates will have to pay the prescribed fees and join the Post Graduate School by the due date notified.

6.12.8 The Dean may, however, in exceptional cases, and in consultation with the Professor concerned, grant extension of the date of joining or permit the selected candidates to join in the II trimester, subject to the condition that this shall not involve corresponding extension of the maximum time limit for completion of studies.

6.12.9 If the candidate does not join the Post Graduate School by the prescribed date or if no extension has been asked for and granted, the admission shall stand cancelled automatically and the seat shall be offered to the candidate in the waiting list in order of merit. This shall apply to all selected candidates including nominees of State Departments of Agriculture, Universities and other Institutions as also departmental candidates.

6.12.10 If any new admitted student leaves the Post Graduate School/discontinues his/her studies within the validity period of the Waiting List, the seat shall be offered to the candidate in the Waiting List in order of merit. The candidate in the waiting list has to join the Post Graduate School and pay the requisite fees within seven days of the issue of the communication regarding his/her admission.

6.12.11 The number of seats already allocated by the Academic Council to each discipline shall in no case be increased to accommodate the candidates in the waiting list.

6.12.12 There shall be uniformity of dates of registration for IARI M.Sc./M.Tech. students and M.Sc./M.Tech. students of other Universities selected for admission to Ph.D. degree Programmes at IARI. Accordingly, the students of other Universities selected for Ph.D. at IARI shall be allowed for their registration upto the date of validity of the selected/waiting list of the candidates as in the case of IARI M.Sc./M.Tech. students.

6.12.13 While admitting students of other Universities and IARI to the Ph.D. programmes, the condition of completion of minimum residential requirement prescribed by the University of the candidate for admission to Ph.D. degree programme at IARI shall apply.

6.12.14 The validity of the select list and waiting list shall cease on the last day of August of the year of admission.

6.12.15 The marks statement shall not be declared/issued to the candidates concerned who appear in the written test for admission to Ph.D. programme at IARI.

6.13 Requirements for New Students

6.13.1 On production of the communication intimating admission, the students shall be asked to appear for medical examination before the Medical Officer of the Institute.

6.13.2 On receipt of satisfactory medical report and production of original certificates to the Post Graduate School for verification and on payment of the prescribed fees, an enrolment card addressed to the Professor concerned shall be given to the candidate indicating his/her roll number. On production of the enrolment card he/she will be allowed to mark attendance in the discipline, utilise library facilities and secure hostel accommodation.

6.13.3 In order to make all fresh students fully conversant with requirements and working of the course credit system, an orientation programme shall be arranged immediately after the admission at which attendance shall be compulsory.

B. FACULTY UPGRADATION SCHEME

The number of seats under the faculty upgradation scheme has been fixed at 10 so as to enable more and more scientists of State Agricultural Universities to enhance their qualifications.
6.14 System of Admission

6.14.1 The faculty upgradation scheme was introduced in the academic year 1974-75 for admission of in-service candidates from agricultural universities as part of the faculty upgradation programme. Separate guidelines have been prescribed for this stream of admission.

6.14.2 The scheme shall cover only faculty members of Agricultural Universities and is applicable for admission to Ph.D. programme only.

6.14.3 The quota of seats to be reserved for such category shall not exceed 10 in a particular year. This quota shall be reviewed/revised annually by the Academic Council in the light of the experience gained in a particular year. The quota shall be over and above the quota generally fixed by the Institute in respect of other categories.

6.14.4 Fifteen per cent seats of the quota will be reserved for Scheduled Caste, 7.5% for Scheduled Tribe, upto 27% for OBC and 3% for Physically challenged candidates.

6.15 Eligibility

6.15.1 The candidate must have Master's degree in the concerned discipline and satisfy the qualifications as specified in Para 6.6.1 to 6.6.4.

6.15.2 Candidate fulfilling the required qualification shall apply in the prescribed form as for other candidates.

6.15.3 The candidates sponsored under this scheme should be regular employees of the University and likely to continue in service after obtaining the training. The candidates should normally be sponsored on deputation terms entitling them for full salary and allowances, and no fellowship will be awarded to them by the IARI. Those sponsored on study leave or equivalent terms will also be considered for admission under this scheme. A certificate to this effect should be given at the time of forwarding the application. The Universities sponsoring the candidate under the scheme should also certify that the candidate had not been administered, imposed or awarded penalties for any kind of misconduct. The enrolment card for these candidates shall be issued only if the deputation orders providing for the above facilities are submitted to the Post Graduate School.

6.15.4 Candidates shall be officially sponsored under the scheme and the application shall be sent by the concerned Agricultural University. The words, “Sponsored for admission under Faculty Upgradation Scheme”, shall be clearly inscribed on the application form and the forwarding letter. Not more than three candidates sponsored by any one University shall be admitted in any one year under this scheme.

6.15.5 The candidates shall appear in the written test and interview, of the discipline concerned for determining their eligibility. The final selection of the candidates shall be done on the basis of a merit list prepared separately for faculty upgradation scheme. The Academic Council of the IARI shall have the full discretion of allotting the seats to the universities after taking into account their special needs.

6.15.6 Candidates selected for admission under this scheme shall report to the Post Graduate School for enrolment on the prescribed date announced at the commencement of the academic year.

6.15.7 All the regulations contained in the Post Graduate School Calendar shall be applicable to this category of students also subject to the special provisions mentioned in Paras 6.14.1 to 6.15.6.

6.16 Admission of In-service Candidates from the Agricultural Universities for doing Course Work only at IARI for their Ph.D. Degree Course

6.16.1 Facilities for doing course work only for Ph.D. degree may be provided to staff members sponsored by the Agricultural Universities, subject to the conditions that the sponsoring Universities should certify that they do not have the requisite facilities for doctoral level teaching in the respective disciplines and the University concerned intends to strengthen its faculty in the respective area with a view to improving teaching/research programmes therein. No fellowship shall be awarded to the candidates by IARI.
6.16.2 The studentship of the candidates of this category shall be regulated by the following terms and conditions:

(i) The candidates will not be formally enrolled as IARI students and will be treated as trainees only.

(ii) The Plan of Post Graduate Work (PPW) of the candidates shall be finalised by the respective Chairman at the University concerned in consultation with the concerned Professor at IARI.

(iii) The candidates will be attached to the concerned Professor at IARI for advise in respect of their course work. There will be no Co-Chairperson at IARI.

(iv) The candidate shall take only the specialised and advanced courses at this Institute for which facilities are not available in his/her parent University.

(v) The transcript to be given by the University should acknowledge the courses attended by the student at IARI. This should also be acknowledged in his/her thesis.

(vi) The concerned Professor or any other faculty member nominated by the Board of Studies of IARI shall be co-opted as a member in the qualifying examination of the candidate. TA/DA of the Professor or of the other Faculty member nominated by the Board of Studies for any journeys performed for the purpose shall be payable by the sponsoring University.

(vii) The sponsoring University/Department will remit the salary/deputation allowance, etc., directly to the candidates.

(viii) The IARI shall not be under any obligation to provide hostel accommodation. No family accommodation will be provided in any circumstances.

(ix) The candidates will themselves be responsible for making payment of tuition fee and other dues in the prescribed manner with the Syndicate Bank, Pusa Branch by the prescribed dates.

(x) The candidates admitted for course work only at IARI shall not be eligible to apply for admission as regular candidates for Ph.D. programme in any stream at IARI.

C. DEPARTMENTAL STREAM

A limited number of eligible staff members working at IARI /IASRI /NBPRG /NRCPB /DMR /DFR /NCIPM /NCAP shall be admitted as departmental students to the regular Post Graduate programmes of the Institute. The rules governing such admissions are indicated below.

The persons working in ICAR Institutes are free to enhance their qualifications by competing through open competition, if they fulfill the minimum required qualifications. The Academic Council has approved that the candidature of persons who fulfill other qualifications to compete for admission at Post Graduate School, IARI should be allowed to compete irrespective of the Institutes where they have completed their qualifying services.

6.17 Scientific Staff

6.17.1 Only the scientists, upto and including Scientists/Scientists (Senior Scale) or equivalent position who are having an M.Sc./M.Tech. degree and have satisfactorily completed period of probation and rendered not less than 5 years regular continuous service including period of probation at IARI including its Regional Research Stations as on 31st March of the year of submission of application, shall be eligible to be considered for admission to the Ph.D. course in the disciplines relating to their M.Sc./M.Tech. degree at IARI as departmental candidates provided they have already been granted, or have been assured the grant of study leave for a period of 3 years.

6.17.2 A Scientist can compete under open stream for admission at IARI after completion of 2 years of service. However, for appearing as departmental candidate, the candidate should complete 5 years of continuous service at IARI.

6.18 Technical Staff

6.18.1 Technical staff holding posts upto the scale of ₹ 15,600-39,100 with Grade Pay of ₹ 6,600 who are science graduates and have satisfactorily completed period of probation and rendered not
less than 5 years regular continuous service including period of probation shall be eligible to apply for admission to the M.Sc./M.Tech. programme in the discipline in which they have been working at the IARI as departmental candidate.

6.18.2 Seats reserved for technical staff shall be restricted to one seat per discipline only but the seat will be inter-transferable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.

6.18.3 Scientific/Technical personnel, who are registered for a higher degree with an outside university will also be eligible. In case such an employee is selected for admission as a departmental candidate, an intimation to this effect will be sent by the PG School to the outside University requesting for cancellation of his/her registration with that University. A suitable column for this information will be incorporated in the application for departmental candidates.

6.18.4 An employee of the categories indicated above shall be given the facility of admission as departmental student once, either for obtaining the M.Sc./M.Tech. or Ph.D. degree, to ensure that maximum number of employees get this facility.

6.19 Procedure for Fixing the Quota of Seats

6.19.1 The number of departmental candidates at any time in any discipline shall not exceed 20 per cent of the strength of the eligible staff of the discipline (as per admission standard prescribed), subject to a minimum of 2 seats per discipline at any one time. The eligible staff in the Regional Research Stations shall be treated as part of the discipline to which they belong.

6.19.2 Fifteen per cent seats will be reserved for Scheduled Caste, 7.5% for Scheduled Tribe, upto 27% for OBC and 3% for Physically challenged candidates.

6.19.3 The allocation of seats for purposes of admission of departmental candidates shall be discipline-wise with respect to the disciplines approved for teaching. Currently, this will be with respect to the 24 disciplines approved for teaching.

The eligible scientists should be categorised and listed according to the teaching disciplines and the quota of seats calculated accordingly. Every eligible scientist shall be informed about the parent discipline to which he/she belong based on academic qualifications and job requirements. He/she will be given an opportunity to express his/her views about the discipline-wise categorisation and the final decision about his/her field of discipline will be taken after considering his/her views, if any.

6.19.4 Whenever a new teaching discipline is set up and if an employee who is also a student is transferred, he/she shall be shown against the quota of seats of the new discipline.

6.19.5 The list of eligible employees shall include only those, who have put in 3 years' service at IARI including the Regional Research Stations as on 31st March of the year of submission of application and possess the minimum educational qualifications prescribed and indicated in Para 6.20.1 below. Those employees who have availed or are currently availing of the facility as departmental students shall not be included in the list.

6.19.6 A seat shall be deemed to have been vacated for the purpose of admitting a fresh departmental candidate as soon as the student has successfully completed his/her qualifying examination. The qualifying examination of such of the departmental candidates as are due to vacate their seats in a particular academic year should be held by the 31st March of that year. This should be strictly adhered to and individual requests for relaxation should not be entertained under any circumstances.

6.20 Eligibility Standards for Application

6.20.1 Master's degree for admission to Ph.D. is essential. The candidate should satisfy one of the qualifications as specified in Paras 6.6.1. and 6.6.2.

6.20.2 Weightage shall be given to the scientific/technical staff at IARI/IASRI/ NBPGR/ NRCPB/DMR/DFR/NCIPM/NCAP at the rate of 2 marks for each completed year of service limited to a maximum of 5 marks for determining their eligibility.
6.21 Procedure for Submission of Application, Entrance Examination and Selection

6.21.1 The last date for receipt of applications from the employees shall normally be the last date prescribed for receipt of applications from remote areas.

6.21.2 The application of a departmental candidate shall be routed through the Director/ Joint Director (Administration) so that questions of grant of study leave to the applicant and the feasibility of alternative arrangements being made are clearly decided before forwardal of the application for admission.

6.21.3 (i) A staff member shall be eligible to apply for only one subject pertaining to the parent discipline to which he/she is allocated.

(ii) At the time of submitting the application for admission the staff member should give full information about his/her establishment, specialisation, area of work, etc.

6.21.4 (i) All those employees who fulfill the qualifications prescribed shall be eligible to be called for the written test for admission.

(ii) The minimum qualifying marks for admission in respect of General/OBC candidates, faculty upgradation scheme, ICAR nominee’s scheme and under departmental quota would be 50 and that for SC/ST/PC candidates in any stream would be 45, in both cases out of 100 maximum marks.

6.21.5 The departmental candidates seeking admission as departmental students shall be treated as a separate category. However, they will appear in written test and interview with all other categories of candidates.

6.21.6 The Interview Board constituted for selecting full time students will also interview the staff members seeking admission under this stream.

6.21.7 The admission of any staff member as departmental student shall automatically stand cancelled if he/she fails to join the course on the due date.

6.21.8 A staff member not selected in a particular year shall not be debarred from consideration for admission in the next academic year in case a vacancy is available in the concerned discipline.

6.21.9 If a departmental student is transferred or promoted during his/her studentship to another post, the Post Graduate School should be notified. A ‘No Objection Certificate’ should also be obtained from his/her immediate supervisory officer in his/her new post to the effect that he/she has no objection to the candidate working with his/her previous major adviser and on a research problem chosen by him/her prior to his/her transfer/promotion. This shall apply even to candidates registered with outside Universities.

6.21.10 A candidate who has already been awarded the degree of Master of Science or Doctor of Philosophy by the IARI or by any other University/Institute shall not be granted admission to the same degree course at IARI.

D. ICAR IN-SERVICE NOMINEES SCHEME

6.22 System of Admission

6.22.1 A separate stream of admission to Ph.D. degree programme has been started with effect from the academic session 1979-80 for in-service candidates of the Indian Council of Agricultural Research (ICAR). The number of seats reserved for the ICAR in-service candidates shall not exceed 5 in a particular year, and the total number of students under this stream shall not exceed 15 at any time. Only such ICAR employees who are awarded ICAR Senior Fellowship shall be eligible to apply under this stream.

6.22.2 The persons working in ICAR Institutes are free to enhance their qualifications by competing through open competition, if they fulfill the minimum required qualifications. The ICAR Scientists who fulfill other qualifications to compete for admission at PG School, IARI should be allowed to compete irrespective of the Institutes
where they have completed their qualifying services.

**6.22.3** Fifteen per cent seats will be reserved for Scheduled Caste, 7.5% for Scheduled Tribe, upto 27% for OBC and 3% for Physically challenged candidates.

**6.22.4** The procedure prescribed for admission of candidates under the Faculty Upgradation Scheme will apply *mutatis-mutandis* to this scheme.

**6.22.5** Candidates sponsored by the ICAR will appear in the written test and interview. A single merit list will be prepared for candidates under quota of this stream.

**E. FOREIGN STUDENTS**

In view of large number of foreign students desirous of getting admission at IARI, the Academic Council has approved 30 number of seats for admission of foreign students to the M.Sc./M.Tech./Ph.D. degree courses at IARI in an academic year.

**6.23 System of Admission**

International students seeking admission shall forward their applications through their respective Embassies at New Delhi or through the respective Indian Missions abroad to the Government of India/ICAR and their candidature shall be considered only if they are sponsored by the Government of India/ICAR.

**6.24 Eligibility**

Foreign students are exempted from appearing in the written test and interview. Thus admission shall be made on the scrutiny of the bio-data and on the recommendation of the Professor of the concerned discipline.

**6.25 Procedure for Application**

**6.25.1** The last date for receipt of applications and results/mark sheets from the applicants who are foreign nationals but are resident in India will be the same as prescribed for the applicants who are Indian citizens, and the self-financing foreign students out of them will be called for the written test and interview only if they have prescribed qualifications as for the Indian applicants for admission through the open competition stream.

**6.25.2** The application of foreign students shall be forwarded to the Professor of the concerned discipline for determining their eligibility and their admission shall be finalised without any written test. Foreign students who are already resident in India will, however, have to appear in the written test and interview. Besides, candidates mentioned in Para 6.14, those sponsored by International Organisations like the Agricultural Development Corporation, FAO, African Fellowship etc., shall also be considered for admission at IARI provided such requests are received through the ICAR/DARE.

Their cases shall also be considered along with other regular students without giving them any concession in minimum marks but they shall be exempted from appearing in the written test and interview.

**6.25.3** Foreign students should arrive in New Delhi one week before the onset of the academic session to acquaint themselves with the operation of the Post Graduate School and with the city of Delhi and to attend the orientation programme. They should contact the Foreign Students’ Adviser upon their arrival for obtaining guidance concerning registration procedure, campus location and all other matters except those of a strictly academic nature for which they should contact Registrar, Post Graduate School, IARI.

**6.26 Online Registration of Students in Each Trimester**

**6.26.1** Every student enrolled shall be required to register online at the beginning of each trimester, on a date pre-determined, till the completion of his/her degree requirements unless otherwise permitted by the Dean, failing which his/her enrolment shall be cancelled. Re-admission in such cases shall be on application and not as a matter of right.

Registration shall consist of the following steps:

(a) Filling-up the roster cum-registration forms online for courses to be offered in that trimester. (Annexure III).
(b) Submission of progress report online for the preceding trimester. (Annexure IV) (To be submitted to the Post Graduate School by the Professor of the discipline concerned).

c) Payment of the fees and other dues to the Post Graduate School in time.

6.26.2 Online registration for the first trimester of the academic year for fresh students is a part of the admission procedure and shall be governed by the admission rules. Online registration in respect of continuing students in such trimester shall however be completed at least three days before the commencement of each trimester and the classes shall commence thereafter.

6.26.3 The registration of continuing students shall not be permitted later than 7 days from the date of commencement of the trimester unless allowed by the Dean as a special case. If during the registration days, a student is required to be outside the Institute campus on the basis of prior permission, in connection with the duties, field work, research work or due to other unavoidable and legitimate circumstances, he/she may be permitted by the necessary registration forms and fees.

6.26.4 A continuing student who does not register on the notified date shall be required to pay a late fee of ₹ 400/- up to the period of 7 days. After this the permission of Dean will be required for his/her registration.

6.26.5 A student may be exempted from the payment of late registration fee by the Dean where he is convinced that the student is late due to circumstances beyond his/her control.
7 Fees and Other Charges

7.1 To bring about uniformity in fee structure in all the four Deemed Universities, the ICAR, has finalised the fee and other charges with effect from the academic session 2011-12. The same has been implemented at the IARI. The fee structure shall be liable to change from time to time with the approval of the Academic Council.

The following charges shall be payable by a full time student (both M.Sc./M.Tech. and Ph.D.) admitted to the Post Graduate School.

<table>
<thead>
<tr>
<th>Description of fees</th>
<th>Masters Programme (₹)</th>
<th>Doctoral Programmes (₹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caution money</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Registration fee (Per annum)</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Examination fee (per annum)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Comprehensive Examination (once in degree Programme)</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>Thesis Evaluation (once in degree programme)</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>Hostel fee per annum</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Hostel fee for Married Hostel and Saraswati Apartments</td>
<td>1000 per month</td>
<td>1000 per month</td>
</tr>
<tr>
<td>Electricity &amp; Water Charges for Married Hostel and Saraswati Apartments</td>
<td>Actual</td>
<td>Actual</td>
</tr>
</tbody>
</table>

**TRIMESTER WISE BREAKUP OF CHARGES**

<table>
<thead>
<tr>
<th>Description of fees</th>
<th>Masters Programme(₹)</th>
<th>Doctoral Programmes(₹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition fee</td>
<td>I Trim. 4000 II Trim. 3000 III Trim. 3000</td>
<td>I Trim. 4800 II Trim. 3600 III Trim. 3600</td>
</tr>
<tr>
<td>Electricity &amp; Water Charges</td>
<td>1200 I Trim. 900 II Trim. 900 III Trim. 900</td>
<td>1200 I Trim. 900 II Trim. 900 III Trim. 900</td>
</tr>
</tbody>
</table>

*Hostel Fee will be applicable to both old and new students

**Annual Charges**

- Students’ Union Fee: ₹ 300
- Magazine: ₹ 100
- Welfare Fund: ₹ 200
- Sports Fund: ₹ 200
- Cultural and Literary Activities Fee: ₹ 200
- Fee for foreign students: US $ 4000 per year
- Institutional economic fee as prescribed by the ICAR: US $ 400 per month
7.2 All departmental candidates on rolls shall be required to pay all fees as applicable in the case of general candidates.

7.3 Students belonging to the Scheduled Caste/Tribe community are entitled to the reimbursement of tuition and examination fees mentioned at items 3 and 11.

7.4 The tuition fee shall include the charges for accommodation in the hostel, irrespective of whether a student is residing in hostel or not.

7.5 Fees and the hostel water and electricity charges shall be payable before the student is permitted to register at the beginning of each trimester. Failure to pay the fees and other prescribed charges shall result in the cancellation of the registration of the student and such cases will be governed as per the provision in Para 7.7.

7.6 The Post Graduate School shall reserve the right to recover the dues from the fellowship amount or any other amount payable to the students.

7.7 Unless specially permitted by the Dean, the name of the defaulter shall stand struck off from the rolls if the registration is not made within one month of the date of commencement of the respective trimester. In the case of a student whose name is struck off from the rolls, the Master of Halls of Residences shall confirm within a week that the room in the hostel has been vacated by the student and the Professor of the discipline concerned shall confirm within a week that the student is not being allowed to attend the classes/laboratory in the Division. He/she may, however, be re-admitted at the discretion of the Dean on the submission of an application through the Chairperson of the Advisory Committee and the Professor and on payment of prescribed admission.

7.8 The period during which a student's name remained struck off the rolls shall not be counted towards his/her minimum residential requirement at the School nor will attendance in class during that period be counted.

7.9 Students discontinuing their studies on and from any date following the commencement of a trimester shall be liable to pay the full tuition fee for that trimester.
7.10 Tuition fees once paid are not refundable. Exemption from this clause shall, however, be granted by the Dean on the merits of each case. Registration fees once paid shall not be refunded.

7.11 The caution money is repayable on completion of course of studies after deducting dues, if any.

7.12 Where a student fails in the qualifying examination or the final *viva-voce* examination or is required to resubmit the thesis, the student will be required to pay the prescribed examination fee again for each such re-examination.

7.13 The caution money of the students may be transferred to the Students' Welfare fund automatically if they fail to withdraw it within a period of one year of the completion of their respective degree programme.

7.14 In case of sponsored candidates (Indian/Foreign), if the sponsoring agency is not paying any compulsory fee/due, fully/partially, the concerned student shall have to pay it fully/remaining balance.

7.15 An Amount of ₹ 500/- shall be charged from Indian private agencies (US $50/- from private agencies from abroad) for verification of documents in respect of former students of IARI.
8 Academic Requirements for Course and Research Work

8.1 Programme of Studies - Plan of Post Graduate Work (PPW)

8.1.1 The programme of training in the Post Graduate School shall be so designed as to give the student a sound mastery of the respective field of specialisation and in the closely related supporting scientific disciplines. The individual programme shall be planned after taking due account of previous academic training of each student.

8.1.2 The programme of studies indicating the Plan of Post Graduate Work (PPW) of each student shall be finalised by his/her Advisory Committee which shall give considerable latitude in the choice of courses, taking into account the requirement needed to provide training for a high level of scholarship and research in that particular field. The Advisory Committee and the PPW of the students should be finalised within the first trimester. The research problem of every student may be finalised at the time of finalization of PPW and indicated in the proforma. The courses required to be taken may be decided and the Advisory Committee formed accordingly.

8.1.3 The PPW shall be forwarded online as per the prescribed proforma (Annexure V) for the approval of the Dean within the first or before the end of I-trimester of admission and any deviation from the same shall require the prior approval of the Dean, who may in exceptional circumstances and for valid reasons permit a student to submit the PPW in the second trimester. No PPW will be accepted after the second trimester and the student will not be allowed to register in the subsequent trimesters.

8.1.4 If a student insists on not taking a course suggested by the Advisory Committee for inclusion in the PPW, the concerned Course Leader shall give the student an exam in order to ensure that he/she has adequate knowledge in the course, before permission is given not to include the course in the PPW.

8.1.5 The PPW shall also indicate the tentative subject of the thesis of the student. The topic of the thesis shall be within the major field of specialisation of the student. A brief (nearly one page) note on the problem shall also be attached with the PPW.

8.1.6 Course work shall usually receive primary emphasis during the first part of the student’s programme so as to give the requisite background in the scientific disciplines. In the later part the programme shall give greater emphasis to research work. It shall be permissible for a student to complete any remaining course work even during the trimester in which the thesis is submitted.

8.1.7 The Chairperson or the Professor, in case the Chairperson has not been appointed, should allot maximum course work to the student in the first three trimesters so as to enable Post Graduate School to judge their suitability to continue their programme as stipulated in para 9.2 of the Post Graduate School Calendar. The students are required to maintain OGPA at the levels prescribed in the para 9.2 of the Post Graduate School Calendar for entitlement of fellowship and continuance in Post Graduate School.

8.2 Major and Minor Fields of Specialisation

8.2.1 The programme of studies shall provide a set of core courses in the general field of the
student’s major specialisation and a secondary grouping of courses in the minor field(s) of specialisation.

8.2.2 A M.Sc./M.Tech. student shall take one minor of nine credits in a supporting discipline.

8.2.3 A Ph.D. student shall take two minors of nine credits each in other supporting disciplines. This may be decided by the Advisory Committee after carefully examining the background of each student. Split minors, wherever desirable, shall also be permissible subject to the condition that both the split minors should be outside the discipline concerned and the student shall have to take 5 credits to each split minor.

8.3 Constitution of Advisory Committee

8.3.1 Advisory Committee shall be constituted for each student which shall consist of members from both the major and minor fields of specialisation.

8.3.2 The Advisory Committees of the students should meet frequently to monitor the progress of the student.

8.3.3 The Chairperson of the Advisory Committee should enforce the students to devote at least 6½ hours a day towards their research/study in their respective division. Highest priority should be given to practicals in each discipline.

8.3.4 Every student shall have a major advisor who shall be from the major field of specialisation to which the student has been admitted. The major advisor shall function as the Chairperson of the Advisory Committee.

8.3.5 A proposal for the formation of the students’ Advisory Committee along with the PPW shall be forwarded in the prescribed proforma (Annexure V) to the Dean for approval within six weeks from the date of admission of the student.

8.3.6 The Professor of each discipline shall issue a notice listing the names of faculty members who are eligible for allotment of M.Sc./M.Tech./Ph.D. students and who are willing to accept the students together with the area of interest of each such faculty member. During the orientation week, the students should meet the different faculty members in their discipline to ascertain the possibilities of conducting research problem in their area of specialisation. Thereafter, the Professor shall ask each student to submit a list of three choices for Chairpersonship by name and the proposed fields of investigation which he/she wishes to undertake as precisely as possible in the area of specialisation of the proposed Chairperson. The Board of Studies will take a final decision regarding the choice of major guide and the research problem of each student keeping in view the choice of students and the guidelines regarding allotment of students given as under:

8.4 Guidelines Regarding Nomination of Chairperson and Assignment of Research Topics to the Newly Admitted Students

8.4.1. Prior to start of the academic year, even before selection of new students, the Professor shall request all faculty members of his discipline to indicate whether they would like to be nominated as Chairperson of the Advisory Committees of M.Sc./M.Tech./Ph.D. students in that particular year. Those who have not guided 2 M.Sc./M.Tech. students will be eligible to guide only M.Sc./M.Tech. students.

8.4.2. Based on the above information, the Professor of each discipline shall issue a notice listing the names of faculty members available for guidance of M.Sc./M.Tech./Ph.D. students and the area of specialisation of each such faculty member. (In cases of doubt regarding the area of specialisation, this may be ascertained from the faculty member concerned and got confirmed by the Head of the Division, if necessary with reference to the approved Divisional Research Projects of the scientists concerned). The names of Chairperson already guiding 4 students should be circulated with asterisk mark indicating that they are already having 4 students. Normally, the students choice will be considered for those faculty members who have less than 4 students; and only in the event of non-availability of faculty member in the discipline, the names of faculty members having more than 4 students will be considered for allotment of students. However, even in the later case, no faculty member shall be allowed to guide more than 5 students at any time.
Note: In the Divisions where there are large number of faculty members who have not guided even M.Sc./M.Tech. students, the faculty members who are eligible to guide Ph.D. students should not be allotted M.Sc./M.Tech. students and the names of such faculty members should not be circulated to M.Sc./M.Tech. students while calling for their choice of Chairperson. The senior faculty members can, however, be nominated as number 2 in the Advisory Committee of the students.

8.4.3 During the Orientation week, the newly admitted students may be encouraged to freely meet the different faculty members in the discipline and discuss possibilities of research problems in their respective areas of specialisation. After allowing a reasonable time for such discussions (say about a week or 10 days), the Professor shall ask each student to submit a list of three choices of Chairperson by name and the proposed fields of investigation as he/she wishes to undertake as precisely as possible in the area of specialisation of the proposed Chairperson.

8.4.4 A meeting of the Board of Studies will then be convened to consider the choices exercised by the students and decide on the nomination of the Chairperson of each student. The Board will normally agree to the choice of the student in the order of preference. Whenever there are ties in the choice of Chairperson or there are other important considerations, this may be decided in favour of the student with better rank in the merit list prepared at the time of selection. The final decision rests with the Board of Studies. In the case of students under the faculty upgradation scheme, foreign students and ICAR nominees, the Board may give the consideration also to special requests, if any, received from their sponsors, the candidate’s own background and area of specialisation in which he/she has been working prior to joining IARI.

8.4.5 A faculty member shall not be nominated as Chairperson of a Ph.D. student unless he/she has already guided two M.Sc./M.Tech. students.

8.4.6 As per existing rule, a faculty member may be nominated Chairperson of only one student in a year of a maximum of five students at a time. However, in disciplines where the strength of the faculty is not adequate or for any other reason supported by proper justification, the Board of Studies may recommend relaxation in the operation of this rule in specific cases. The Dean may give relaxation after considering each such case on merit, but not more than 5 students at a time and not more than 2 students in a year in any case.

8.4.7 The Professor shall obtain the final approval of the Dean before announcing the nominations of Chairperson of the newly admitted students finalised by the Board of Studies.

8.4.8 The nomination of Chairperson of Advisory Committees of all newly admitted students should be completed by the middle of the 1st trimester and proposals for constitution of Advisory Committees sent to the Dean before the end of the trimester.

8.4.9 In each Division, the Professor should identify research problems which could be tackled by M.Sc./M.Tech. students considering the short time available with them, in consultation with the Faculty of the Discipline. For each problem so identified, a one page write-up should be provided by way of introduction and the objectives to be achieved. The process of identification of problems should be a continuous process so that the problems are suitably modified from time to time. The identified problems should be circulated to the Chairperson of the M.Sc./M.Tech. students to select suitable problems for the students allotted to them. Such files of research problems should be developed and maintained in all the Divisions which will be taken up by the Institute on priority basis.

While the broad field of investigation to be assigned to each student would already have been identified at the time of nomination of Chairperson of Advisory Committees, it may take some time to decide on a specific research project and its title. In doing so, the Chairperson, Advisory Committee may not suggest specific projects themselves, but encourage initiative and independent thinking, especially on the part of Ph.D. students, in proposing projects, in the formulation of the technical programme and the techniques to be followed.
8.4.10 The thesis title along with Outline of Research Work (ORW) will have to be approved by the Advisory Committee and forwarded by the Chairperson of the Committee to the Professor by the beginning of the 3rd trimester. All the thesis problems will have to be first considered by the Board of Studies. The Board may invite the faculty member and the student concerned for discussion and if necessary make constructive suggestions for modification and improvement of the project so as to conform to standards expected of M.Sc./ M.Tech./ Ph.D. thesis. After approval by the Board, the ORW will be presented in the Divisional Seminar for suggestions and approval. It is the responsibility of the student and his/her Chairperson to incorporate all useful suggestions in the ORW and get it online forwarded to the Dean's office for approval before the end of the third trimester.

8.4.11 It is clarified that thesis projects of students should not be part of the approved Divisional project of the faculty member concerned, but may be related to the latter and should be consistent with the facilities available with the faculty member and the division. The research projects should not be of a routine nature but should have a major emphasis on originality and development of new concepts, models, methodologies and techniques.

8.4.12 Subject to the above modifications, all the other provisions in the existing rules and regulations will continue to be followed.

8.5 Guidelines for Departmental/Staff Members Admitted

8.5.1 Departmental students will also submit three choices for nomination of Chairperson of Advisory Committee as per provision in Para 8.4.

8.5.2 The scientific/technical staff admitted to the post-graduate programme at IARI under departmental quota can be relieved after completion of course work and qualifying examination for doing thesis research, provided they have put in minimum 2 years residence for M.Sc./M.Tech. and 3 years for Ph.D. students. A candidate if admitted in discipline other than 'the Division in which he/she is borne will be transferred to the discipline in which he/she is admitted for post-graduate programme so that he/she may be able to do his/her thesis research in that particular discipline. All such candidates will, however, be required to submit their thesis within the prescribed time limit of 4 and 5 years (M.Sc./M.Tech. and Ph.D., respectively) of their enrollment to the Post Graduate School.

8.5.3 In case of departmental students, who are admitted in one discipline, but are working in the divisions not related to the disciplines of admission, the Chairperson of the Advisory Committee should invariably be from the major field of specialisation and the immediate supervising officer should be a member of the Advisory Committee, if he/she does not belong to the major field of specialization and he/she is a faculty member.

8.5.4 Staff members transferred from the Regional Research Station for admission to the Post Graduate School shall take the minimum possible time to complete their course work and qualifying examination and shall return to their Station for doing their research work. The research problem shall therefore, be chosen that it is in line with the activities of the Regional Research Station and facilities for it are already available with the Station.

8.5.5 The other members of the Advisory Committee shall be suggested by the Chairperson of the Advisory Committee in consultation with the Professor of the major and minor disciplines, and also with the knowledge and consent of the members concerned. The second member in the Advisory Committee shall be from the student's major field and he/she should be eligible to become Chairperson of the student in case the original Chairperson is not available. In case of difference of opinion between the Chairperson and the Professor regarding nomination of minor adviser, the Dean shall decide the matter in consultation with the Professor of the minor discipline.

8.5.6 A faculty member shall function as a member of the Advisory Committee of not more than 10 students. However, this limit can be extended upto 20 students for the discipline for which the Board of Studies recommends that there is a paucity of faculty. This shall be in addition to the limit of 5 students mentioned in Para 3.22.7.
8.5.7 In the case of newly admitted students, the Professor of the discipline shall discharge the functions of the Chairperson of the Advisory Committee till the Chairperson is chosen as per procedure prescribed above.

8.5.8 A faculty member should be allowed to guide a Ph.D. student only after he/she has guided at least 2 M.Sc./M.Tech. students.

Note: (a) The Dean may permit faculty members to guide Ph.D. students, in relaxation of the provision in Para 8.4.6, in case where some problems arise due to non-availability of faculty members in a particular discipline/major field, on the recommendations of the Board of Studies with sufficient justification in each case.

(b) In the discipline where M.Sc./M.Tech. students have not been admitted, a faculty member, who has not guided 2 M.Sc./M.Tech. students may be permitted by the Dean to guide Ph.D. students in relaxation of the existing guidelines.

(c) As and when a student is relieved, his/her name shall not be counted towards the total number of students against the name of the Chairperson for the purpose of allotment of new students, subject to the condition that maximum number of students with the Chairperson shall not exceed 5 at any time.

8.5.9 A scientist not working in IARI /IASRI /NBPRG /NRCPB /NCAP /NCIPM /DFR /DMR and who are not members of IARI faculty shall not be appointed as Chairperson or Members of the Advisory Committees of the students except with the prior permission of the Dean.

8.5.10 No departmental student shall be allowed to teach or guide students. However, a faculty member who is registered with an outside university for higher studies may be permitted in special cases to teach a course but shall not be allowed to act as a member or Chairperson of a student's Advisory Committee.

8.5.11 Whenever the Chairperson of a student's Advisory Committee leaves the Institute or is transferred from the headquarters, the second member from the student's major field should take over as Chairperson with the approval of Dean and the vacancy so caused in the membership of the major field shall be filled up by appointment of another faculty member with the approval of Dean. The second member shall, therefore, be closely associated even in the preliminary discussions while formulating PPW and outline of research work (ORW).

8.5.12 If a faculty member functioning as Chairperson of student's Advisory Committee goes abroad or is absent on other grounds for more than three months and six months in the case of members, his/her name on the Advisory Committee shall immediately be substituted by a new Chairperson/Member, respectively. The new Chairperson/Member shall continue to function as such even after the return of the original Chairperson/Member. No last minute substitution in the Advisory Committee of a student shall be made for conducting examinations except in special cases with the prior approval of the Dean.

Note: (a) In divisions, where a large number of faculty members go abroad on deputation for training or where special situation exists, the Board of Studies will examine each case individually and forward a proposal to the Dean for relaxation of this rule, where necessary. The Dean may give relaxation in suitable cases upto 6 months.

(b) No faculty member who is due to retire within 24 and 36 months from the date of commencement of the academic session can be nominated as Chairperson of a M.Sc. /M.Tech. /Ph.D. student respectively, in order to ensure that the work of the student does not suffer particularly at the final stages of his/her studies. Such faculty members can, however, be nominated as members of the Advisory Committee of a student.

8.6 Syllabus and Organisation of Programme of Teaching

8.6.1 The subjects, courses thereunder, the pre-requisites, the detailed syllabus and the course numbers, etc. in respect of each discipline are given in Part II of the Calendar. The courses listed represent the total syllabus in respect of each discipline; the actual list of courses to be offered in a particular academic year or trimester shall be decided by the Board of Studies of each discipline
after taking into account available facilities and faculty strength. If any course is not to be offered in a particular trimester scheduled for it, a notice shall be given well in advance.

8.6.2 The taking of a pre-requisite course whenever prescribed may not be a mandatory provision in all cases. If the Advisory Committee and the Course Leader are satisfied that in the case of a student, it is not necessary to insist upon taking a pre-requisite course, considering the student's academic background, the student may be exempted from taking the pre-requisite course.

8.6.3 The courses shall be organised as discrete units or blocks of subject matter and shall be assigned a certain number of credits. One credit shall represent approximately 12 hours of lectures (one hour per week for 12 weeks) and the necessary reading and preparation outside the class required for mastery of the subject matter. In the case of practicals, one credit represents approximately 12 practicals normally of 3 hours' duration each. Each course shall, in general, be so planned that it may be completed within a given trimester.

8.6.4 A proposal for introducing a new course or revision of the course shall first be submitted in the prescribed proforma (Annexure VI) to the Board of Studies of the discipline concerned. The proposals of the Board of Studies shall be considered by the Standing Committee on Courses, Curricula and Academic Affairs, and the recommendations of the Standing Committee shall then be placed before the Academic Council for final approval.

8.6.5 There should be at least two faculty members available in a discipline having specialisation in the area in which a new course is proposed to be started.

8.6.6 There shall be no rigid rule or guideline regarding the minimum number of students required for offering a course. It may be necessary to offer the course even for a single student. If the demand for a particular course is likely to be limited, the notice for dropping the course shall be given well in advance.

8.6.7 Matters regarding the allotment of courses, designating faculty members as course leaders and course associates shall be decided by the Board of Studies in each discipline well in advance of the start of a trimester. The Board of Studies should however, maintain liaison with the faculty of the discipline in this regard.

8.6.8 Generally, only one instructor shall be made responsible for teaching a course. However, in certain special cases, it may be necessary to associate other persons with the teaching of the courses. In such cases, only one instructor should be designated as course leader. The total number of instructors with the teaching of the course shall generally be not more than three including the staff members assisting the conduct of practical classes.

Note: The teaching load of the Course Leader should not be less than 30 per cent. In exceptional cases where more than 3 instructors are required to be associated with a course because of the specialized nature of the subject or because the course is of five credits or more, the Board of Studies should give proper justification based on which the Professor will obtain the approval of the Dean. There will be no objection to designate a non-faculty member as Course Leader. If, however, faculty members are available for teaching the course, the Board of Studies should not designate non-faculty members as course leader.

8.6.9 Before the trimester begins, full syllabus of the course indicating date-wise schedule of lecture topics and practicals, schedule of examinations and the weightage to be given for various types of examinations shall be prepared for the information of the students. This shall be given in the very first lecture of the course. A copy of the same may be given to the Professor also, who in turn will forward it to PG School for uploading online.

8.6.10 When a course is shared by more than one teacher, their names shall be mentioned against the lectures to be delivered by them. In such cases, the course leadership may be given by rotation and this may be decided by the Board of Studies after taking into consideration the quantum of work done by each teacher associated with a course.

8.6.11 The course leader shall have the overall responsibility for organising teaching, conducting examinations, submission of results etc., but he/she shall consult the others associated with him/her in such matters.
8.6.12 The maximum number of courses under the charge of each instructor shall be two in an academic year. In exceptional cases, an instructor may be made in charge of three courses with the permission of the Dean.

8.6.13 Guest lecturers may be invited to give lecture on some highly specialised topics only, as supplemental to the work done at IARI and not for covering part of specific courses.

8.7 Language Requirement

As the medium of instruction at the Institute is English, the students shall be expected to be able to write, read and speak English fluently and be able to prepare high quality research paper in English. If a candidate’s knowledge of English is found deficient, he/she shall be required to undergo a course in English on his/her own expenses and the duration of his/her study shall, if necessary, be extended for this purpose.

8.8 Credit Requirement

8.8.1 The number of credits of course work required for each candidate shall be specified by the Advisory Committee of the candidate subject to the guidelines on the subject and approval of the Dean.

8.8.2 A minimum of 45 (55 for courses in Agricultural Statistics, Computer Applications, Agricultural Extension and Agricultural Economics) credits of successful post-graduate work shall be required for students preparing for M.Sc./M.Tech. degree, in addition to other compulsory courses. At least 20% of the course work shall be in fields outside the major discipline.

8.8.3 In the case of students preparing for Ph.D. degree, they shall have to take minimum 36 credits (45 in case of Agricultural Statistics, Agricultural Extension and Agricultural Economics) including two minors of 9 credits each. The students may also be assigned courses in other supporting disciplines (not taken as minor field of study) depending upon the requirements, to provide training for higher level of scholarship and research in their particular fields. The student should also take the compulsory courses.

Note: Ph.D. students competing for award of IARI Merit Medals should have completed a minimum prescribed load of 25 credits in one academic year. Please See Chapter 13 (Part I).

8.8.4 A student's programme of studies shall not include more than 15 credits in any particular trimester. The student may be allowed to take more than 15 credits in a trimester besides remedial courses, if any, and PGS courses, if he/she is capable to do so, on specific recommendation of Student’s Advisory Committee and subject to prior approval of the Dean, Post Graduate School.

8.8.5 A departmental student’s programme of studies shall not include more than 15 credits in a particular trimester. Marginal enhancement of the ceiling of credits in case of students taking courses on Introductory Agriculture would be granted by the Dean on merit of each case.

8.9 Submission of Roster

8.9.1 Each student on rolls, whether taking course work or not, shall submit roster-cum-registration forms online (Annexure III) at least three days before the commencement of each trimester to the Professor of the discipline indicating the courses for which he/she would be registering in that particular trimester. If a course is taken without inclusion in the roster, the grades earned in that course will not be counted, unless permitted by the Dean.

8.9.2 No course shall be entered in the roster unless it is included in the PPW of student.

No adding/dropping is allowed after the last date prescribed for this purpose.

The time for adding/dropping of courses included in the roster after registration will be 15 days.

8.10 Core Courses

8.10.1 Each discipline shall prescribe a set of core courses for students majoring in that discipline which are considered as the irreducible minimum and which the students should successfully complete in order to ensure the requisite and basic knowledge necessary for qualifying for a degree in that particular discipline. The core courses are
indicated under each discipline in Part II of PG School Calendar (syllabus).

8.10.2 Core courses are prescribed for M.Sc./M.Tech. and Ph.D. students. A discipline may also prescribe courses from other disciplines as core courses, if such courses are considered essential for acquiring the requisite standard of knowledge in the students' major field of specialisation.

8.10.3 The prescribed core courses shall be counted towards the minimum requirement of 9 credits in respect of the minor field(s) of specialisation.

8.10.4 A student desirous of seeking exemption from undertaking the prescribed core course(s) shall undergo the qualifying examination(s) to be conducted in each discipline, at the satisfactory completion of which, exemption shall be granted from taking the core courses.

8.10.5 The PPW of each student shall be drawn up only after the core courses to be taken are decided.

8.11 Auditing of Courses

No student shall be allowed to audit a course included in the PPW. However, he/she may be allowed to audit any other regular course.

8.12 Remedial Courses

8.12.1 Students who have not been exposed to agricultural scientific disciplines in their Bachelor's or Master's degree programme, shall be required to undergo introductory courses on agriculture during the first year of their study at IARI.

All the international non-agricultural graduates admitted at IARI shall have to complete the prescribed Remedial Courses on Introductory Agriculture as per the approved schedule given below for the same. Their respective sponsoring agencies/Governments may be made aware of this requirement at the time of admission of non-agricultural students at Post Graduate School.

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Title of Course</th>
<th>Name of the Discipline</th>
<th>Credit</th>
<th>Trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 001</td>
<td>Agronomy of Rainy Season Crops</td>
<td>Agronomy</td>
<td>1+2</td>
<td>I</td>
</tr>
<tr>
<td>AGR 002</td>
<td>Agronomy of Winter Season Crops</td>
<td>Agronomy</td>
<td>1+2</td>
<td>II</td>
</tr>
<tr>
<td>AGR 003</td>
<td>Agronomy of Summer Season Crops</td>
<td>Agronomy</td>
<td>1+1</td>
<td>III</td>
</tr>
<tr>
<td>AGR 004</td>
<td>Soil and Environment</td>
<td>SSAC</td>
<td>2+1</td>
<td>I</td>
</tr>
<tr>
<td>AGR 005</td>
<td>Major Pests of Crops and Their Management</td>
<td>Entomology</td>
<td>1+2</td>
<td>I</td>
</tr>
<tr>
<td>AGR 006</td>
<td>Crop Morphology and Physiology</td>
<td>Plant Physiology</td>
<td>1+1</td>
<td>I</td>
</tr>
<tr>
<td>AGR 007</td>
<td>Principles of Horticultural Crops</td>
<td>Horticulture</td>
<td>2+1</td>
<td>I</td>
</tr>
<tr>
<td>AGR 008</td>
<td>On-farm Education and Visits to Different Institutions</td>
<td>Agricultural Extension</td>
<td>0+2</td>
<td>II</td>
</tr>
<tr>
<td>AGR 009</td>
<td>Principles of Post Harvest Technology</td>
<td>Post Harvest Technology</td>
<td>1+1</td>
<td>II</td>
</tr>
<tr>
<td>AGR 010</td>
<td>Elements of Genetics and Plant Breeding</td>
<td>Genetics</td>
<td>2+1</td>
<td>II</td>
</tr>
<tr>
<td>AGR 011</td>
<td>Crop Diseases and Their Management</td>
<td>Plant Pathology</td>
<td>1+1</td>
<td>II</td>
</tr>
<tr>
<td>AGR 012</td>
<td>Basics of Seed Technology</td>
<td>Seed Science and Technology</td>
<td>1+1</td>
<td>II</td>
</tr>
<tr>
<td>AGR 013</td>
<td>Economic Botany and Plant Genetic Resources</td>
<td>Plant Genetic Resources</td>
<td>1+1</td>
<td>III</td>
</tr>
<tr>
<td>AGR 014</td>
<td>Fundamentals of Economics and Business Management</td>
<td>Agricultural Economics</td>
<td>1+1</td>
<td>I</td>
</tr>
<tr>
<td>AGR 015</td>
<td>Basics of Extension Education</td>
<td>Agricultural Extension</td>
<td>1+1</td>
<td>III</td>
</tr>
<tr>
<td>AGR 016</td>
<td>Basic Agricultural Engineering</td>
<td>Agricultural Engineering</td>
<td>1+1</td>
<td>III</td>
</tr>
</tbody>
</table>
During III trimester, the following activities should be undertaken by the non-agricultural students:

i) They should visit at least two Agricultural Universities for a duration of one week each.

ii) They should spend at least a fortnight each at any two of the IARI Regional Stations at Karnal, Indore, Katrain and Pusa (Bihar).

iii) Non-agricultural students should spend at least one month at Krishi Vigyan Kendra of IARI to get familiar with Transfer of Technology activities and also to gain Rural Agricultural Work Experience.

8.12.2 Students who had not obtained a Bachelor’s or Master’s Degree in agricultural sciences but claim exemption from attending the remedial courses/courses on Introductory Agriculture on the grounds of having been previously exposed to the agricultural discipline at either Master’s or Bachelor’s level, can be given exemption only if they are able to pass the qualifying examination in the respective course(s) on Introductory Agriculture.

8.12.3 The courses on Introductory Agriculture shall be over and above the prescribed minimum credit load for the M.Sc./M.Tech./Ph.D. degree, and will be counted for calculating OGPA like regular courses.

8.12.4 The concerned Advisory Committee shall recommend the exact time schedule for taking the courses on Introductory Agriculture and indicate whether any extension of the minimum period of study is required for taking the extra load.

8.12.5 The students shall maintain the prescribed attendance in the remedial courses/courses on Introductory Agriculture and sit for the examination. Their performance shall be counted as in other courses. However, the credits and grades in respect of the courses on Introductory Agriculture shall not count towards the minimum credit requirements of the student or for award of IARI Merit Medals or any prize.

8.13 Compulsory Courses

Following courses have been introduced as compulsory courses for all M.Sc./M.Tech. students: (i) Library and Information Services, (ii) Technical Writing and Communication Skills, (iii) Basic Statistical Methods in Agriculture, and (iv) History of Agriculture. For Ph.D. students, the compulsory courses are: (i) Intellectual Property and its Management in Agriculture, (ii) Agricultural Research, Research Ethics, and Rural Development Programmes, as well as all the four compulsory courses of M.Sc./M.Tech., in case, these are not done at M.Sc./M.Tech level. These courses will be over and above the prescribed minimum credit load for M.Sc./M.Tech./Ph.D. degrees, and will be graded and counted for calculating OGPA like regular courses. Basic Statistics Methods in Agriculture course will not be a compulsory course for the students of statistics. The details of these courses are given Part II of PG School Calendar (Syllabus).

8.14 Outline of Research Work (ORW)

From the start of IV trimester, all Ph.D. students shall have to devote maximum time towards their specific research problem and study of the related literature.

8.14.1 An outline of research work (ORW) of a student in the prescribed proforma (Annexure VII) and recommended by the Chairperson and members of the Advisory Committee shall be sent online for approval of the Dean by the end of second or third trimester from the date of admission.

8.14.2 The procedure for formulation and finalization of ORW shall be as under:

(i) In the first instance, the student and the Chairperson may prepare a draft ORW after discussing in detail the problem chosen to ensure the full involvement of the student in the research problem. The draft ORW should indicate in detail the method of tackling the problem, the various facilities required in terms of land, equipment, chemical etc., the division where such facilities are available, and the time schedule for completion of the research work. If facilities available in another divisions are to be utilized, the Chairperson may consult the division concerned regarding its availability.
(ii) The draft ORW may be discussed by the Advisory Committee of the student and the Professor may be informed of this to join the discussion. This should be done by the end of second trimester or the beginning of the third trimester.

(iii) The draft ORW approved by the Advisory committee should be given to the Professor and Head of the Division for discussion.

(iv) There should be a common seminar in each Division for presenting ORWs of the students in which all the faculty members and students would participate to ensure full interaction. In the seminar the student shall explain in brief the nature of the problem and the techniques to be adopted for tackling the problem and the expected output.

(v) The ORW may be finalised by the student and the Chairperson in the light of the discussion in the seminar and forwarded to the Dean’s office (online) through the Professor by the end of III trimester. A copy of the ORW should be sent to the Division concerned, if the facilities of that division are proposed to be utilized.

(vi) If necessary, the ORW may be revised subsequently in the light of difficulties faced in tackling the research problem. If there is any difficulty in following the above procedure in exceptional individual cases, the reasons for the same may be forwarded to the Dean for consideration.

(vii) Study tour for preliminary surveys for framing the problem and finalising the ORW are generally to be avoided. However, specific cases with adequate justification may be considered by the Dean for approval.

8.14.3 Once the commitment regarding the use of the facilities has been given in the ORW, the officer concerned shall take all necessary steps to ensure that the student is in a position to utilise the equipment and get the work done quickly. The Chairperson of the Advisory Committee shall also pursue the matter with the establishment concerned.

8.14.4 The students may have to visit, if their training so requires, different research institutions and sub-stations of the Institute. They shall be entitled to the payment of second class railway fare as per terms specified under the relevant scholarship rules.

8.15 Inter-Institutional Collaboration in Research Work

The Institute has a provision for inter-institutional collaboration in the investigation of the research problems chosen by the post-graduate students. The Institute has a fruitful phase of collaboration in the post-graduate education with the Indian Agricultural Statistics Research Institute (IASRI), New Delhi, in collaboration with which, the post-graduate courses are being conducted in Agricultural Statistics and Computer Application. Post-graduate programme (M.Sc.) in Plant Genetic Resources has been initiated from the academic session 1996-97 and the Ph.D. programme from the academic session 2004-2005 in collaboration with National Bureau of Plant Genetic Resources (NBPGR), New Delhi. From the 2011-12 academic session, M.Sc. course on Bioinformatics will be initiated at IARI which will be taught by faculty members drawn from different disciplines of IARI. In addition, the Institute permits students to conduct field experiments and research work in approved research institutes after taking into account the needs of the students and the nature of the research problem. The MoU to this effect is signed for mutual benefit of both IARI and the identified institute.

8.16 Attendance

8.16.1 All students shall attend a minimum of 85 per cent of the total number of lectures and practicals separately in each course.

8.16.2 If a student falls short of required attendance in lectures, practicals or field work by 5 percent or less in any particular course, the shortage may be condoned by the Dean, provided (i) it is made up in the aggregate and (ii) the shortage was due to unavoidable circumstances.

8.16.3 Students falling short of the prescribed minimum attendance in the particular course shall
not be permitted by the course leader to take the examination for that course without prior approval of the Dean.

8.16.4 The Chairpersons of the students Advisory Committee should monitor the attendance of the student in the division in addition to the regular procedure of marking the attendance by the students with the Professor.

8.16.5 The attendance sheet of the students should be forwarded by the Professors to the Post Graduate School during the 1st week of every month to avoid the wrong/over-payment of fellowship to the students. The fellowship for the preceding month will be paid to the students after the receipt of the attendance sheet in the Post Graduate School by the 7th of the next month.

8.17 Leave

The nature of leave admissible to students is given below:

(a) 8 days casual leave per annum.

(b) Special leave for ten days per annum on medical ground only on full scholarship / fellowship.

(c) In exceptional cases, leave up to a maximum of one trimester during the entire course of studies for sufficient and valid reasons only without any scholarship.

(d) Summer vacations or any other holiday announced by the IARI.

(e) Maternity and Paternity leave as per the Govt. of India guidelines.

(f) The leave will not be granted as a matter of right.

8.17.1 The Head of the Division is competent to sanction leave to students for a period not exceeding a full trimester during the entire course of studies for sufficient and valid reasons under intimation to the Post Graduate School for record. The award of scholarship during the leave period shall be determined as per the terms and conditions of the respective Scholarship /Fellowship scheme.

8.17.2 Cases of absence of more than one trimester due to illness of the student may be decided by the Dean on the recommendation of the Medical Officer and in case of absence for any other reasons, the Dean shall examine each case on merit and decide the matter.

8.17.3 Cases of students remaining on unexplained absence for more than 15 days shall be promptly reported to the Post Graduate School office by the divisions and the Hostel Office, and the names of those students shall be struck off from the rolls of Post Graduate School for unauthorised absence.

8.18 Residential Requirements and Duration of Studies

8.18.1 The minimum residential requirements for both the M.Sc./M.Tech. and the Ph.D. degree courses is 2 and 3 academic years, respectively, from the date of admission.

This requirement shall be treated as satisfied in the cases in which a student submits his/her thesis any time during the sixth trimester of his residentship at the IARI in the case of M.Sc. student and ninth trimester for Ph.D.

8.18.2 The maximum time limit for completion of the M.Sc./M.Tech. degree is 4 years and for Ph.D. degree is 5 years from the date of admission.

8.18.3 The departmental candidates will be required to submit their theses within the prescribed time limit of 4 and 5 years for M.Sc./M.Tech. and Ph.D. courses respectively, as in the case of regular students mentioned at Para 8.18.2 above.

8.18.4 The date on which the thesis, complete in all respect is submitted to the Post Graduate School shall be taken as the date for the purpose of calculating the maximum time limit prescribed.

8.18.5 The time limits mentioned shall be inclusive of all interruptions (except the interruption due to name being struck off from the rolls) and shall not be relaxable except on medical ground.

The following procedure will govern requests for extension of time limits:

(i) Whenever any event takes place which is likely to delay the submission of thesis, such event shall be duly reported through the Progress Report.
(ii) All requests for extension must be received in the Post Graduate School three months in advance of the last date for submission of thesis (including the extended date).

(iii) Dean may grant extension upto six months provided he is fully satisfied that the causes of the delay is beyond the control of the student.

(iv) In exceptional circumstances, the Dean may also grant another extension of six months, wherever necessary, with the approval of the Chairman, Academic Council. However, no further extension shall be granted beyond this period.

8.19 Review of Students Progress in Course and Research Work

In order to review and continuously watch the progress of the students in both the course work and the research work, each student shall submit online, at the end of each trimester, a progress report in the prescribed proforma (Annexure IV). The following guidelines shall be observed in this regard:

(i) The trimester progress report shall be reviewed by the Chairperson of the Student's Advisory Committee and in case of any difficulty faced by the student, the entire Advisory Committee shall review his/her trimester progress.

(ii) The copy of Progress report may be submitted online through the Professor for use of Post Graduate School.

(iii) The Professor in each discipline will prepare an overall resume of the progress of students in that discipline which will include the cases of students where special problems are faced.

(iv) The Board of Studies in each discipline will meet at the end of each trimester and consider this resume for taking appropriate action under intimation to the Dean.

8.20 Students Discipline

8.20.1 The Dean, Post Graduate School is charged with the general control of students and the maintenance of discipline.

8.20.2 The Dean shall have the discretion to remove a student from the rolls of the Post Graduate School for any of the following reasons

(i) Failure to profit by the course of studies

(ii) Misbehaviour

(iii) Failure to pay the prescribed fees and dues in time without prior permission

(iv) Continuous absence from studies without prior permission

8.20.3 A record of the students found guilty of misdemeanour/indiscipline along with details of such incidents shall be kept in the Post Graduate School for future reference and consultation, if any.

8.20.4 If any property/equipment in the campus is damaged and loss caused to the Institute as a result of demonstration/strikes resorted to by the students, the loss would be recovered either directly from the persons specifically identified where possible; or else collectively from such groups or associations as were responsible for organising the demonstration/strike.
A. COURSE WORK

9.1 Grading in 10 Point OGPA System

9.1.1 The Post Graduate School has adopted 10 point OGPA scale from the academic session 2001-2002.

The main highlights of the 10 point OGPA scale are as under:

<table>
<thead>
<tr>
<th>OGPA</th>
<th>Description of Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0 to 10.0</td>
<td>(90 to 100%) I\textsuperscript{st} Class with distinction</td>
</tr>
<tr>
<td>8.0 to 8.99</td>
<td>(80 to 89%) I\textsuperscript{nd} Class</td>
</tr>
<tr>
<td>7.0 to 7.99</td>
<td>(70 to 79%) II\textsuperscript{nd} Class</td>
</tr>
<tr>
<td>6.0 to 6.99</td>
<td>(60 to 69%) Pass</td>
</tr>
<tr>
<td>Below 6.00</td>
<td>(less than 60%) Fail (F)</td>
</tr>
<tr>
<td>Incomplete</td>
<td>I</td>
</tr>
</tbody>
</table>

9.1.2 Minimum requirement of OGPA:

i) For passing a course and to continue on the PG School rolls = 6.0

ii) For obtaining the degree = 6.5

iii) For competing for IARI Merit Medal = 8.0 and above

All M.Sc./M.Tech./Ph.D. students will be required to maintain the minimum OGPA as mentioned above.

9.1.3 The minimum OGPA (cumulative) for continuing in the Post Graduate School shall be earned at the end of the third trimester. A student who fails to satisfy this requirement shall not be permitted to continue in the Post Graduate School. This rule shall be relaxed with the approval of the Academic Council in special cases, if the student concerned has made a substantial improvement in his/her OGPA by attaining the minimum OGPA of 6.00 out of 10.00 or above on a course load of 9 credits or more during the third trimester. This average of 6.00 out of 10.00 shall be earned in courses taken in the subsequent trimesters until the minimum cumulative OGPA of 6.00 is attained.

Note: Students who do not obtain minimum OGPA at the end of the III trimester may be permitted by the Dean to continue in the IV trimester provided he is satisfied on the recommendations of the Advisory Committee that the concerned student has the potential to improve his/her grade by the IV trimester.

9.1.4 (i) By the end of the VI trimester of his/her residence in the School, the student shall have to attain cumulative OGPA of 6.50 out of 10.00.

(ii) The payment of scholarship/fellowship should be reviewed at the end of III trimester and only those students will be permitted to continue getting scholarship/fellowship who maintain the OGPA of 6.50 out of 10.00 at the end of third trimester.

(iii) Student failing to attain this level shall not be permitted to continue or qualify for the degree at the Post Graduate School.

(iv) Dean shall himself dispose off requests for continuation beyond the VI trimester in the cases where the OGPA of the student concerned falls short of the prescribed minimum requirement by not more than 0.1. The case of the student whose OGPA deficiency exceeds 0.1 may not under any circumstances be considered for
continuation beyond the VI trimester and shall not be referred to the Academic Council for relaxation.

9.1.5 The prescribed “continuing OGPA” and “passing OGPA” shall have to be earned and maintained subsequently by the end of their III and VI trimesters of admission, respectively by the Departmental students also.

9.1.6 A student may repeat once a course in which he/she gets a OGPA below 6.50 out of 10.00 and that too on the recommendation of the Advisory Committee. In case a course is repeated, the grade obtained on repetition alone shall be counted for calculating the overall grade point average. The transcript will reflect all the courses taken including the courses repeated.

9.2 Trimester Examinations

9.2.1 All students shall have to take examinations given by the instructors concerned in the various courses registered by them in that particular trimester both in the major and minor fields. The types of examinations and the weightage attached to each, including practicals shall be announced by the Course Leader at the commencement of the trimester. Generally, the examination shall be of the following types:

(i) Short quizzes (announced and unannounced) to be held periodically.

(ii) Mid-term examination to be held between the sixth and seventh week of commencement of the trimester.

(iii) Term paper(s) as may be decided by the Course Leader. The term papers given should be presented in the class.

(iv) Final trimester examination: The written and practical examinations held at the end of each course should be followed by an oral discussion with the student before the marking is done.

9.2.2 A schedule of final trimester examination for each trimester shall be circulated by the Post Graduate School.

9.2.3 In order to check use of unfair means at the various examinations, the following regulations shall be followed:

(i) The invigilation at the examination shall be done by the instructor himself/herself and not by anybody else.

(ii) A student found adopting unfair means at the examination for the first time shall be declared ‘Fail’ in that course by the instructor himself/herself. The decision of the instructor shall be final. A report should be sent to the Dean, Post Graduate School by the instructor through the Professor of the discipline concerned.

(iii) In case a student is found adopting unfair means at the examination for a second time, he/she shall be declared ‘Fail’ in that course by the instructor himself/herself and the matter reported to the Dean. The Dean shall take action for rusticating him/her from the Post Graduate School for one year.

(iv) A student adopting unfair means at the examination for the third time shall be expelled from the Post Graduate School by the Dean.

(v) In case a departmental student is found adopting unfair means at the examination, apart from taking action as mentioned above, the matter shall also be reported to the competent authorities for initiating action for violation of conduct rules with particular reference to the provision requiring a high code of conduct and behaviour from public servants.

9.2.4 The instructor shall be responsible for judging the student’s performance and their mastery of the material covered in the various courses taken by them through a system of quizzes, term papers, mid-term examination and a final examination. The Course Leader shall, as a rule, show the answer books to the students in respect of the various examinations and discuss the same with them. For facilitating this discussion, the course instructors may themselves declare results at the end of the evaluation and discussion with students shall be completed within two days of such declaration and the results communicated to the Post Graduate School in the proforma at Annexure VIII within 7 days of the examination. The course instructor shall certify that the types of examinations and
the weightage attached to each course including practicals had been announced by him at the commencement of the trimester. The Course Leader will deposit the answer books with the Professor concerned. The copies may be retained for at least one year by the Professor.

9.2.5 A student failing to attain the prescribed minimum of 85 per cent of attendance separately in lectures and practicals in any course shall not be permitted by the instructor concerned to sit for the final trimester examination for that course without prior approval of the Dean as per Para 8.16.

9.2.6 All examinations prescribed shall be taken by the student and absence from examination shall not be permitted without valid reasons such as illness, to be certified by the Institute's Medical Officer. The student, however, has to obtain written permission from the instructor concerned before absenting himself from any examination.

9.3 Make-up Examination

9.3.1 The following guidelines shall be followed while giving make-up examination:

(i) **Quizzes**: No make-up test in lieu of missed quizzes shall be allowed. In exceptional circumstances when a student misses quizzes in a trimester on account of illness or any other bonafide cause and the leave of absence has been duly sanctioned, the Dean may, on the recommendation of the Course Leader/Chairperson concerned, permit that the grades of the student be determined on the basis of his/her performance in the remaining examinations after excluding the total marks of the quizzes missed.

(ii) **Mid-term examination**: Make-up examination shall ordinarily be given in lieu of only one mid-term examination missed by the student in exceptional circumstances. The make-up examination shall be given only after the Dean has accorded his permission to the student to take the make-up examination. Such make-up examination shall be completed before the end of the eleventh week of the trimester. A make-up examination shall be given at one time only to all such students. It shall be the responsibility of the student concerned to present himself before the Course Leader for the make-up examination at the end of the examination missed. After obtaining the necessary permission of the Dean, the instructor shall fix a suitable date and time for the make-up examination.

(iii) **Final trimester examination**: Normally no make-up examination shall be permitted in lieu of the missed final trimester examination except with the approval of the Dean and subject to the following conditions:

(a) If a student fails to appear at any final trimester examination for really valid reasons, such as illness, an application shall be filed with the Course Leader on the very date on which the examination is missed.

(b) The application for make-up examination must be supported with the medical certificate from the Institute's Medical Officer and the report should be routed through the Master of Halls of Residences and the Chairperson concerned.

(c) No application for make-up examination shall be considered if it is not received within 24 hours from the expiry of last date of the final trimester examination.

(d) The make-up examination for the final trimester examination missed shall be held within 15 days of the starting of the following trimester.

(e) The grade awarded in make-up examination shall carry notation ‘X’ with the remarks that this grade has been obtained by appearing in make-up examination and such shall not be considered for the award of the IARI Merit Medal.

9.3.2 If a student had to drop a course on valid and bonafide medical grounds after the last date prescribed for such purpose and without completing 85% of the attendance, the student
shall be given ‘I’ grade, i.e. “Incomplete”, and may be allowed to repeat that course. The “I” grade shall be entered in the transcript also. In all other cases of dropping of courses after the prescribed date, the student shall be declared ‘Fail’ in the course. No adding/dropping is allowed after the last date prescribed for this purpose.

9.3.3 The time for adding/dropping of courses included in the roster after registration will be 15 days.

9.3.4 In case a student could not take the midterm or final examination, or make-up examination, average of the marks obtained by him/her in all the examinations held in the trimester shall be taken under intimation to the Post Graduate School office. For purposes of averaging, all examinations including the ones missed shall be taken into consideration and the examination missed shall be awarded zero mark.

9.4 Grade Cards

9.4.1 The PG School shall enter the results of the trimester examinations in a register and shall issue a grade card (proforma at Annexure IX) to each student at the end of every trimester indicating the grades obtained in the courses offered in that trimester.

9.4.2 Any discrepancy in the grade card issued shall be reported to the Post Graduate School within 30 days of the issue of the grade card.

9.4.3 Individual cases where ‘F’ (Fail) grade has been shown in the grade card may be reconsidered for the deletion of the grade if it is conclusively proved within 30 days of the issue of the grade card that a student had not undertaken the examination in that course on the advice of his/her major advisor.

9.5 Transcript

A transcript in the prescribed proforma (Annexure X) showing the cumulative performance of the student in course work shall be issued, on request, by the Post Graduate School at the completion of the entire course work. If a student wants a transcript even before completion of the course work, the same shall be issued to him/her on payment of the prescribed charges and on proper justification.

B. QUALIFYING EXAMINATION

9.6 Proposal for Holding Qualifying Examination

9.6.1 After having successfully completed the major portion of the course work required (at least 75%) as judged from the minimum average grade point prescribed for passing (6.50 out of 10.00), a pre-comprehensive oral examination shall be held by a common departmental committee to be nominated by the Board of Studies of the discipline. The pre-comprehensive oral examination shall be conducted only after the student has successfully completed the written qualifying examination in the major and/or minor fields. Thereafter, a qualifying examination shall be held to test each student’s general mastery of the concerned scientific discipline and his/her general fitness for becoming a candidate for the degree.

Note: The pre-qualifying examination should be held only once and if it is clear that the student is not ready for the final qualifying examination, it is obvious that sufficient time should be given to him/her to prepare for it. Normally it will be very difficult, if not impossible, for a student to overcome the weakness over a period of two to three weeks. It may take as much as two to six months for the required preparation. This fact should be kept in view while determining the date for the qualifying examination based on the pre-qualifying performance.

The common departmental examination committee which may be nominated by the respective Board of Studies should include, besides the Professor and the Head of the Division, faculty members representing all the major fields/sub-disciplines and also the Chairperson and in his absence the second member of the Advisory Committee of the student appearing in the pre-qualifying examination. The strength of the committee shall not exceed 6-7 members including the Chairperson who shall normally be the Professor, and in his absence, the Chairperson of the Advisory Committee of the student.
The Board of Studies may prescribe a time gap shorter than 2 months for holding the qualifying examination in the case of M.Sc./M.Tech. students.

9.6.2 The Chairperson of the Advisory Committee shall forward a proposal in the prescribed proforma (Annexure XI) to the Professor of the discipline concerned for holding qualifying examination of the concerned student after completion of 75% of the course work both in the major and minor fields (as already listed in his/her approved PPW), indicating therein the schedule of examination including the proposed dates of written and *viva-voce*. The Chairperson of the Advisory Committee shall suggest a panel of 3 names for considering the co-opted member of the examination committee for the qualifying examination to which the Professor shall add two more names before forwarding the panel to the Dean. The Head may also, if he/she likes, add any names to the above panel. Where the Professor himself is the Chairperson of the Advisory Committee, the Professor will suggest three names and the Head shall suggest two more names for the panel. Similarly, when the Head is the Chairperson, he/she would suggest the first three names and Professor shall suggest two more names for the panel.

9.6.3 After examination of each student’s record, permission of the Dean shall be conveyed to the Professor under intimation to the Chairperson concerned to proceed with the qualifying examination. The qualifying examination should normally be completed within a period of three months from the date of issue of the letter from Post Graduate School permitting such an examination.

9.6.4 The Dean shall also nominate the co-opted member in the examination committee and take such action as may be required in arranging for the participation of the co-opted member.

9.7 General Requirements for Qualifying Examination

9.7.1 The examination shall be both written and oral, the written test to precede the oral. The oral examination shall be held only after the student has successfully completed the written examination.

9.7.2 The written qualifying examination in the major field both for the M.Sc./M.Tech. and Ph.D. shall be arranged/evaluated externally as per the following terms:

<table>
<thead>
<tr>
<th>Master's Programme</th>
<th>Weightage</th>
<th>Doctoral Programme</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major subject</td>
<td>One paper</td>
<td>50%</td>
<td>Two papers: at least one paper by external examiner</td>
</tr>
<tr>
<td>Minor subject</td>
<td>One paper</td>
<td>25%</td>
<td>One paper</td>
</tr>
<tr>
<td>Viva voce</td>
<td>Internal</td>
<td>25%</td>
<td>External</td>
</tr>
<tr>
<td>Qualifying marks</td>
<td>60%</td>
<td></td>
<td>60%</td>
</tr>
<tr>
<td>Paper setting</td>
<td>Internal</td>
<td></td>
<td>Internal</td>
</tr>
<tr>
<td>Evaluation Grading</td>
<td>External</td>
<td></td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>2 Credit</td>
<td></td>
<td>2 Credit</td>
</tr>
<tr>
<td></td>
<td>Grade 0-10</td>
<td></td>
<td>Grade 0-10</td>
</tr>
<tr>
<td></td>
<td>Scale</td>
<td></td>
<td>Scale</td>
</tr>
</tbody>
</table>

9.7.3 The qualifying examination can be held at any time during the academic year, including the summer vacation.

9.7.4 For holding qualifying examination and final *viva-voce*, notice of a minimum period of 10 days shall be given and no prior approval of the members of the Advisory Committee shall be required. Faculty members shall so arrange their programme that they are present at the time of the student’s examination. No last minute substitution in the Advisory Committee of students will be made at the time of examination except in special cases with the permission of the Dean.

9.7.5 The qualifying examination shall be given at least 3 months before the date of completion of the student’s programme of studies (i.e. the date on which the final *viva-voce* examination is held) in the case of M.Sc./M.Tech. students and six months in advance in the case of Ph.D. students.

*Note*: The Dean is empowered to relax this rule on the recommendation of the respective Board of Studies in suitable cases.
9.7.6 After having successfully completed the major portion of the course work required (at least 75%) as judged from the minimum average grade point prescribed for passing (6.50 out of 10.00) for M.Sc./M.Tech. and Ph.D. students, the departmental students shall appear for qualifying examination in not later than the V trimester.

9.7.7 Any member of the Post Graduate faculty shall have the option to attend the viva-voce of any student as an observer.

9.8 Qualifying Examination for M.Sc./M.Tech. Students

The written qualifying examination for M.Sc./M.Tech. students shall consist of one or more papers, each of not more than three hours duration, covering suitably the subject matter of the courses taken by the student in the major field and one paper of two hours duration covering the minor field. The papers shall be set and evaluated in accordance with the procedure as given in para 9.7.2. The paper in the minor field shall be set and evaluated by the member of the student’s Advisory Committee representing the minor field. The oral qualifying examination shall be conducted by the Advisory Committee with one additional member designated by the Dean from among the faculty members of IARI, but from a discipline other than the student’s major field.

9.9 Qualifying Examination for Ph.D. Students

The written qualifying examination for Ph.D. students shall cover, besides the courses taken by the student in major and minor fields, all aspects of the major discipline of study in which the degree is to be awarded, irrespective of the particular courses taken in the discipline. There shall be three or more written papers, one or more each of three hours duration covering the major field and one each of two hours duration covering the two minor fields. For Ph.D. programmes, the papers for the written examination in the major fields shall be set and evaluated in accordance with the procedure as given in para 9.7.2. The papers in the minor field shall be set and evaluated by the members of the student’s Advisory Committee representing the minor field. The oral qualifying examination for Ph.D. shall be conducted by the Advisory Committee with one additional member who will be designated by the Dean and shall be a specialist in the student’s major field but from outside the IARI and its Regional Research Station.

9.10 Report on the Performance in Qualifying Examination

9.10.1 The Chairperson of the student’s Advisory Committee shall act as Chairperson of the Examining Committee and shall be responsible for communicating the results of the examination through the Professor to the Dean, in the prescribed form (Annexure XII) and with the signatures of all the members of the Examining Committee.

9.10.2 The student’s performance in the qualifying examination may be considered satisfactory on the unanimous recommendation of the Examining Committee. It shall be within the competence of the Committee to indicate deficiencies in the student’s course work and overall training at this stage and the Committee may recommend that the student makes up these deficiencies in any suitable manner.

9.11 Qualifying Re-examination

9.11.1 A student failing in one or more subjects in the written examination shall be re-examined only in that/those subjects and the viva-voce shall be held only after the written examination is successfully completed, provided that there is not more than two months gap between the written examination and the viva-voce. If a student fails in the viva-voce, the Examination Committee shall make specific recommendation as to whether the student is to be re-examined in the viva-voce alone or in the written portion also.

9.11.2 A student failing in the qualifying examination shall apply for permission to appear for a second time to the Dean with the recommendation of the Chairperson of the Advisory Committee. Permission to appear for a second time may be given, but re-examination shall not take place earlier than three months after the first examination. Re-examination for a third time is not permitted and a student failing for a second
time cannot continue or qualify for a degree from the Post Graduate School.

9.12 Admission to Candidacy

A student who has passed qualifying examination shall be admitted to candidacy for the degree and formal intimation to this effect shall be communicated to the student, through the major adviser and the Professor.

C. THESIS SUBMISSION, EVALUATION AND FINAL VIVA VOCE


9.13.1 The topic of thesis shall fall within the major field of specialisation in which the student has been admitted. The subject of thesis shall have the approval of the student’s Advisory Committee and the Dean at the time of formulation of the student’s plan of post-graduate work (PPW). The thesis shall be based on the results of the student’s own work.

9.13.2 The thesis of the Master’s degree should be of such nature as to indicate a student’s potentiality for conducting research. The thesis for Ph.D. must indicate that the candidate possesses the ability and imagination necessary to do independent constructive thinking and should be of the nature of a definite contribution to the subject, and the results and the conclusions presented should be of sufficient importance as to merit publication.

9.13.3 It shall contain chapters on Introduction, Background, Materials and Methods, Results in the form of research papers, Discussion, Conclusions and Literature Citations.

9.14 Submission of Thesis

9.14.1 (i) A student shall submit a proposal for submission of the thesis in the prescribed proforma (Annexure XIII) to the Chairperson at least two months before the proposed date of actual submission of the thesis. This shall be signed both by the Professor and the Head of the Division with comments, if any, and shall be forwarded by the Professor to the Dean in sealed cover.

(ii) The Chairperson of the Advisory Committee shall suggest a panel of three names for the nomination of the outside examiner for evaluation of thesis to which the Professor shall add two more names before forwarding the panel to the Dean. The Head may also, if he likes, add any names to the above panel. Where the Professor himself is the Chairperson of the Advisory Committee, the Professor shall suggest three names and the Head shall suggest two more names for the panel. Similarly, when the Head is the Chairperson, he shall suggest the first three names and the Professor shall suggest two more names for the panel.

9.14.2 A student shall deliver a seminar on his/her thesis research problem before the submission of thesis and all the faculty members may be invited to participate in the discussions and make constructive criticism of the thesis. The provision has been prescribed more as a guideline and the actual details of implementing it shall be left to the various disciplines.

9.14.3 All the Ph.D. students shall write at least two quality research papers for publication before submission of their thesis and the copy of at least one paper published or accepted for publication in the referred journal of repute with NAAS rating of not less than 3.50 out of 10.00 at the time of submission of thesis to the PG School. In the absence of these papers, their thesis will not be accepted for further processing.

9.14.4 The candidate shall be required to complete and submit the thesis to the Professor of the discipline concerned along with “No Dues Certificate” and other formalities. The thesis shall be forwarded by the Professor to the Post Graduate School without any further examination of its contents.

9.14.5 The thesis shall be submitted in a bound form as per the guidelines given below:

(i) The thesis shall be prepared in the form of research papers.

(ii) The thesis shall have a first general ‘Introduction’ chapter including objectives,
which may be followed by ‘Background’ chapter, ‘Materials and Methods’ chapter, ‘Results’ chapter in the form of a set of research papers, ‘General Discussion’ chapter, ‘Summary and Conclusion’, ‘Abstracts’ (English and Hindi), ‘Bibliography’ and ‘Appendix’.

(iii) Each research paper may be self-contained in its title, introduction (including review of literature), materials and methods, results, discussion and summary/abstracts.

(iv) The bibliography may be common to avoid duplication in the different papers.

(v) There shall be a final chapter summarizing the conclusions from all the research papers proposed and included in the thesis.

(vi) Since it is mandatory to submit at least 2 research publications for Ph.D. thesis, one research paper should have been accepted and second submitted for publication in referred Journal of repute with NAAS rating of not less than 3.5 out of 10.0 or one patent filed out of the thesis work. The acceptance certificate/reprint of the paper published shall be included in the thesis.

The thesis shall be reviewed in the light of the comments of the external examiner (as per the evaluation format given at Annexure XXI) by the Examining Committee. In case, the external examiner suggests modifications/re-submission of the thesis, and these are not acceptable to the student, he/she may be permitted to defend his/her thesis at the time of the final viva-voce, and such of the modifications as are finally agreed upon may be carried out after the viva-voce.

9.14.6 The Chairperson of a student’s Advisory Committee shall ensure that all members of the Advisory Committee are duly consulted before the draft thesis is submitted by the student. In cases where the student’s Advisory Committee has been reconstituted or Chairperson changed, the student shall clearly indicate the name of the previous Chairperson and the period for which he served as Chairperson.

9.14.7 The thesis shall be accompanied by certificates duly endorsed by the major adviser to the effect that: (a) the thesis is the result of the student’s own work, and (b) the contents, while being submitted for the award of the degree, have not been published, in part or in full, even in annual reports of the Institute or of schemes financed by the Indian Council of Agricultural Research, the Council of Scientific and Industrial Research etc. However, if a student and the major advisor so desire, a part of the thesis may, with the prior approval of the Dean, be published prior to submission of thesis for establishing priority.

9.14.8 Each M.Sc./M.Tech./Ph.D. student should submit four copies of the thesis, of which one copy would eventually be deposited in the Post Graduate School, other with the Central Library, another in the Divisional library and the fourth with the major adviser. The student should also submit the thesis in PDF format to library. The student shall also submit with the thesis five copies of the abstract of the thesis (both in English and Hindi), neatly typed (about 500 words). The abstract shall be of high quality and properly edited after perusal by the Examining Committee. The abstract of the thesis submitted by the students should be carefully scrutinised by the Professor concerned and sent to the Post Graduate School after editing.

9.15 Evaluation of Thesis for the Award of M.Sc./M.Tech. Degree

9.15.1 The thesis submitted in partial fulfillment of the M.Sc./M.Tech. degree shall be evaluated by an Examining Committee composed of the student’s Advisory Committee and an additional member, with the major adviser as Chairperson. The additional member shall be a specialist in the student’s major field of study and shall ordinarily be appointed by the Dean from a panel of three names of specialists in the particular field in India submitted to him confidentially from the discipline concerned, but outside the IARI and its sub-stations.

The Dean shall have the discretion to select the additional member from outside the standing panel of specialists suggested by the discipline after consulting the concerned Head of the Division, Professor and the Chairperson of the Advisory Committee. The additional member shall send his/her report directly to the Dean.
9.15.2 In case the additional member does not recommend the thesis for the award of the degree, the Dean may on the special recommendation of the Advisory Committee refer the thesis for scrutiny and independent judgment to a second additional member chosen and appointed by the Dean either from the original panel or from outside the original panel. If the second member recommends the thesis for acceptance, this recommendation may be accepted. If, however, opinion is still not unanimous the degree shall not be awarded. In such cases the student shall have the option to continue the work, rewrite the thesis and submit it once again after the lapse of at least one trimester but not for a third time.

9.15.3 A final viva-voce shall be held by the Advisory Committee after the receipt of the full report of the additional member and after thesis is recommended by the Examining Committee for consideration. The result of the viva-voce examination shall be sent in the prescribed proforma given at Annexure-IV. The report of the dissenting examiner if any, shall also be considered by the Examining Committee at the time of the final viva-voce. A notice shall be displayed on the notice board of each discipline regarding the date and time of the final viva-voce of each student so that interested faculty members may attend the same.

9.15.4 The degree shall be awarded on the unanimous recommendation of the Examining Committee. The Chairperson shall send the recommendations of the Examining Committee to the Dean in the prescribed form.

9.16 Evaluation of Thesis for the Award of Ph.D. Degree

9.16.1 The thesis of the Ph.D. students shall be sent to two external experts for evaluation as per the existing guidelines. However, the student shall give a seminar in the presence of external expert(s) and other members of the discipline/division concerned.

9.16.2 The thesis submitted in partial fulfillment of the Ph.D. degree shall be read and examined by an Examining Committee appointed by the Dean and composed of the Advisory Committee and an additional members (co-opted). The major adviser shall be the Chairman of the Examining Committee. The additional member shall be from outside the IARI and its sub-stations. He/She shall ordinarily be chosen by the Dean from a panel of at least five names of specialists in the particular field which shall be submitted to him by the concerned discipline confidentially. The Dean shall, however, have the discretion to select the additional members from outside the standing panel of such specialist suggested by the discipline, after consulting the concerned Head of the Division, Professor and the Chairperson of the Advisory Committee or from the examiners bank of the concerned discipline maintained by the PG School. The additional members shall send their reports on the thesis directly to the Dean.

9.16.3 In case the reports of both the additional members are unfavourable, the thesis shall not be considered for award of the degree. In case of only one unfavourable report, the Dean, may, on the recommendation of the Advisory Committee refer the thesis for scrutiny and independent judgment to a third additional member chosen and appointed by the Dean either from the original panel or from outside the original panel, after consulting the concerned Head of the Division, Professor and the Chairperson of the Advisory Committee. If the third additional member recommends the thesis for award of the degree, this recommendation may be accepted provided at least one of the two other original additional members, who have read the thesis also agree with this recommendation. If not, the thesis shall not be considered for the award.

9.16.4 If a thesis is not accepted for the award of the degree, the candidate may be permitted to continue the work by rejoining the Post Graduate School within a period not exceeding six months from the date of communication of the rejection of the thesis and submit it once again after the lapse of at least one trimester after rejoining the Post Graduate School.

9.16.5 After a student’s thesis for the Ph.D. degree is evaluated and recommended by both the examiners for award of degree, the thesis shall be finally accepted for the award only after the student completes satisfactorily a final viva-voce, which shall
be conducted by the student’s Advisory Committee with the addition of one of the additional members who evaluated the thesis and recommended it for the award of the degree. The *viva-voce* shall be conducted only on the basis of the full report of the examiner, and not on the basis of the intimation of the approval of the thesis. The report of the dissenting examiner, if any, shall also be considered by the Examining Committee at the time of final *viva-voce*. The *viva-voce* shall relate mainly to the thesis problem; the Examining Committee shall, however, be free to test the student in his/her major and minor fields of study. The candidate shall be expected to defend the thesis at the oral examination. A notice shall be displayed on the notice board of each discipline regarding the date and time of the final *viva-voce* of each student so that interested faculty members may attend the same.

**9.16.6** The degree shall be awarded on the unanimous recommendation of the Examining Committee taking into consideration the merit of thesis itself and the performance of the student in the final *viva-voce*. The recommendation of the Committee shall be forwarded by the Chairman to the Dean in the prescribed form (Annexure XIV) which shall be signed by all members of the Examining Committee.

**9.17 Re-examination in the case of Failure in Final Viva-voce**

**9.17.1** A student who fails in the final *viva-voce* examination may apply again to the Dean with the recommendation of the Chairperson of the Advisory Committee for permission to appear a second time. Permission to appear for the second time may be given but the re-examination shall not take place earlier than three months after the first examination and it will be conducted by the committee as previously constituted, as far as possible. Re-examination for third time is not permissible and a student who fails for a second time cannot continue as a student in the PG School and qualify for a degree from the Post Graduate School.

**9.17.2** The particulars of the candidates who have successfully completed all the requirements shall be placed for approval before the Academic Council. After the Academic Council declares the candidates eligible for the award of the respective degrees of the Institute, a notification containing the names of the candidates so declared eligible, along with the title of their thesis, shall be issued by the Post Graduate School. The award of the degree shall be made at the next Convocation of the Institute.

**9.18 Venue of Examination**

No examination would be conducted outside the IARI campus without obtaining prior written permission of the Dean.

**9.19 Rights Regarding Thesis, its Publication and Reference**

**9.19.1** The thesis submitted by a student shall become the property of the Institute and no part thereof shall be published without the prior permission of the Dean or Head of the Division who shall be regarded as exercising this power on behalf of the Dean, and there shall be no objection to the abstracts of the thesis being published in the Divisional publications. Whenever an extract from the thesis is published, a footnote shall always be given saying that the thesis had been submitted for the degree of the Post Graduate School at the Indian Agricultural Research Institute.

**9.19.2** All patents, prototypes, designs and inventions derived from the thesis research work shall belong to the Institute which may, at its discretion, allow or direct any benefit thereon to be retained by or given to the author of the thesis.

**9.19.3** The thesis may be published in the form of an abstract/article in the publication “Abstracts of Post Graduate Students’ Thesis”. The student shall be the author of the article. The names of all the members of the student’s Advisory Committee shall be printed as an “Inset”, the name of the Chairperson appearing in bolder type.

**9.19.4** Copies of thesis deposited in the Institute Library or in the Divisional Libraries shall not be available for reference for a period of two years from the date of submission and shall, under no circumstances be issued on loan.
9.19.5 In case where students do not care to publish their thesis work even after many years of completion of their degree, there is no objection to the Chairperson of the student taking the initiative to write a paper in consultation with the student provided the student is given first authorship and the Chairperson takes credit for second authorship.

9.20 Abstracts of Post Graduate Student’s Thesis

9.20.1 The “Abstract of Post Graduate Students’ Thesis” is intended for publication of abstracts of all the approved M.Sc. and Ph.D. thesis of the Post Graduate School in the Post Graduate School Journal. The abstract of the thesis should also be published in Hindi. Each issue of the ‘Abstracts’ may also carry some invited articles. The ‘Abstracts’ is normally published once in a year.

9.20.2 The abstract to be published (about 500 words) shall be of high quality and properly edited. This abstract shall be bound along with the final thesis.

9.20.3 All abstracts of thesis submitted by the students should be carefully scrutinised by the Professor concerned and sent to Post Graduate School after editing. The Post Graduate School shall arrange for the publication of the Post Graduate School Journal after getting the draft approved in a meeting of the Editorial Board.

9.20.4 The abstract shall be in the exclusive authorship of the student and he/she shall give his/her roll number, degree for which the thesis is submitted, the discipline, date and year of submission and the names of the Chairperson and the members of the Advisory Committee.

9.20.5 A suitable Editorial Board shall be constituted by the Chairperson of the Academic Council for bringing out the above publication.

9.20.6 The rates for the annual subscription of Post Graduate School Journal shall be decided by the Dean. These rates are subjected to change as and when necessary.
10 Seminars

10.1 Each student shall be required to give seminars during the course of his/her studies on a topic relevant to the discipline concerned as per following details:

- M.Sc.: 2 Seminars in Major field
- Ph.D.: 2 Seminars in Major field
  1 Seminar in one Minor field

85% attendance in each Seminar will be required by each students.

10.2 Attendance in the divisional student’s seminar is compulsory for all the students.

10.3 When a student is enrolling for a seminar course in the minor field, he/she may be exempted from attending the seminar in his/her own discipline during that trimester.

10.4 All seminars are to be held on Saturday. As far as practicable, no other class should be scheduled on that day.

10.5 A student can register for only one Seminar course in his/her major discipline during one trimester.

10.6 While forwarding the seminar grades to the Post Graduate School, the Professor of the discipline must forward the Seminar evaluation pro-forma of each student.

10.7 The procedure for selection of seminar topics, preparation of synopsis, evaluation of seminar, write-up of seminar, etc. is given below:

A M.Sc. student is required to give at least two seminars in the major field and a Ph.D. student three seminars (one of which should be in the minor field outside the discipline) during the course of the study at the Post Graduate School.

The objective of the seminar is to judge the student's capability to present a critical survey of the subject matter, mode of presentation, capacity to draw general conclusions from literature and ability to answer questions relevant to the seminar topic during the discussions.

10.8 General

Seminars will be usually held on a fixed day in the lecture theatre of the Division. Notices should be circulated well in advance to the members of staff and students of the discipline, and the members of the Advisory Committee. A register shall be maintained to record attendance of students at the seminar.

10.9 Selection of Topics

The topic for the seminar should be relevant to the discipline. It should not fall within the purview of the object of the student’s thesis but instead should cover a subject of topical interest. Certain relaxations may be allowed to the M.Sc. students. The Seminar Leader in each discipline shall be free to select a seminar topic in consultation with the student and if necessary in consultation with the faculty members concerned. The Seminar Leader in consultation with the Professor/Head of the Division shall fix up the schedule for the seminars. Except under the unavoidable circumstances, the seminar date thus fixed will not be changed.

10.10 Synopsis of the Seminar

Each student will be required to submit to the Seminar Leader the synopsis of the seminar with the approval of the Chairperson of the Advisory Committee. The office will arrange to have sufficient number of monographed copies of the synopsis for distribution to the persons attending the seminar. The synopsis should precisely state the main theme of the talk and should bring out clearly and briefly (limited to about 300 words)
the entire subject matter to be dealt with during the talk. It should be well written so as to be easily understood and should be self-explanatory, complete and clear in itself.

10.11 Seminar Evaluation

The Board of Studies may appoint a Seminar Evaluation Committee consisting of 3 to 4 faculty members with one Seminar Leader. This Committee may assess the performance of the students, taking into account all the relevant factors like introduction and review of literature, presentation of subject, capacity to draw general conclusions from literature and ability to answer questions and allot the grade to the students.

The Seminar Evaluation Committee shall award the grade. For sending the result of the Seminar, the proforma meant for forwarding trimester examination result should be used.

10.12 Seminar Write-up

The student shall prepare a full account not normally exceeding 3000 words of the subject covered in the seminar keeping in mind the points raised during the discussion, and submit the same to the Seminar Leader within a fortnight from the date of delivering the seminar. The evaluation report of the seminar will not be forwarded to the Dean's Office until this condition is fulfilled.
11 Relief from the Post Graduate School

11.1 Temporary Withdrawal from Studies

11.1.1 Temporary withdrawal shall not be allowed in the midst of a trimester under any circumstances except those mentioned in Para 11.1.2 below. The trimester during which such temporary withdrawal is taken, will however be counted as a full trimester.

11.1.2 Temporary withdrawal will be allowed only on the following grounds:

(i) Illness of self to be supported by medical certificate;
(ii) Death of parent/guardian or, in the case of married student, the spouse;
(iii) Temporary withdrawal should be restricted ordinarily to one trimester only, but in the case of illness of the student concerned it may, subject to medical advice, be allowed for two trimesters within the duration of the course;
(iv) No temporary withdrawal will be allowed for taking up employment.

11.1.3 Such withdrawal shall be permitted only with the prior permission of the Dean and no ex-post-facto approval shall be given.

11.1.4 The request for withdrawal shall be recommended by the Chairperson of the student’s Advisory Committee and the Professor of the concerned discipline.

11.1.5 The withdrawal shall be permitted subject to the condition that the student shall complete the programme of studies within the maximum period prescribed for completion of studies.

11.1.6 The request shall be sent at least 15 days in advance of the proposed date of withdrawal and the decision on the request shall be communicated by the Post Graduate School within 10 days of the date of receipt of such request.

11.1.7 The request for temporary withdrawal from Post Graduate School should be accompanied by ‘no dues certificates’ from all concerned.

11.1.8 During the period of temporary withdrawal, the name of the student shall be kept on the rolls and as such he/she shall be liable to pay fees and other prescribed charges.

(i) The temporary withdrawal from studies under above rules 11.1.1 to 11.1.8 shall not exceed two trimesters; and
(ii) No student except departmental students, shall be allowed temporary withdrawal from his/her studies if he/ she has not started his/ her course work.

11.2 Relief before Submission of Thesis

11.2.1 A student may be relieved from the Post Graduate School with the prior permission of the Dean for accepting employment outside or for rejoining duty in the parent department if all the requirements including research work except submission of thesis are completed at the time of applying for relief subject to the following terms and conditions:

(i) The request for relief shall be submitted in the prescribed proforma (Annexure XVI) and shall give details of the progress of the research work, laboratory work, analysis of data and the stage of preparation of thesis.
(ii) The Chairperson and the Professor concerned shall certify that all the work except the submission of thesis has been completed by the student. If necessary, the Professor may request the Chairperson of the student’s Advisory Committee to call a meeting of the
Advisory Committee in which the Professor would be present to satisfy himself about the completion of research work of the student before issuing the certificate under this rule. In case of difference of opinion, the Professor would send the proceedings of the Advisory Committee meeting along with his own recommendations to the Dean for a final decision by the latter.

(iii) The minimum residential requirement of two and three years for M.Sc./M.Tech. and Ph.D. students, respectively should be fulfilled.

(iv) Application for the job should have been routed through proper channel and forwarded by the Dean. If the application was sent prior to joining the Post Graduate School, the student shall inform the Dean about this application soon after admission.

(v) The student shall undertake to pay the prescribed tuition fee from the month of relief till the date of submission of thesis so as to continue on the rolls of the Post Graduate School.

(vi) The student shall not be entitled to hostel accommodation after relief. However, the Dean may consider the request for accommodation for the limited period, for which the student will be at IARI while actually submitting the thesis and he/she should be on leave from his/her employers.

(vii) The student can be relieved from the Post Graduate School on his/her request on the completion of his/her research work pending submission of the thesis with a clear stipulation that he/she should submit his/her thesis within the prescribed period of five years from the date of his/her initial enrollment as M.Sc./M.Tech/Ph.D. student, in which his/her name shall be removed from the rolls of the Post Graduate School.

(viii) The student shall be relieved from the Post Graduate School only after he/she delivers the seminar on his/her research and after furnishing a certificate in this regard by his/her Chairperson and Professor concerned.

11.2.2 A departmental part-time student may also be relieved provided he/she has been on the rolls of the Post Graduate School for not less than two academic years,

11.2.3 No student shall leave the Post Graduate School for accepting employment outside or for any other reason, without prior permission or relief and without obtaining relieving certificates before his/her departure. The concerned teaching discipline shall not relieve the student without the permission of the Dean.

11.3 Relief after Submission of Thesis

11.3.1 A student shall be relieved, with the prior permission of the Dean, from the Post Graduate School at his/her own request after the submission of the thesis for accepting employment or for any other purpose.

11.3.2 The name of the student shall remain on the rolls of the Post Graduate School till the date of completion of the final viva-voce examination.
12 Convocation and Award of Degrees

12.1 Award of Degrees

12.1.1 A convocation shall be held for conferring M.Sc./M.Tech. and Ph.D. degrees to the successful candidates declared eligible for the award of the degree by the Academic Council. The programme of the convocation shall be approved by the Academic Council.

12.1.2 Every successful candidate shall appear in person at the convocation to receive the degree. However, if a candidate does not appear in person, the degree shall be conferred in absentia. The fee for conferring a degree in absentia shall be prescribed from time to time. The degree certificates in such cases will be sent to the candidate's notified address on payment of the prescribed fee.

12.1.3 In order to become eligible for award of the degree in a particular convocation, the student shall submit the thesis at least two months before the date of the convocation or a date notified by the Post Graduate School from time to time.

12.1.4 The degree may be awarded posthumously to a student if he/she had completed all the requirements for the award of degree including the final viva-voce examination before his/her death.

12.2 Duplicate Degrees and Certificates

Issue of duplicate degrees and other certificates shall be governed by the following guidelines:

(i) A request for duplicate degree/ certificate shall be granted only on the production of an affidavit on a non-judicial stamp paper to the effect that applicant has lost the degree/ certificate issued earlier or that it has been destroyed.

(ii) A fee of ₹ 2000/- shall be charged for the issue of a duplicate certificate.

(iii) The word “duplicate” shall be inscribed in bold letters at the top of such degree/ certificate.

(iv) The duplicate degree/diploma/ certificate shall be signed by the Registrar and the words “Sd./” along with the name of the original signatories shall be inscribed in the appropriate places.

12.3 Award of Honorary Degrees

12.3.1 The Academic Council of the Institute may decide to confer degrees of Doctorate of Science (Honoris Causa) on persons who have distinguished themselves in the field of science but are not either serving staff members of the IARI or serving members of the Agricultural Research Service (ARS) of the ICAR.

12.3.2 All the proposals for conferment of honorary degrees shall be received and processed by the office of the Dean, Post Graduate School.

12.3.3 The Dean shall call all such requests, with necessary background information, to be placed for consideration before a Special Committee consisting of the following:

(i) Dean, Post Graduate School – Chairman (Ex-Officio)

(ii) Dy. Director General (Edn.), ICAR – Member (Ex-Officio)

(iii) One representative of each of the 5 Schools namely, the Natural Resource Management, Crop Protection; Crop Improvement; Basic Sciences, and Social Sciences (to be nominated by the Chairman, Academic Council) Member

(iv) One external scientist member of the Academic Council (to be nominated by the Chairman, Academic Council) – Member
(v) Registrar, Member-Secretary (Ex-Officio)

The Committee shall consider the proposal(s) for conferment of honorary degree(s) referred to it and make its recommendations thereon to the Academic Council.

12.3.4 The Dean shall place the recommendations of the aforesaid Special Committee before the Academic Council for consideration. The decision to confer an honorary degree shall require two-thirds majority of the members present and voting in the meeting of the Academic Council.

12.3.5 After approval of the Academic Council, the Dean shall issue a notification and take the necessary steps for the award of the degree. The degree may be awarded at the annual Convocation or if necessary by holding a special Convocation.
A. IARI MERIT MEDALS

IARI Merit Medals shall be awarded to 5 M.Sc. and 5 Ph.D. students on the basis of following criteria and procedure:

13.1. Eligibility

(i) All M.Sc./Ph.D. students having overall grade point average of 8.00 out of 10.00 or above will be eligible for consideration for the award of IARI Merit Medals. However, only two names (1 Ph.D. and 1 M.Sc.) will be forwarded by each Professor. In case there are more than two students, a divisional level presentation will be arranged and finally two names communicated to Post Graduate School based on their performance.

(ii) M.Sc. students should have completed a minimum of 45 credits (55 credits for Ag. Stat. and Ag. Economics students) in major, minor and other supporting fields excluding compulsory courses on Introductory Agriculture of 36 credits, meant for non-agricultural graduates, and other compulsory courses.

(iii) Completed all the prescribed course load requirements within the maximum period of six trimesters (nine trimesters for non-agricultural graduates).

(iv) Ph.D. students should have completed a minimum prescribed load of 25 credits in one academic year in major, minor(s) and other supportive fields, excluding compulsory courses onIntroductory Agriculture meant for non-agricultural students, and other compulsory courses.

(v) Obtained a minimum OGPA of 8.00 out of 10.00. Those who obtain ‘F’ or ‘I’ grade in any course or have repeated a course are not eligible for consideration for award of Merit Medals.

(vi) The students taking ‘make-up examination’ will not be eligible for award of the Merit Medals.

(vii) Students should not have been awarded disciplinary punishment during studentship at the IARI.

(viii) The grades earned in respect of the credits added after the first two trimesters after enrolment shall not be counted for the purpose of award of IARI Merit Medals.

(ix) Candidates dropping any course from the PPW (as originally approved) after completing two trimesters of study will not be eligible for the award of IARI Merit Medals.

13.1.1 Criteria for assessment of comparative merit

(i) The weightage given to the different aspects for consideration of the award of IARI Merit Medal is given below:

For M.Sc. (100 Marks)

(a) OGPA : 60 marks (OGPA 10= 60marks)

(b) Thesis presentation : 20 marks

(c) Thesis evaluation reports : 10 marks

(d) Research papers/ Patents/ (3 marks for each) Software/Prototypes etc. in : Max. 6 marks thesis

(e) Patent filed/Software/Prototypes registered (2 marks each)

No. of Papers accepted/published

| NAAS rating > 5.0 | 2 marks each |
| NAAS rating ≤ 5.0 | 1 mark each  |

Max. 4 marks
For Ph.D. (100 marks)

(a) OGPA : 30 marks (OGPA 10=30marks)
(b) Thesis presentation : 30 marks
(c) Thesis evaluation report : 20 marks
(d) Research papers/Patents/ : (2 marks for each):
Software/Prototypes etc. Max. 10 marks in thesis
(e) Patent filed/Software/Prototypes registered
(2.5 marks each)

No. of Papers accepted/published:
NAAS rating > 5.0 : 2.5 marks each Max.
NAAS rating \leq 5.0 : 1.5 marks each 10 marks

(ii) In case there is a tie between two candidates,
the one having earned the OGPA with larger
number of credits in the discipline and if
there is a tie in this respect also, the one having
completed the larger course work (i.e. total
course load including minors) shall receive
the award.

(iii) The Dean, with the approval of the Chairman,
Academic Council shall constitute the
Judging Committee. All the eligible
candidates will present their thesis work
before the Judging Committee during the
Convocation Week. The Committee shall
award marks which would have 60% and 30%
weightage in the final evaluation for M.Sc. and Ph.D.,
respectively.

(iv) The Professor of the concerned discipline will
send edited abstract of the students (along
with a CD) considered for the medal to the
Convenor who will get these published in a
booklet form.

(v) The Convenor with the help of Judging
Committee shall award marks obtained in
thesis evaluation reports in the Performa
provided by the Post Graduate School which
would have 10% and 20% weightage in the
final evaluation for M.Sc. and Ph.D. students,
respectively.

(vi) Each member of the Judging Committee
shall award marks on the sheet/Proforma
provided by the Post Graduate School.
Convenor shall take average of the marks
awarded by the members of the Judging
Committee which would have 20% and 30%
weightage in the final evaluation of M.Sc. and Ph.D. students, respectively.

(vii) Finally, just after the presentation is over, the
Convenor will prepare final merit list with the
help of the Judging Committee on the basis
of the marks obtained in OGPA, thesis
analysis, thesis presentation and thesis
evaluation reports of the candidates. Names
of candidates selected for the IARI Merit
Medal will be announced in the auditorium
after presentation.

(viii) The Dean shall place the results before the
Academic Council for information.
**Best Student of the Year Award**

Two outstanding Post Graduate Students (one M.Sc. and one Ph.D.) are selected for Best Student award for the year.

The following guidelines shall govern the said award:

Six students each for Ph.D. and M.Sc. shall be selected by following the same procedure as being followed for finalizing the award of IARI Merit Medals. Out of these six students one student each in Ph.D. and M.Sc. will be selected for the award of BEST STUDENT OF THE YEAR by assigning additional weightage of 10 marks for the following attributes:

Common Criteria for both M.Sc./Ph.D. candidates:

(i) Overall attendance of the student in classes: 2 marks
(ii) Attendance in seminars: 2 marks
(iii) Organization / PGSSU office: 1 mark
(iv) Extra Curricular Awards: 5 marks

<table>
<thead>
<tr>
<th>Institute level</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-Institute</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

The criteria for assigning relative weightage to various aspects will be as follows:

(a) OGPA

<table>
<thead>
<tr>
<th></th>
<th>M.Sc.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>30</td>
</tr>
</tbody>
</table>

(b) Thesis presentation (Before the Common Evaluation Committee): 30 marks
(c) Thesis evaluation report: 10 marks and 20 marks for M.Sc. and Ph.D., respectively.
(d) Research papers/patents/softwares etc: 10 marks and 20 marks for M.Sc. and Ph.D., respectively.
(e) General Attendance/Attendance in classes/Attendance in Seminars/Extra curricular activities: 10 marks

After finalising the merit of six students in each for Ph.D. and M.Sc. for award of IARI Merit Medals, the marks awarded for extra-curricular achievements and discipline out of ten will be added in the total marks secured for academic performance and the topper of them will be declared as best student of the year, one for M.Sc. and other Ph.D.

The award will be presented at the Annual Convocation.

The award will carry a sum of `10,000/-, a Medal and a citation.

**13.2 Other Divisional Level Medals for M.Sc. Students**

The following medal is awarded to the M.Sc. students nominated for IARI merit medals in the prescribed discipline.

(i) **Pradeep Memorial Award**: Donated by Dr. B.L. Aggarwal for best M.Sc. student in the discipline of Environmental Sciences.

**13.3 Other Divisional Level Medals for Ph.D. Students**

(i) **Gurprasad Pradhan Medal**: Donated by Dr. S. Pradhan for award in the discipline of Entomology.

(ii) **Seth Lachhiram Chudiwala Medal**: Donated by M/s Prabhat General Agencies, Bombay, for award to M.Sc./Ph.D., Students for outstanding research on Agricultural Chemicals.

(iii) **Assam Government Medal**: Donated by the Government of Assam for significant research on rice.
14 Awards

14.1 Institute Level Award

Following are the awards presented at the Institute level at the Convocation of the Institute or any other occasion as deemed fit by the Institute:

14.1.1 Hooker Award

The Institute has instituted an award entitled “Hooker Award” for outstanding contributions in any field of research in agriculture, animal husbandry and fisheries leading to increase in food production. The award has been instituted on the basis of a legacy bequeathed to the Institute by Mr. and Mrs. Richard Hooker of Longmeadow, Massachusetts, USA.

Name of the Award

Hooker Award for Agricultural Research.

Donor of the Award

Late Mr. & Mrs. Richard Hooker of Longmeadow, Massachusetts, USA.

Nature of the Award

A prize of the value of ₹ 15,000/- in cash or kind or both plus a scroll for outstanding research in any field or subject within the purview of research in agriculture, animal husbandry and fisheries. Prize money is exempted from income tax vide Ministry of Finance, Government of India order No. F. No. 199/23/83-IT (AI). dated 27.2.1981.

Periodicity of the Award

The Award shall be made once in two years.

Purpose of the Award

To create incentive for research workers in India for the purpose of improving food production in India.

The Award shall be made for either fundamental research or applied research including inventions, discoveries, etc. leading to results of practical value in the field of agricultural production.

14.1.2 Sukumar Basu Memorial Award

The Institute has instituted an Award entitled “Sukumar Basu Memorial Award” for outstanding research in Agriculture including Animal Husbandry and Forestry. The Award has been instituted on the basis of the amount donated by late Dr. Sib Das Basu to commemorate the name of his brother, late Dr. Sukumar Basu.

Name of the Award

Sukumar Basu Memorial Award for Outstanding Research in Agricultural including Animal Husbandry and Forestry.

Donor of the Award

The award has been donated by late Dr. Sib Das Basu, M.B. DIH; DPH; Ex -Joint Director of Health Service, Govt. of West Bengal, to commemorate the name of his brother, Late Sukumar Basu, ICS, who was for many years concerned with various aspects of Agriculture in the Government of India and the Government of undivided Bengal and was also associated with the ICAR in the capacity of its Secretary, Vice-Chairman and Chairman.

Nature of Award

A prize of the value of ₹ 10,000/- and a scroll for outstanding research in agriculture including animal husbandry and forestry. The Academic Council will, however, have the power to vary the amount of the award provided the expenditure is...
met out of the return on the capital. Prize money
is exempted from income tax vide Ministry of
Finance, Government of India order No. F. No.
199/23/80-IT (AI) dated 27.2.81.

Periodicity
The Award will be made once in two years.

Purpose of the Award
To create incentive for research workers in the
country for the purpose of improving the quality
of life in the villages through improvement of eco-nomics of agriculture by research in all fields
of agriculture.

The Award shall be either for fundamental
research or applied research including inventions,
discoveries, etc. leading to results of practical value
in the field of agriculture production.

14.1.3 B.P. Pal Memorial Award
This Award was instituted in the year 1995 in
the memory of late Dr. B.P. Pal, former Director
of IARI and the first Director General of the
reorganised ICAR. The credit of establishment of
the Post Graduate School at IARI in the year 1958
also goes to Late Dr. Pal. Dr. Pal willed a major
portion of his moveable and immovable property
to IARI.

Dr. B.P. Pal Award is awarded to the Scientists
(Staff and Students) working at the Indian
Agricultural Research Institute or its sub-stations
for best piece of original research in Genetics and
Plant Breeding during 3 to 5 years preceding the
award. The award carries sum of \text{Rs} 50,000/- and
periodicity of 3 years and a Medal.

14.1.4 Best Teacher Award
Since 1995, Best Teacher Award is presented
to five faculty members of Post Graduate School
for their outstanding contributions to teaching at
IARI.

Name of the Award
Best Teacher /Outstanding Teaching Award
amongst the SAUs/ICAR Institutes, Deemed
Universities(DUS) and CAU.

Nature of Award
The Best Teacher Award at University/
Institute level shall be annual. This award will be
fully funded by ICAR.

Administration of the Award
The Best Teacher Award will be decided by
the respective SAUs/DUs/CAU (here-to-after
referred to as University).

Eligibility of the Award
All the Teachers/Scientists/Extension
Specialists working under the Universities shall be
eligible to make an application before the last date
prescribed in the proforma circulated for the
purpose.

The participating teacher should have
minimum of 5 years teaching experience in the
subject of his/ her specialisation.

A maximum of five Best Teacher Awards are
available in each University with faculty strength
of more than 300, otherwise three awards for
faculty strength from 200-300 and one award if
faculty strength is less than 200.

Amount of the Award
\text{Rs} 10,000/- per awardee and a commendation
certificate.

Presentation of Awards
The Best Teacher Award shall contain Plaque,
Scroll with a cheque of \text{Rs} 10,000/- to an awardee
to be conferred at the time of Convocation.

14.1.5 Shri Hari Krishna Shastri Memorial
Award

Name of the Award
Hari Krishna Shastri Memorial Award

Nature of the Award
The Award will carry a sum of \text{Rs} 25,000/- and
a commendation certificate for outstanding
contribution in Agricultural Sciences.
Periodicity of the Award

The award shall be made annually.

Purpose of the Award

To motivate agricultural scientists by recognising their outstanding contributions to agricultural research, education and extension in India.

The Award shall be made for either fundamental research or applied research including inventions, discoveries, etc. leading to the results of practical value in the concerned discipline.

14.1.6 Rao Bahadur Dr. B. Viswanath Award

This Award has been instituted from the academic year 2004-2005 in the field of Agricultural Sciences to commemorate the memory of late Rao Bahadur Dr. B. Viswanath, the first Indian Director of the Indian Agricultural Research Institute, New Delhi.

Name of the Award

Rao Bahadur Dr. B. Viswanath Award

Nature of the Award

The Award will carry a sum of ₹ 1,00,000/- (Rs. one lakh only), a Medal and a Citation.

Eligibility for the Award

The award shall be given to Indian nationals engaged in the field of agricultural sciences. It may include subjects like all aspects of field crops, horticulture, animal husbandry, veterinary science, dairy sciences, fisheries including marine fisheries, home sciences, agricultural engineering and technology, food sciences and agroforestry etc. The award should be bestowed on a person who has made outstanding contributions to agriculture, with particular relevance and impact on Indian Agriculture. The nominee should not be less than 50 years and with a standing of 25 years outstanding contributions in the concerned field of Agricultural Sciences. Nominations are to be made by the Secretaries of Science departments of Government of India, Vice-Chancellors, Directors of Agricultural Research Institutes of national importance and Presidents of National Academies. The nominations (10 copies) recommended by two renowned persons should be submitted in the prescribed proforma available at the Institute website: http://www.iari.res.in.

The award shall be made for outstanding original research work, inventions/discoveries, both fundamental and applied as evidenced by research publications, monographs and patents etc.

Administration of the Award

The Institute shall have the sole right of selection of the recipients of the award and of the formulation of rules governing such selection from time to time. The decision of the Director, IARI shall be final.

Screening Committee

The Vice-Chairman of the Academic Council will constitute the Screening Committee consisting of seven members concerning the major areas of the subjects pertaining to the applicants for the concerned year for scrutinising the applications. The quorum will be at least 4 members including Chairman and Member Secretary.

Judging Committee

There will be a Judging Committee consisting of eight members including Chairman and Member Secretary which will be appointed by the Chairman of the Academic Council.

The members will be from each of the relevant disciplines of Agricultural Sciences and the quorum will be at least five members including Chairman and Member Secretary. Wherever deemed necessary by the Judging Committee, Chairman of the Academic Council may identify non-member experts for in-depth evaluation of the applications/ nominations.

The function of the Judging Committee shall be to recommend the name of the recipient for the Award in accordance with the procedure laid down hereinafter to the Post Graduate School, IARI for approval of the Chairman of the Academic Council.
In the opinion of the Judging Committee, if no deserving candidate is available, the award will not be given.

The award will be given to only one person at one time and will not be shared.

Evaluation Criteria

i) Conceptual clarity and originality of the research work.

ii) Scientific, technological and socio-economic relevance and priority of research project.

iii) Quality of organization and implementation of research work. Any innovative approaches used.

iv) Principal research findings, their scientific, technological and socio-economic significance.

v) Potential of research findings for increasing agricultural production, productivity, profitability and sustainability in the relevant agricultural system.

vi) Actual impact on production, productivity, profitability and sustainability of relevant agricultural system.

vii) Quality of publications arising from the research work.

Presentation of the Award

The Post Graduate School shall notify the recipient of the Award.

The recipient shall be required to present the account of his/her contributions/achievements in a lecture organized by the Institute.

The expenditure relating to the arrangements for the award and the TA/DA restricted to the to-and-fro II\textsuperscript{nd} AC train fare will be met out from the interest accrued on the deposit.

14.2 Divisional Level Awards

The administration of the divisional level awards shall be the responsibility of the concerned Head of the division under intimation to Post Graduate School.

14.2.1 S.S. Bains Memorial Award

Instituted by the Scientific Staff of IARI and Indian Farmers Fertiliser Cooperatives Ltd. (IFFCO) in the memory of late Dr. Sher Singh Bains, erstwhile Head of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi. The award carries a prize money of ₹ 2,000/- plus a medal and is awarded for Ph.D. thesis for the outstanding contribution in the field of Agronomy once in two years.

14.2.2 R.D. Asana Endowment Lecture Scheme

To be bestowed upon an eminent and distinguished Plant Physiologist in the country who has helped in the promotion and progress of the discipline of Plant Physiology through research and teaching. Payment of an honorarium of ₹ 2,000/- and a plaque is recommended.

14.2.3 D.N. Puri Memorial Award

Dr. D.N. Puri Memorial Award donated by Mrs. Nirmal Puri w/o Late Dr. D.N. Puri carries a sum of ₹ 10,000/- in cash and a commendation certificate. The award shall be made once in two years for either fundamental or applied research including inventions, discoveries, etc. leading to results of practical value in the discipline of Agronomy.

All research workers up to the age of 60 years and actively engaged in research in the discipline of Agronomy in India shall be eligible for the said Award.

14.2.4 P.B. Sarkar Memorial Endowment Lecture Award

Dr. P.B. Sarkar Memorial Endowment Lecture Award carries a sum of ₹ 10,000/- in cash and a commendation certificate. The Award shall be made once in two years for either fundamental or applied research including inventions, discoveries, etc. leading to results of practical value in the discipline of Agricultural Chemicals.

All research workers up to the age of 60 years and actively engaged in research in the discipline of Agricultural Chemicals in India shall be eligible for the said Award.
14.2.5 Dr. K.M. Singh Memorial Award

This award has been instituted in the memory of Dr. K.M. Singh, former Head, Division of Entomology at IARI for outstanding scientist in the field of Entomology.

Name of the Award

Dr. K.M. Singh Memorial Award

Nature of the Award

The Award will carry a sum of ₹10,000/- with a Commendation Certificate.

Periodicity of the Award

The award shall be made once in two years.

Purpose of the Award

The award shall be made for either fundamental or applied research including invention, discoveries, etc. leading to results of practical value in the discipline of Entomology.

Administration of the Award

The Institute shall retain the right to designate the general field of endeavour in which the award shall be made.

The Institute shall have the sole right of selection of the recipients of the award and of the formulation of rules governing such selection from time to time.

Eligibility for the Award

All the research workers up to the age 60 years and are actively engaged in research in the discipline of Entomology in India shall be eligible for the said award.

The award shall be made for notable or original research both fundamental and applied in the field of Entomology as revealed in the form of publications, monographs, papers, patents or any other published account of outstanding research work inventions or discoveries. However, contributions or achievements which have received any other award shall not be eligible for consideration.

The candidates shall be judged on the bases of results of research contributions made by them during the five years preceding the year of award, in the case of claim based on evolution of new varieties, the final trials should have been completed within the five years preceding the year of award.

Screening Committee

The applications received for the award shall be screened at the divisional levels by a Committee of 3 members consisting of the Head and Professor of Division of Entomology and one co-opted member (either Head or Professor) from another discipline.

Judging Committee

There will be Judging Committee consisting of five members which will be appointed by the Chairman of the Academic Council on the recommendations of the Head of the Division of Entomology. The external experts from the discipline of Entomology and one member from other related discipline shall be included in the Judging committee. The Professor of the Division of Entomology will act as the Member-Secretary of the judging committee. The quorum of the judging committee for finalising the recommendation shall be at least 3 members including Chairman and the Member-Secretary.

If any member of the Screening Committee as well the Judging Committee himself is to be considered for the award, he/she shall cease to be a member of these committees and some other Scientist shall be appointed by the Academic Council in his place.

The function of the judging Committee shall be to recommend the name of the recipient for the award in accordance with procedure laid down hereinafter to the Dean & Joint Director (Education) IARI for further approval of the Director, IARI.

The award will be given to only one person in two years and will not be shared.

Procedure for Selection of Recipients

Applications will be invited by the Head of the Division of Entomology, IARI for the award from Research Institute/State Agricultural
Universities and Scientific Societies in India giving at least two months for application. Each such application, which shall be in the prescribed form shall be required to be accompanied by detailed statements of the work and attainments of the candidates to be submitted by a specific period.

The Award shall be withheld by the Judging Committee, if in their opinion, no sufficiently meritorious candidate is forthcoming.

**Presentation of the Award**

After getting the approval of the Director, IARI, the Head, Division of Entomology of the Institute shall notify the recipient of the Award.

The Award shall be made at a Divisional Level function at any suitable occasion as notified to the awardee and in the Institute at least 15 days in advance.

At the time of presentation of the Award, the recipient shall present an account of his/her contribution/achievement at a special seminar which will be arranged in the Division.

The expenditure relating to the arrangements for the award and the TA/DA to the Awardee to be paid as per the ICAR rules will be met out from the interest accrued from the deposit.

**14.2.6 B. Lakshminarayana Memorial Award**

With the approval of Academic Council, IARI in its meeting held on 15th March, 2002, this Award was instituted in the name of Shri B. Lakshminarayana in the field of Soil Science, Agricultural Chemistry and Agricultural Physics.

**Name of the Award**

B. Lakshminarayana Memorial Award

**Nature of the Award**

The Award will carry a sum of ₹ 10,000/- and a Commendation Certificate.

**Periodicity of the Award**

The award shall be made biennially.

**Purpose of the Award**

The Award shall be made for either fundamental or applied research including inventions, discoveries etc. leading to results of practical value in the field of Soil Science, Agricultural Chemistry and Agricultural Physics.

**Administration of the Award**

The Institute shall have the sole right of selection of the recipients of the award and of the formulation of rules governing such selection from time to time.

**Eligibility for the Award**

All the research workers up to the age of 40 years and are actively engaged in research in the field of Soil Science, Agricultural Chemistry and Agricultural Physics shall be eligible for the said award.

The award shall be made for notably outstanding or original research work, inventions or discoveries both fundamental and applied as evidenced in the form of publications, monographs, papers, patents or any other published account. However, contributions or achievements, which have received any other award, shall not be eligible for consideration. The candidate will be judged on the basis of original results of research contributions.

**Screening Committee**

A Committee of 3 members consisting of the Head, Professor of Division of Soil Science and Agricultural Chemistry and one co-opted member (either Head or Professor) from another related discipline shall screen the applications received for the award at the divisional level. The co-opted member will be nominated by the Dean & Joint Director (Education), IARI, New Delhi.

**Judging Committee**

There will be a Judging Committee consisting of five members which will be appointed by the Chairman of the Academic Council on the recommendations of the Head of the Division of Soil Science and Agricultural Chemistry. The external experts from the discipline of Soil Science and Agricultural Chemistry and one member from Agricultural Physics discipline shall be included in the Judging Committee. The Dean & Joint Director
(Education), IARI or his nominee shall also be member of this committee. The Professor of the Division of Soil Science and Agricultural Chemistry will act as the Member Secretary of the Judging Committee. The quorum of the Judging Committee for finalising the recommendation shall be at least 3 members including Chairman and the Member-Secretary.

If any member of the Screening Committee as well the Judging Committee himself is to be considered for the award, he shall cease to be a member of these committees and the Chairman, Academic Council in his place shall appoint some other scientist.

The function of the Judging Committee shall be to recommend the name of the recipient for the award in accordance with procedure laid down hereinafter to the Post Graduate School, IARI for further approval of the Chairman of the Academic Council.

The award will be given to only one person in two years and will not be shared.

**Procedure for Selection of Recipient**

The Head of the Division of Soil Science and Agricultural Chemistry, IARI will invite applications for the award from Research Institutions/State Agricultural Universities in India giving at least two months for application. Each such application, which shall be in the prescribed format, shall be required to be accompanied by detailed statements of the work and attainments of the candidate to be submitted by a specified period.

The Judging committee shall withhold the Award if in their opinion no sufficiently meritorious candidate is forthcoming.

After the acceptance of the recommendations of the Judging Committee by the Chairman, Academic Council, the award shall be announced.

**Presentation of the Award**

The Head of the Division of Soil Science and Agricultural Chemistry shall notify the recipient of the Award. The recipient shall be required to present the account of his/her contribution/achievement in a lecture organized by the Division concerned.

The Award shall be presented at a Divisional Level function.

The expenditure relating to the arrangements for the award and the TA/DA to the Awardee as per the ICAR rules will be met out from the interest accrued from the deposit.

**14.3 Guidelines to be Followed for Institution of New Awards at IARI**

The academic Council in its 381st meeting held on 9/7/2010 approved the following guidelines for the institution of new Institutional or Divisional Level Awards at IARI.

1. Institutional or Divisional level award may only be instituted in the memory of a scientist/alumni of IARI, who has made outstanding contributions in research, teaching and/or extension in his/her field of specialization.

2. For instituting an annual award, the proposee (of the award) will be required to deposit corpus money of ₹15.00 lakhs, while for a biennial award this sum will be ₹7.5 lakhs.

3. The amount of cash prizes of all Institutional/Divisional level awards to be instituted henceforth will be kept same (i.e. ₹50,000/-).

**Guidelines governing the award in the memory of: _______________________________In the discipline of __________________________**

1. Name of the Award

2. Nature of Award

   The Award will carry a sum of ₹50,000/- with a Commendation Certificate.

3. Periodicity of the Award

   The award shall be made annual or biennial.

4. Purpose of the Award

   The award shall be made for either fundamental or applied research including
invention, discoveries, development of technologies, and package of practices (name of discipline) and leading to results of practical value and development in relevant subject in India.

5. Administration of the Award

The Institute shall retain the right to designate the general field of endeavour in which the award shall be made. The Institute shall have the sole right of selection of the recipients of the award as per the criteria governing such selection from time to time.

6. Eligibility for the Award

All the research workers up to the age of 62 years who are actively engaged in the relevant field of research in India shall be eligible for the said award.

The award shall be made for notable and original research (both fundamental and applied) in the relevant field as evidenced in the form of publications, monographs, papers, patents, varieties and technologies developed and popularization, dissemination and adoption of technologies by the stakeholders. However, contributions or achievements, which have received any other award for the same work, shall not be eligible for consideration.

The candidates shall be judged on the basis of results of contributions made by them during the last 10 years preceding the year of award. In the case of claim based on development and adoption of new varieties, the final trials should have been completed within the five years preceding the year of award.

7. Screening Committee

The applications received for the award shall be screened at the Divisional level by a Committee of 3 members consisting of the Head and Professor of the concerned Division (name of discipline) and one co-opted member from the related discipline (outside the discipline). Professor of the concerned discipline will be the Member Secretary of the Committee.

8. Judging Committee

There will be a Judging Committee consisting of five members, which will be appointed by the Chairman of the Academic Council on the recommendations of the Head of the concerned Division and of the Dean & Joint Director, IARI. The external experts from the concerned discipline and one member from other related discipline shall be included in the Judging Committee. The Head of the concerned Division will act as the Member Secretary and the recommendation shall be of at least 3 members, including the Chairperson and the Member Secretary.

If any member of the Screening Committee as well as the Judging Committee himself/herself is to be considered for the award, he/she shall cease to be a member of these committees and some other Scientist will be appointed by the Chairman, Academic Council in his/her place.

The function of the Judging Committee shall be to recommend the name of the recipient for the award in accordance with procedure laid down hereinafter to the Dean & Joint Director (Education), IARI for further approval of the Director, IARI.

9. Procedure for Selection of Recipients

Applications will be invited by the Head of the Division, IARI for the award from Research Institutes/State Agricultural Universities and Scientific Societies in India giving at least three months for application. Each such application, which shall be in the prescribed form shall be required to be accompanied by detailed statements of the work and attainments of the candidates to be submitted for the last 10 years period with supporting documents.

The Award shall be withheld by the Judging Committee, if in their opinion, no sufficiently meritorious candidate is forthcoming.

10. Presentation of the Award

After getting the approval of the Director, IARI, the Head of Division of the Institute shall notify the recipient of the Award.
The Award shall be made at a Divisional Level function at any suitable occasion as notified to the awardee and in the Institute at least 15 days in advance.

At the time of presentation of the Award, the recipient shall present an account of his/her contribution/achievement at a special seminar, which will be arranged in the concerned Division.

The expenditure relating to the arrangements for the award and the TA/DA to the Awardee to be paid as per the ICAR rules will be met out from the interest accrued from the deposit.
15 Scholarship/Fellowship

15.1 The Scholarships/Fellowship is offered as financial assistance to the post-graduate students at IARI. This provision is made to assist as many students as possible who have good academic record and who are making diligent efforts to pursue higher education.

15.2 No student holding IARI scholarship shall apply for or accept any other scholarship/ fellowship/ award or employment without the prior approval of the Dean.

The details of the various scholarships/ fellowships available are indicated below:

15.3 IARI Scholarships

The Indian Agricultural Research Institute (hereinafter referred to as Institute) Junior and Senior Scholarship shall be awarded to M.Sc. and Ph.D. students admitted under General Open Competition Scheme on the following terms and conditions:

The Awards shall be made by the Dean and Joint Director (Education) of the Institute on the advice of the “Standing Committee on Scholarships Financial Assistance and Academic Progress”, which shall take into consideration the merit of each applicant based initially on his admission and subsequently on his performance at the Post Graduate School.

15.3.1 Duration

The normal duration of junior scholarships for M.Sc. course will be two years and that of senior scholarships for Ph.D. course will be three years. However, on the recommendation of the Chairperson of the student and Professor of the Division based on appraisal of the progress and details of justification for the extension needed, the period of junior/senior scholarships is extendable in exceptional cases for period not exceeding three months/six months, respectively.

In the case of SC/ST/PC students, the scholarships are extendable up to a period of six months/one year, respectively.

15.3.2 The students who have undergone introductory courses on agriculture in the first year of their study at IARI shall be provided Institute scholarship for a period of one year in addition to the provisions mentioned above.

15.3.3 The scholarships shall be awarded initially for a period of one academic year from the date of joining the Post Graduate School or the commencement of the academic year, whichever is later, and can be renewed for another year in the case of M.Sc. and two years in the case of Ph.D. students, subject to the earning of Overall Grade Point Average for continuing in the Post Graduate School.

15.3.4 Requests for extension beyond these limits will be examined by the Dean on their merits. The total period for which scholarships shall be awarded including extension period shall not exceed three years and three months in the case of M.Sc. students, and four years and six months in the case of Ph.D. students.

15.3.5 The payment of scholarship/fellowship should be reviewed at the end of 3rd trimester and only those students will be permitted to continue getting fellowship who maintain the OGPA of 6.50 out of 10.00 at the end of 3rd trimester. All M.Sc./ Ph.D. students will be required to maintain the minimum OGPA of 6.00 out of 10.00 at the end of 3rd trimester to continue on the Post Graduate School rolls.

15.3.6 The scholarship shall be paid only for the period of residence of the recipient at Post
Graduate School (inclusive of the summer vacation, the trimester breaks and such other leave as may be sanctioned under the rules) upto the date of final *viva-voce* (i.e. till they are on the rolls), subject to the condition that the maximum period of scholarship prescribed shall in no case be extended and provided he/she continues to reside in the Post Graduate Hostel and marks his/her attendance in the concerned division.

### 15.4 Value of Scholarship

The value of the M.Sc. and Ph.D. scholarship will be ₹ 7,560/- and ₹ 10,500/- per month, respectively. The scholarship shall be drawn in the extension period also where such extension beyond two/three years, respectively, has been granted. The scholarship will be inclusive of all fees and other charges of the teaching institution. In addition to the monthly amount of junior/senior scholarship a contingent grant of ₹ 6,000/- per academic year for M.Sc. students, and ₹ 10,000/- per academic year for Ph.D. students will be paid towards the cost of experimental material, books, the thesis and the study tours required for the study as recommended by the Chairperson/Professor concerned.

### 15.5 Scholarship to the In-service Candidates/Departmental Students

As per ICAR norms, the In-service candidates joining M.Sc./Ph.D. course on study leave/deputation who are in receipt of study allowance/halting allowance/deputation allowance etc. in addition to full leave salary, the scholarship amount will be adjusted so that they will get a maximum benefit of ₹ 3,000/- p.m. only in addition to full leave salary. This is in addition to the payment of contingent grant. Those in-service candidates who are not in receipt of JRF/SRF and receiving partial salary (half or leave without pay) will also be eligible to get Institute Scholarship of ₹ 3,000/- p.m. provided they are employed by ICAR/SAU system, either nominated by ICAR or selected for admission by any university and who opt to join at a place other than the one where working and provided further that the third degree is not from the same institute.

### 15.6 The scholarships will be admissible to students of Indian Nationality as defined in the constitution of India or persons domiciled in India, irrespective of sex, race or religion.

### 15.7 A fellow will be under the administrative control of the Dean. He/she will work under a recognised Guide on the faculty of the concerned discipline.

### 15.8 Each fellow will submit to the Dean, Post Graduate School for approval: (i) a Plan of Post Graduate Work, and (ii) an Outline of Research Work in the proforma prescribed, recommended by Advisory Committee, Professor and Head of the concerned discipline.

### 15.9 The scholarships will be effective from the date, the fellow joins the course of study at IARI.

### 15.10 A fellow will devote his/her whole time to the approved study and will not be allowed to accept or hold another appointment paid or otherwise.

### 15.11 If any residential accommodation is provided by the Institute, license fee will be payable by him in accordance with the rules of the Institute.

### 15.12 The Institute will not provide the benefits of Provident Fund to the fellow.

### 15.13 Payment of Scholarship

#### 15.13.1 The payment of scholarship will be made on receipt of the following certificates submitted by the students in the prescribed proforma circulated by the Post Graduate School:

(i) A written undertaking by the student to complete the study and research work assigned to him/her by the Guide;

(ii) A certificate that he/she is not drawing any other scholarship/fellowship.

#### 15.13.2 A scholar will not be allowed to avail any other scholarship/fellowship during the tenure of IARI scholarship. In case a candidate is already receiving any other scholarship/fellowship, it will be surrendered by him before accepting the IARI scholarship.
(i) The applications of students who have completed not more than one year of study as IARI fellows may be forwarded for grant of external scholarships/fellowship.

(ii) The students who accept external scholarships/fellowship which are available for a period shorter than the maximum period of tenability of the IARI scholarships may be granted IARI scholarships for the period of deficiency in continuation of the external scholarship/fellowship.

15.14 Extension of Scholarship/ Fellowship

An application for extension of the term of scholarship will be forwarded to the Dean, Post Graduate School through the Chairperson/Professor in the prescribed proforma (Annexure-XVII). The Dean, Post Graduate School will be the final authority to grant extension.

15.15 Termination of the Scholarship

15.15.1 The scholarship will be terminated

(i) On the date the fellow ceases to be on the rolls of the Post Graduate School.

(ii) On the date the fellow completes his/her study which may include submission of thesis, viva-voce and written examination.

(iii) On the date of sanction of the scholarship expires, whichever is earlier.

(iv) If at any time, in the opinion of the Dean, Post Graduate School, a fellow is found to be negligent in his/her work or is guilty of unbecoming conduct, with or without notice.

15.15.2 If a fellow completes his/her study before the expiry of sanctioned term of his/her scholarship, the Guide will immediately inform the Dean, Post Graduate School.

15.15.3 A fellow shall not leave the course before its completion without prior approval of the Dean, Post Graduate School.

15.15.4 A fellow will not be allowed to apply for or accept any post/other scholarship/fellowship/award during the currency of the scholarship without the permission of the Dean. If he/she is selected he/she will be relieved only after he/she has completed the study. He/she will be required to give an undertaking in the prescribed proforma (Annexure-XVIII).

15.16 Thesis

A Fellow will submit a copy of the thesis to the Dean, immediately after the final viva-voce examination is over for onward transmission to the IARI Library. The fellow will not be paid the last full month’s stipend without production of a certificate from the Professor that a copy of the thesis has been received for submission to the Dean, Post Graduate School.

The receipt of financial assistance from the IARI should be suitably acknowledged by the fellow in the thesis submitted by him.

5.17 Career

A fellow will send to the Dean, Post Graduate School particulars of the post, he/she has taken up on termination of his/her scholarship.

15.18 ICAR Fellowship

The Indian Council of Agricultural Research has a scheme of awarding Senior Research Fellowship of the value of `12,000/- per month for first two years and `14,000/- per month for third year onwards for Ph.D. students with contingent grant of `10,000/- per annum, and Junior Research Fellowship of the value of `8,640/- per month for M.Sc. students with contingent grant of `6,000/- per annum. The detailed terms and conditions of the scheme are available with the Deputy Director General (Education), Indian Council of Agricultural Research, New Delhi.
16 Utilisation of the Contingent Grant

16.1 Contingent Grant

16.1.1 The contingent grant of ₹ 10,000/- per academic year will be paid to the senior fellows towards the cost of experimental material, books required for the study as prescribed by the Chairperson/Professor of the student and for preparation of thesis and study tour. The students holding junior fellowship will be eligible for the payment of contingent grant of ₹ 6,000/- per academic year for meeting the expenditure on study tours, experimental materials, purchases of books and preparation of thesis.

16.1.2 While utilising the contingent grant due care should be taken to keep adequate provision for the purchase of recommended books, thesis preparation and purchase of special chemicals etc. In this context, the following guidelines may be observed:

**Ph.D. Purpose**

1st year Purchase of books and special chemicals.

2nd year Purchase of books and special chemicals.

3rd year Purchase of books, special chemicals and thesis preparation.

**M. Sc.**

1st year Purchase of books and special chemicals.

2nd year Purchase of books, special chemicals and thesis preparation.

Note: The contingent grant can be utilised for general requirement of students in the Division in consultation with the Professor and Chairperson of the concerned student keeping in view the availability of funds and the individual student’s own requirements for books, tour, thesis preparation and other contingent expenditure on special chemicals etc.

16.1.3 In the beginning of each academic year, Post Graduate School will send an expenditure statement showing the amounts spent under the contingent grant and the balance amount available in respect of each student to Professor of the discipline concerned so that he can ensure that the amount is spent equitably and sufficient funds are available for preparation of the thesis.

16.1.4 In no case, the total contingent expenditure per fellow will be allowed to be more than the provision indicated in Para 16.1.1 above.

16.1.5 The contingent amount left unspent at the end of the year of fellowship tenure could be spent in the subsequent year in addition to the provision for that year (subsequent year). The year for this purpose is to be reckoned from the date and/or month of award of the sanction.

16.1.6 Any tools, equipment, laboratory supplies, animals and any other items of non-consumable nature purchased out of the contingent grant for use of the fellows will become the property of the Division after the completion of his/her study.

16.1.7 On termination of fellowship, books and publications purchased out of the contingent grant will become the property of the fellow concerned.

16.1.8 The academic year for the purpose of availing of contingent grant will be reckoned from the beginning of August of the year of admission to the end of July of the following year, irrespective of the date of issue of sanction of other award.

16.1.9 Students may be provided full reimbursement of their contingent bills subject to the availability of balance in their respective accounts and sanctioned by the competent...
authority for the full tenure/extended period of their study without making proportionate deductions for the left out period after their final viva-voce examination subjected to the condition that the final bills are submitted by them to the Post Graduate School within the period of 15 days from the date of their final viva-voce examination.

16.1.10 A Division desirous of purchasing chemicals, equipment, glass apparatus etc., from out of contingent grant should procure the same in accordance with the normal procedure followed for all divisional purchases of stores item and the pre-receipted bills be sent to the Dean's Officer after recording the prescribed certificates on the body of the bills as in the case of normal divisional purchases. The expenditure involved in such cases should be deducted against respective student's contingent grant and the particulars of the student for whom the item has been purchased by the Division should be indicated on the body of the bill to enable the Dean's office to book the expenditure accordingly in the student's individual ledger.

16.1.11 The Post Graduate students may be permitted to have their field experiments/trials etc. done on contractual basis in case of non availability of departmental staff. However, the expenditure on this account should be met out of the contingent grant of the concerned student.

16.1.12 The students of Agricultural Statistics and Computer Application are authorised to purchase computer consumables, such as floppy discs, computer discs, pen drives etc. worth ₹ 1,000/- per annum for M.Sc. and ₹ 1,500/- per annum for Ph.D. students.

16.2 Purchase of Books

16.2.1 Re-imbursement of expenditure towards purchase of books, publications and for preparation of their thesis from out of the contingent grant will be made only on production of vouchers/cash memos etc. in duplicate to the Dean's office after incorporating the following certificates in each copy of the vouchers/cash memo etc. by the Chairperson and Professor of the student:

(i) Certified that the amount as shown in the cash memo/paid receipt has actually been spent by me towards purchase of books/preparation of thesis/Research work/ Publication/ Registration etc. Also certified that all material for which cash memo/paid receipt is presented is in my possession.

(Signature of student with date)

OR

Certified that the material as shown in the bill/pre-receipted bill has been received by me and is in my possession and will be utilised for preparation of thesis/research work/publication/purchase of books etc. connected with my studies at IARI. Amount shown in the bill may, therefore, be paid to the firm concerned directly.

(Signature of student with date)

(ii) Certified that the amount as claimed and utilised for the purpose as shown in the voucher is an essential requirement for his/her research work and the student has purchased only the recommended items in fulfillment of his/her research work.

(Signature of the Chairperson with date)
(Signature of the Professor with date)

16.2.2 The books not related to the research or course work of the students will not be purchased from contingent grant. The students should prepare the lists of books proposed to be purchased by them and get them approved from the Professor before the books are purchased. The Professor should ensure that a uniform policy is followed in the matter of purchase of books by the students and no deviations are permitted in the selection of books.

16.2.3 Fellows are required to purchase books from bonafide booksellers only, who are members of the Delhi State Book-Sellers’ Association, the list of which is available in the IARI Library.

16.2.4 Fellows are required to produce books along with the cash memo to the Post Graduate School Officer for physical verification of books and embossing the prescribed stamp on the books.
16.2.5 The students can purchase calculators, books, Atlas, dictionary etc. prior to the date of their proposal for submission of thesis or three months before submission of thesis, whichever is earlier. Thereafter, no such claim will be entertained for reimbursement by the Post Graduate School Office.

16.2.6 As the pocket calculator is an essential requirement and will be useful to the fellows for training and research in future, there should be no objection in permitting the students to purchase pocket calculator at a cost not exceeding ₹ 500/- which they can retain with them. The student can purchase Atlas or dictionary not exceeding a total cost of ₹ 500/- for both.

16.3 TA/DA for Study Tour

16.3.1 The expenditure on study tours will be met out of the TA head of contingent grant. For journeys undertaken in this regard during the tenure of the scholarship/fellowship, the scholars/fellows will be paid travelling allowance at the following rates:

(i) For journey by rail: One IIInd class single rail fare both ways by shortest and convenient route. Reservation, sleeper and super express charges are admissible over and above the 2nd class rail fare for both study tours and for joining the Institution and return journey to home on completion of course.

(ii) Journey by road: Before or in continuation of rail journey or for journey by road between places not connected by train, TA will be paid at actual cost of road travel by public conveyance. Whenever the road journey is performed between places connected by rail, TA for the road journey will be paid at the actual cost of bus fare limited to 2nd class rail fare.

(iii) Journey by road in hill areas: Whenever a road travel is undertaken for study tours in connection with their approved course of study in hill areas only, where railway facilities do not exist, fellows will be paid TA for hill journey only at the rates equal to one actual single fare by public bus or ₹ 0.50 per kilometer or journey by motor cycle/scooter.

16.3.2 Return journey ticket wherever admissible should be availed of on all study tours.

16.3.3 Scholars/fellows are required to indicate ticket number of their railway journey, while submitting their TA bills and are also required to produce tickets, in support of their actual bus journey wherever claimed for in hill areas and in plains.

16.3.4 No travelling allowance will be admissible for journey undertaken within 8 km radius of this Institute.

16.3.5 The scholars/fellows will be entitled for daily allowance @ ₹ 50/- per day limited to 50 days in a year.

16.3.6 The students can avail reimbursement of TA for study tour subject to a maximum ceiling of ₹ 2,000/- per year on production of original tickets. Considering that the monetary ceiling of ₹ 2,000/- may not be sufficient in some cases where intensive study tour is required by the students in some disciplines like Agricultural Economics and Agricultural Extension etc., the power to approve reimbursement of expenditure on TA/DA to the students out of their contingent grant may be exercised by the Dean on the merit of the case.

16.4 Payment of Fees

16.4.1 No fees and other charges of the Institute which are required to be paid by the fellows would be met from the contingent grant.

16.4.2 However, the scholarship/fellowship holders will get reimbursement of registration fee for attending/participation in Symposium organized by Scientific Societies/International Congresses/Seminar etc. up to ceiling of ₹ 500/- and ₹ 1,000/- in respect of M.Sc. and Ph.D. students respectively in an academic year. However, in any case, the registration fee reimbursable during the entire period of tenure of scholarship/fellowship would not exceed ₹ 500/- and ₹ 1,000/- in respect of M.Sc. and Ph.D. students respectively. This reimbursement will be admissible only if the full justification for attending the seminar/conference etc. has been furnished and approval of the Dean obtained in advance.
16.5 Preparation of Thesis

16.5.1 A maximum of ₹ 5,000/- for Ph.D. and ₹ 2,500/- for M.Sc. students holding scholarship/fellowship other than ICAR Fellowship will be available for preparation of thesis during the tenure of the scholarship/fellowship. However, the ICAR Junior/Senior Fellowship holders will be eligible to get reimbursement of ₹ 2,500/- only for preparation of their thesis.

16.5.2 The contingent grant is not intended for meeting the expenditure on furniture, payment of labour charges for field experiments etc. Items like towels, buckets, locks, pen etc are not covered as research items and cannot be purchased out of contingent grant. Essential photocopies claims up to a maximum of ₹ 1,000/- and stationery items up to ₹ 1,000/- in the tenure of studies is reimbursable to the student from their contingency.

According to ICAR guidelines, the contingent grant will be used for supporting purchase of chemicals, glassware and other items required for research work. A maximum of ₹ 2,500/- in the first year could be utilised for purchase of books and ₹ 2,500/- for preparation of thesis. The remaining contingent grant would exclusively be utilized for contingency connected with conduct of research work.
Introduction

The IARI Library was established at Pusa (Bihar) in 1905 with a small collection of 5,000 publications donated by the Department of Agriculture, Government of India. After the devastating earthquake in 1934, the Institute was shifted along with the Library to its present premises in New Delhi; where it was inaugurated in 1936 by Lord Linlithgow, the then Viceroy and Governor of India, and the Library was named after him as Linlithgow Library.

The Library has been keeping pace for the last 105 years with the ever-growing needs of the scientific and student community at National and International level. It has been regarded as one of the 10 best agro-biological libraries of the world and assumed the de-facto status of National Agricultural Library of India.

There is no library parallel to IARI library in the country so far as rare and classical literature is concerned. The oldest English journal available in the Library dates back to 1665-66 named Philosophical Transactions of Royal Society of London, and the oldest book available is of 1597 Herbal General History of Plants by Gerald. Several other old books are available which give an account of agriculture in ancient India. The Library functions as the depository of FAO and CGIAR Institutes’ publications.

National and International Linkages

Library is the member of DELNET (Developing library Network) and contributing in the databases of DELNET. Library is also participating in resource sharing within member libraries.

Library is member of AGLINET (Agricultural Library Network) of FAO Rome. Library is contributing in document delivery service.

Currently Library is also participating in Worldcat through OCLC (On-line Computer Library Centre). A network of 71,000 libraries of 212 countries of the world to share cataloguing and resources.

Collection

It has 6 lakh publications including 1 lakh books/monographs, 3,50,000 journal volumes, 45,000 bulletins, 15,000 post-graduate thesis, 10,000 pamphlets, 30,000 news clippings, 30,000 reports, and other reference materials. The Library has 10,500 journals/serials through subscription, gifts and exchanges. Exchange relations have been maintained with 185 institutions/parties globally and nationally by sending annual reports/ Indian journals and society publications.

Library is procuring 7 International Agricultural Databases, on-line journals and have links with publisher's databases.

Timings

The library services of the Institute are available throughout the year (except three National holidays and Holi festival). The timings of the Library services are as under:

Working days: 08:30 A.M. to 08.30 P.M.
Gazetted holidays/ 2nd Saturdays/ Sunday : 09:00 A.M. to 01.00 P.M.

Normal Working Days and Hours

• The Library remains open on all working days from 8.30 AM to 8.30 PM. Stack rooms are
closed one hour before the closing time of the Library.

- On Sundays, second Saturdays and other gazetted holidays, the reading rooms alone shall be kept open from 9 AM to 1.00 PM in summer as well as in winter.
- Issue counter for loan and return of books and serials shall remain open only from 8.30 AM to 8.00 PM in winter and from 8.30 AM to 8.00 PM in summer on all working days. Overnight loan of text books to students shall be issued only from 7 PM till 15 minutes before closing time of the library on working days and from 12.30 PM to 1 PM on holidays.
- The Library remains completely closed on 26th January (Republic Day), 15th August (Independence Day), 2nd October (Mahatma Gandhi’s birthday) and on the day of ‘Holi’ festival.

**Do’s and Don’ts of the Library**

- Publications taken out on loan are subject to check by the person on duty at the entrance gate.
- All personal belongings, such as umbrellas, hats, walking sticks, books and files, briefcase and hand bags etc., shall be kept near the counter at a place provided for the purpose. Only loose sheets, cards and note books shall be allowed to be brought inside the library.
- Smoking is strictly prohibited in the reading rooms and in the stack rooms.
- No one shall remove any publication outside the library except in accordance with the rules regulating the issues of publications on loan.
- No other object, belongings to the library shall be removed out of its premises except with the written permission of the Head Library Services.
- No one shall, whether for the purpose of correcting an error or otherwise, make any markings whatsoever in publications belonging to the library, underline words and sentences therein, dog-ear pages or otherwise damage or mutilate them in any manner.

**Loss and Damage of Publications**

- If any publication is lost or disfigured or if any page and picture is removed by the reader, he/she must replace it by a new copy or by a photocopy on the discretion of library authorities. If he/she fails to do so, he/she shall be required to pay the cost plus any fine that may be levied by the authorities.
- The borrowers shall examine the books and periodicals at the time of receiving them. When detected, the last borrower shall be held responsible for any damage.

**Members and Users of the Library**

- All bonafide research workers and regular students of this Institute shall be eligible to become members of the library.
- All the research workers and technical staff (from the level of T-I) shall be eligible to get books on loan.
- Honorary research workers, research fellows and students shall be eligible to get books on loan either on their making the prescribed deposit and fulfilling other formalities with the cashier of the Institute or the recommending Head of the Division shall take the responsibility for obtaining ‘no due certificate’ from the library at the time of his/her leaving the Institute.
- All bonafide members of the library shall be provided with the prescribed library tickets for borrowing publications.
- The Library ticket holders shall be exclusively responsible for loss of the ticket and for its misuse by others. In case of loss of the ticket, the holders shall report the matter to the library and apply for its replacement after depositing ₹ 5.00 per ticket.
- Research staff, students and research fellows shall be issued 5 readers ticket, and technical staff in category-III, II and I will get five, three and one readers tickets, respectively.
- Bonafide research workers belonging to other organisations shall be given only consultation facilities on their applying through the Head of the respective organizations.
- Bonafide scientists and research workers of other Institutes/ Organizations shall be enrolled as special members of the library for getting books on loan subject to the
conditions that: (i) the membership application is forwarded by the Head of the respective Institution/Organization, (ii) deposit ₹ 500/- as security money with the cashier of the Institute, and (iii) two permanent staff members of IARI equivalent to gazetted rank shall stand surety for the applicant. The person thus enrolled shall be entitled for loan of only one publication at a time.

Loan and Late Fee

- Publications shall be issued only against the library card issued to members.
- Faculty members shall get one book on loan for teaching purpose and from “Text Books Section” books are given on loan for three months for consultation and overnight loan from reference collection.
- Books taken out on loan shall be retained for a maximum period of 14 days only but the books are liable to be recalled at any time. After due date, a late fee as prescribed shall be charged per day per book.
- Serials (periodicals, annual reports and bulletins) taken out on loan shall be retained for a maximum of two days only but these are liable to be recalled at any time. After the due date, a late fee of Re. 1/- shall be charged per day per publication.
- The late fee amount in cash shall be collected at the counter. A borrower shall not be allowed to borrow books again unless late fee assessed has been paid.
- Text books reserved for Post Graduate Students for overnight loan shall be issued after 7 PM on working days and 12.30 PM on holidays. These must be returned the following day within the first hour of opening the library. Failure to return the book taken on loan within the time prescribed above shall subject the students to a fine as prescribed. This rule shall be rigidly enforced. Persistent abuse of these privileges will attract disciplinary action.
- Faculty members shall be entitled to borrow one book at a time from Text Book Section for three months for teaching purposes provided more than one copy of the book is available in this section. Books kept in any other section shall be available for 14 days and serials for 2 days at a time.
- All loan requisitions for books and serials shall be addressed to the Head, Library Services.
- Transfer of books is strictly prohibited.
- Local borrowers shall not be permitted to take books out of station except with the prior permission of the Director.
- Books from the divisional libraries shall not ordinarily be available for loan to those outside the division except with the special permission of the Head of the Division concerned.
- Publications under the following categories shall not be issued on loan: (i) Reference publications, such as dictionaries, encyclopedias, hand books, yearbooks, atlases, maps and gazetteers, abstracting and indexing journals, manuals and thesis and publications stamped as ‘Reference’, (ii) Publications in damaged and dilapidated condition, (iii) Loose issues of serials, and (iv) Publications kept in closed sequence and such other books as have gone out of print or are not easily replaceable.
- Publications more than 20 years old and unbound issues of periodicals shall not be issued on loan except at the discretion of the Head, Library Services under special circumstances.
- Subject to the rule as above, publications excepting those issued by the Institute and Indian Council of Agricultural Research, with the permission of the Head, Library Services may be loaned to the bonafide research workers under the central and state governments, universities and other institutions on their sending requisitions through respective librarians Head of Offices. All such requisitions shall be addressed to the Head, Library Services, IARI, New Delhi.
- Outside borrowers shall have to bear the transit and packing charges both ways. The borrower shall have to remit postal and
packing charges in advance. The packing charges shall be calculated @ 12% of the cost of postage.

- An infringement of the above rules shall render the defaulter liable to be deprived of the privileges of using the library or to such other disciplinary measures as may be determined by the Director, IARI.

Library Automation

The library started its computerization activities in 1993. The Library has crossed the threshold of automation by creating database of 1,61,931 books, 6,730 serial titles and 14,202 theses in electronic form using library automation software “Libsys” which is accessible on LAN. Computerized circulation system is started from 2004. The Library is providing literature search from CD-Rom since 1990 from International Agricultural databases. 27 Rare Books and 43,00,000 pages of 6,250 publications published before 1950 which are not covered under Copyright Act were scanned and can be accessed on the C-DAC website.

Student’s Facility Unit

The Library has Student Facility Unit with 10 Pentium IV terminals having internet connectivity to access internet, e-mail and literature search.

Wi-Fi Connectivity in Reading Halls

Reading halls have Wi-Fi connectivity with 10 Pentium IV terminals. Students can also bring their Laptop for research work.

Scientist Facility Wing

The scientists of the Institute can use the terminals of training cell for accessing Internet and other services of the Library.

Training Cell

The Library has training cell with a provision of 24 computers with internet connectivity and one LCD Projector to organize training, examinations of IARI and practicals of AIS Course.

GRIS Project

AGRIS (International Information System of Agricultural Science and Technology) is a database of FAO, in which, Library was declared as one of the input centre for National Agricultural Research Database (NARD) under AGRIS Project. The Library was assigned the job of indexing articles with abstract from 10 most important Indian journals.

Services

Inter-Library Loan: Library provides Inter Library Loan services to different institutions on demand by the post-graduate students, research scholars and scientists. The publications, which are not available in the collection of the Library are arranged under Inter-Library Loan Facility.

Reference Service: Library is giving reference services through phone, e-mail and personally.

Document Delivery: Document Delivery Service is given under CeRA and Inter-Library Loan through e-mail by scanning the articles or through post by sending the photocopy of the articles.

Bibliographic services: On demand, library is compiling subject bibliographies.

Documentation services: The Library has unique collection on Indian Agriculture by Indian authors entitled as “Bibliography of Indian Agriculture from 1944-2000” in card format and CDs.

CD-ROM database Searches: This service was started in 1990 from 7 International Agricultural Databases on LAN.

Reprographic Services: The Library has well equipped reprographic Unit with latest equipments. The scientists have been given the facility of getting photocopy 200 pages free of cost. Private photocopying facility is also available from 9.30 AM to 7.00 PM at the rate of 40 paisha per page on all working days.

Current Awareness Services: List of additions, New Arrivals, Current Contents are provided through IARI Intranet page.

CD-Rom Workstation

The Library has CD-Rom Workstation with 10 terminals Pentium IV which are attached with
Linux server. Seven International Databases, namely AGRIS, AGRICOLA, CAB, BIOTECHNOLOGY, ZOOLOGICAL RECORDS, FSTA are procured in this section and accessible on LAN. This service is free for IARI students and scientists, whereas a nominal charge is taken from outside users @ ₹ 50 per hour as consultation charges and Re. 1/- per reference for downloading. E-mail requests are also entertained after getting payment.

Rashtriya Krishi Hindi Pustakalya

In compliance with the directions of the Parliamentary Language Committee in the year 1989, the Rashtriya Krishi Hindi Pustakalya was established at the Ist Floor of the Annexe Building of the Library. Its present collection is approximately 7000 publications.

C-DAC Project

A memorandum was signed with C-DAC (Ministry of Information Technology) and IARI on 4th September 2004 to digitize old documents. About 43,00,000 pages of 6,250 publications published before 1950 which were not covered under Copyright Act were scanned and digitized, which can be accessed through the C-DAC website.

Consortium for e-Resources in Agriculture

A sub-project under NAIP titled ‘Consortium for e-Resources in Agriculture’ was launched on April 30, 2008 at IARI, New Delhi. The main objective of the project is to provide on-line access of journal in 123 institution (including 40 agricultural universities) under the National Agricultural Research System (NARS) for enhancing research capabilities and output. Nearly 2000 journals are available full text online from six publishers and abstracts of nearly 4000 journals are available. In addition to on-line access, the library is providing document delivery services to 123 institutions including SAUs under NARS.

Krishi Prabha: Indian Agricultural Doctoral Dissertations Repository

Under this project theses submitted to all the agricultural universities/deemed universities were digitized full text from 2000 onwards and made available to all the stakeholders through internet. Metadata, abstracts and full text will be made available over internet through IP address. IARI theses submitted after 2000 can be accessed online through LAN with full text. Theses of current three years will be kept in closed sequence.

e-Granth

“Strengthening of digital library and information management under NARS (e-Granth)” is sub-component of ICDS of component-I of NAIP. Twelve Libraries of ICAR Institutes and SAUs are consortia partners in this project in which IARI is a lead centre. Main objectives of this project are:

- To create online public access catalogue (OPAC) under “Indian Agriculture Research Group Catalogues” of all 12 library resources with Online Computer Library Center (OCLC) partnership.
- To digitize important institutional repositories (Limited to IARI, IVRI, UAS, Bangalore) including rare books and old journals and make them open access under NARS.
- To strengthen capacity building for library and information management system (Open to all libraries of NARS).

IARI Library has also to play key role in the project because IARI is a Lead Centre and it is decided that Coordinating centre will be established in IARI Library. The work has already been started for cataloguing in world catalogue through OCLC. Retro conversion of existing database in OCLC platform is also under process. IARI Library is also selected to digitize important institutional repositories including old and rare publications.
18 The Students’ Hostels

18.1 General

18.1.1 There are seven hostels for the residence of post-graduate students. Vasant, Hemant, Shishir, Sharad and Grishm hostels are for male students, Saraswati for married students and Varsha hostel is exclusively earmarked for female students. The general management of hostels is vested in the Master of Halls of Residences, under the overall supervision and guidance of the Dean. The Master of Halls of Residences is assisted by Wardens (including a lady Warden), one Asstt. Warden and also by Student Prefects. The rule for residence in the hostels are given in the succeeding paragraphs. ‘Hostel’ would mean any residential accommodation provided by the IARI to a student on rolls, including Married Student’s Apartments.

18.1.2 (i) Limited Hostel accommodation is available at IARI. Residence in hostels is subject to the availability of accommodation. Hostel stay may be restricted to maximum period of 2 years for M.Sc./M.Tech. (3 years for non-agriculture students) and 3½ years for Ph.D. students. The departmental candidates will be eligible for hostel accommodation provided they have not been allotted IARI accommodation or do not have their own houses in Delhi in his/her own name or that of his/her spouse.

(ii) The hostel charges shall be liable to change from time to time with the approval of the competent authority.

(iii) Without prejudice to the generality of the foregoing clause (i), the following principles shall be adopted in making allotment of the available accommodation to the Post Graduate students:

(a) Locally residing students shall only be provided accommodation in the students’ Hostel unless all those coming from outside Delhi have been provided accommodation at the prescribed scale in the Hostels meant for them;

(b) After the students coming from outside have all been accommodated in the Hostel(s) meant for them, local residents may be allotted accommodation subject to availability as per the following criteria:

(i) Those admitted in an earlier year shall be treated as senior to those admitted in a later year;

(ii) Amongst those admitted in the same year, those living at a more distant place (ordinarily as per the address declared in their applications for admission) from the campus, shall receive preference. Regarding any question as to the relative distance of two or more places from the Campus, the Dean's decision shall be the final;

(iii) The MoHR may, in exceptional cases and for reasons to be recorded allot hostel accommodation to any student in relaxation of these principles. All such cases shall be reported to the Standing Committee on Students’ Problems & Discipline, Welfare Board and Residences.

18.1.3 The students residing in the hostels shall be required to abide by the current hostel rules and other instructions issued by the hostel authorities from time to time. Any breach of hostel rules and of such instructions will render a student liable to disciplinary action.
18.1.4 On admission, each student shall deposit in the Post Graduate School Office the prescribed caution money for residence in the hostel. The allotment of rooms shall be made by the Master of Halls of Residences on receipt of memorandum of admission from the Dean's Office. No change of rooms shall be allowed without prior permission of the Master of Halls of Residences.

18.1.5 Students shall be required to check the furniture, fixtures etc. provided in the rooms allotted to them. They shall make proper acknowledgement of receipt of these articles by signing in a prescribed inventory maintained in the hostel office and shall be responsible for their safe custody. No item of furniture or any part thereof shall be moved from one room to another room or one part of the hostel to the other without the written permission of the Master of Halls of Residences.

18.2 Attendance

18.2.1 The gates of the Hostels shall be closed at 10.30 PM during summer and 10.00 PM during winter, and will be opened at 5.00 AM during summer and 6 AM during winter.

18.2.2 Students shall not remain absent from their rooms after 10.00 PM in winter and 10.30 PM in summer without prior permission of the Master of Halls of Residences. Late comers shall be required to sign in a separate register maintained for the purpose.

18.2.3 A student who wants to remain away from the hostel throughout the night or for a few days should inform in writing to the Master of Halls of Residences about such absence in prescribed slips to be supplied by the hostel office for this purpose. Students remaining absent without intimation shall be doing so at their own risk and the Institute authorities shall have no responsibility for such absence. They will be punished as per rule.

18.3 Leave of Absence

18.3.1 For leave of absence from hostels, students shall obtain prior permission of the Master of Halls of Residences, and the prescribed application forms for this purpose can be had from the hostel office during working hours.

18.3.2 In the case of a student remaining absent from the hostel without prior permission, the hostel authorities may open such rooms and get them vacated after preparing an inventory of the articles found in the room. However, no claim for the loss or damage to these articles shall be entertained.

18.4 Rules for Married Student’s Hostel (Saraswati Apartments)

18.4.1 Allottees of married students’ apartment shall be governed by the additional terms and conditions mentioned in Para 18.4.2 to 18.4.21.

18.4.2 A. Married foreign students:
   i) Where both husband and wife are IARI students,
   ii) Where either husband or wife is IARI student.

B. Ph.D. married students who have completed comprehensive qualifying examination:
   i) Lady married students with children but without spouse,
   ii) Others.

18.4.3 The allotment of apartment shall be made for one year and a half in the first instance and shall be extendable for another four months on the valid ground on written request from the student. The request for extension shall be made at least one month before the date of expiry of allotment.

18.4.4 The allotment shall stand automatically cancelled after 15 days of submission of thesis or taking temporary relief in case of thesis not submitted (applicable to Saraswati Apartment).

18.4.5 The allotment shall also stand cancelled if the family is away from the Apartment for more than 45 days (3 months in case of maternity).

18.4.6 Before allotment of married students hostel, the student(s) shall furnish a Marriage Certificate along with joint photograph of both husband and wife.

18.4.7 No allotment shall be made if spouse is employed. In case where the spouse is staying outside Delhi, the accommodation shall not be allotted.
18.4.8 The above condition (Para 18.4.7) will not, however, affect allotment as per Para 18.4.2 (B) (i) above.

18.4.9 The above guidelines shall apply to all married students (including those at IASRI) of the PG School. In order to check unauthorised stay in Saraswati Hostel, ₹ 100/- per day should be charged from a student for overstay for first thirty days, and thereafter ₹ 150/- per day should be charged for subsequent 30 days. The students should not be allowed to stay in the Hostels beyond the prescribed limit of 60 days as indicated above in any case.

18.4.10 For the purpose of allotment, a married student’s family shall consist of only self, spouse and child(ren), if any.

18.4.11 Married students apartment shall not be allotted to a married student whose spouse does not ordinarily stay with the student. The MoHR will satisfy himself on the need and his decision will be final. However, a female married student having child(ren) to stay with her shall be eligible for allotment.

18.4.12 An M.Sc. student has to vacate the apartment at the end of M.Sc. programme even if he/she secures admission at the Post Graduate School for Ph.D. Such students in the event of Ph.D. admission will be issued enrolment card only when they surrender the existing accommodation provided to them.

18.4.13 An allottee shall have to occupy the apartment within 15 days of the issue of the allotment offer. He/she will, however, be required to intimate the date on which he/she would occupy the apartment. The apartment will be made available only when he/she brings the family. The details of the family (name, age, sex and relation) would be required to be furnished by each allottee.

18.4.14 If a married student has already been allotted accommodation in one married students hostel, normally a change to the other hostel shall not be permitted except in exceptional circumstances to be decided by the Dean on the recommendation of the Master of Halls of Residences.

18.4.15 On allotment of married students apartment, the student shall have to vacate single seated room, if in possession, within 3 days of the occupation of married students apartment, failing which, allotment of the married students apartment shall automatically stand cancelled.

18.4.16 In the event of relief from the Post Graduate School, the students shall vacate the apartment and produce documentary evidence thereof to the Post Graduate School before relief orders are issued by the Post Graduate School.

18.4.17 The allotment of apartments shall be made for one year and six months in the first instance which shall be extendable subject to availability of accommodation for another 4 months on valid ground and on written request from the student. The request for extension shall be made at least one month before the date of expiry of allotment. Normally no extension shall be given beyond this period except in very exceptional cases to be decided by the Master of Halls of Residences strictly on academic consideration and even then the further period of extension should not exceed two months in any case. An M.Sc. student has to vacate the apartment at the end of the studies, even if he/she secures admission at the Post Graduate School for Ph.D.

18.4.18 The allotment of the apartment shall be considered on the basis of the year of admission and in case of tie, the allotment shall be made by draw of lots. On allotment, the students shall surrender their existing hostel accommodation, if any.

18.4.19 If a student’s family is sent out of Delhi for more than 45 days, the apartment shall be surrendered and the student should take the accommodation in the other hostel. For retaining the apartment for 45 days during absence of the family, the occupants shall obtain prior permission from the Master of Halls of Residences.

18.4.20 Charges: The charges for the room is subject to periodical review and revision. The charges shall be deposited in the Syndicate Bank, Pusa Branch by the 10th of every calendar month and receipt to be shown to the Post Graduate Hostel Office for record.
18.4.21 Charges for the Saraswati Apartment will be as under:

(i) ₹ 1000/- per month as hostel fee.

(ii) Actual cost of consumption of electricity.

18.4.22 Guests: Guests of students (Families) can be accommodated in specific guest rooms earmarked in Hemant, Shishir, Varsha and Sharad Hostels, on payment basis as detailed below:

<table>
<thead>
<tr>
<th>Name of Hostel</th>
<th>No. of Guest Rooms</th>
<th>Charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hemant</td>
<td>2 rooms (4 beds, two in each room)</td>
<td>₹ 75/- per day for each bed</td>
</tr>
<tr>
<td>2. Shishir</td>
<td>2 rooms (4 beds, two in each room)</td>
<td></td>
</tr>
<tr>
<td>3. Sharad</td>
<td>2 rooms (4 beds, two in each room)</td>
<td></td>
</tr>
<tr>
<td>4. Varsha (for girls)</td>
<td>2 rooms with one bed in each room</td>
<td></td>
</tr>
</tbody>
</table>

Note: (i) Normally no guest shall be allowed to stay for more than 5 days, but in exceptional/unavoidable circumstances, they can be allowed to stay for one or two days beyond 5 days by the MOHR after consideration on merit. However, such requests will be entertained subject to the availability of guest rooms.

(ii) The same guest cannot be allowed to stay for more than 5 days as guest of some other student.

(iii) No guest shall be permitted in the room of students in any hostel without proper authorization from the competent authority. In case a student is found with unauthorized guest(s) in his/her room the following guidelines shall govern the penalty:

a. He/She shall be imposed with a fine of ₹1,500/-, which shall be deducted from the fellowship of the student concerned. In case any student who is not drawing any fellowship, the amount of penalty shall be deposited by him with the Cashier, PG School within a week of the issue of order to this effect. A strict warning shall be issued with a copy to the personal file of the student concerned.

b. In case of repeat of Breach of discipline by the student(s), besides penalty indicated above, a trimester should be dropped.

c. In case of third instance of Breach of discipline, name of the student should be terminated from the rolls of the PG School.

18.4.23 Furniture: Each student shall be provided with two cots, two chairs, one table, one book rack and one gas burner with cylinder. Payment for gas shall be made by individual student. If extra items of furniture are needed, the permission of Master of Halls of Residences shall be taken and a nominal hire charge per item shall be levied for such purpose.

18.4.24 Cooking and Washing

(i) Cooking shall be done on gas burners only.

(ii) Washing of utensils and crockery shall be done only in bathroom.

18.4.25 Possession and use of electrical appliances: No allottee shall possess or use any electrical appliances like heater, cooking range, immersion rods etc. in the rooms. Violation of this rule shall result in a fine of ₹ 500/-, forfeiture of the appliances and cancellation of allotment.

18.4.26 The allotment of the apartments in Saraswati hostel (married students’ apartments) is liable to be cancelled if the students do not comply with the terms and conditions of allotment.

18.4.27 The departmental students coming to headquarters from Regional Station/Sub-station of IARI for doing M.Sc./Ph.D. at this Institute shall be eligible for hostel accommodation. These students would be required to pay licence fee and also tuition fee for the period they continue to occupy the hostel accommodation.
18.5 Vacation of Rooms in the Hostel

18.5.1 No student is normally allowed to stay in the hostel during the summer vacation without the prior permission of the Master of Halls of Residences. Students desirous of staying in the Hostel during summer vacation shall pay a consolidated charge of ₹ 800/- (subject to revision) per month during the vacation in the first week of April and produce the receipt in the hostel office for record. The hostel office will send a consolidated list of students to Post Graduate School who have not paid summer vacation charges in the last week of April. Students staying in Saraswati Hostel will pay ₹ 1000/- per month during summer vacation (subject to revision).

18.5.2 Student leaving the hostel on long leave of summer vacation or proceeding to any sub-station for training must hand over the charge of their rooms to hostel office.

18.5.3 The student who have submitted their thesis may be permitted to retain hostel accommodation upto three months after the date of submission of thesis or upto seven days (15 days in case of foreign students) from the date of final viva-voce whichever is earlier on payment of water and electricity charges @ 300/- per month (subject to revision) subject to availability of hostel accommodation and provided they actually reside in the hostel. They shall not be allowed to continue in the hotel after they are relieved of studentship from the Dean's office or if their names are struck off from the roll by the Dean. Students desirous of staying in the hostel even after seven days of the completion of their viva voce shall be permitted to stay as guests for not more than 15 days.

18.5.4 While finally vacating the hostel each student must hand over the charge of the room and all hostel properties issued to him/her to the Caretaker/Assistant Caretaker and obtain a no dues certificate to the effect from the Master of Halls of Residences.

18.5.5 (i) Unless otherwise specially authorised by the Dean in any case, the allotment of hostel accommodation to a student/ex-student, as the case may be, shall stand cancelled in the following events:

(a) On expiry of a period of three months from the date of submission of thesis or seven days (15 days in the case of foreign students) from the date of holding of final viva-voce examination, whichever is earlier.

(b) On removal of name, or on relief, from the Post Graduate School.

(c) On expiry of the period of allotment or extended allotment of hostel accommodation in Married Students’ Hostel (i.e., Saraswati Apartment) as prescribed in Para 18.4.17.

(d) On proceeding on leave or training to a sub-station for a period exceeding one month.

(e) On the Dean's permission being granted to vacate hostel accommodation on his/her request.

(ii) A student/ex-student, as the case may be, whose allotment of hostel accommodation gets cancelled, in any of the circumstances mentioned in clauses (a) to (c) of the preceding sub-paragraph (1) shall be liable to pay a fine of ₹ 50/- per day of the first thirty days and thereafter ₹ 75/- per day for subsequent 30 day if the room is located in the Saraswati apartment and ₹ 20/- per day (subject to revision), if the room is located in any other PG Hostel, from the date of such cancellation of allotment, till the date on which he/she hands over, or causes the handing over the charge of hostel room and the hostel properties issued to him/her in the manner prescribed in Para 18.5.4 or on his/her failure to do so till the date of recovery of possession by other means.

(iii) An ex-student, who after appearing at the final viva-voce examination has been allowed to stay as a guest under rule 18.5.3, shall pay room charges (inclusive of water and electricity charges) @ ₹ 75/- per day if staying in any PG Students Hostels, which shall not exceed 15 days in any case.

If a student retains possession of the hostel room without authorisation by the Master of Halls of Residences during the summer vacation or while proceeding on leave or to a sub-station for training, he/she shall be liable...
to a pay a fine of ₹5/- per day (subject to revision) for the entire period of such vacation.

(v) In case of violation of hostel rules the matter will be referred to the Hostel Disciplinary Committee which will be constituted in each case by the Dean. In this Committee, the Master of Halls of Residences (MOHR) and Registrar will be permanent members and two senior faculty members will be nominated as Chairperson and another member. The Committee shall submit the report to the Dean.

18.5.6 If a student/ex-student whose allotment of hostel accommodation gets cancelled in any of the circumstances mentioned in Para 18.5.5 fails to vacate the hostel room and return the hostel property in his/her possession within 48 hours of such cancellation, the Master of Halls of Residences (notwithstanding the provision for the payment of overstayal charges by the student/ex-student) may at any time thereafter take appropriate steps with the help of the Hostel/Security staff and the Police, where necessary, to open the Hostel room and get it vacated after preparing an inventory of the articles found in the room or take such other steps as they may deem necessary to recover the possession of the hostel room and the hostel property from him/her.

18.5.7 If in the opinion of the Dean, circumstances exist in which he considers that the stay of any student or students in the Hostel is not desirable in public interest, he may without assigning any reasons cancel the allotment of hostel accommodation of such student/students, and require the student(s) concerned to vacate the hostel forthwith and it shall be incumbent upon the student(s) concerned in such an event to hand over vacant possession of the hostel room and return the hostel property on the same day or within such period of time as may have been specifically mentioned in the Dean's order. Any violation of such orders, apart from attracting the imposition of the overstayal charges at the rates prescribed in Para 18.5.5(2) shall constitute misconduct on the part of such student(s) and render him/them liable to disciplinary action. The Dean may further cause the recovery of the possession of the room(s) concerned together with the articles of hostel property issued to/in the possession of such student(s) in the manner prescribed in Para 18.5.6.

18.5.8 A student, aggrieved by the cancellation of his/her allotment and the consequential liability of payment of overstayal charges disciplinary action under Para 18.5.5, 18.5.6 and 18.5.7 supra may prefer an appeal to Chairman of the Academic Council. However, the filing of an appeal shall not unless the Chairman of the Academic Council specifically orders otherwise, imply the stayal of the orders appealed against, not per se absolve the appellant(s) from the panel consequences thereof before or after the disposal of such appeal.

18.5.9 The following further guidelines shall be observed regarding the allotment of hostel accommodation to guests:

(i) First preference shall be given to bonafide guests sponsored by students and participants of short-term training programme organised by this Institute; person officially sponsored by other sister associations/universities shall be given the next preference. No allotment shall normally be made to persons who come unannounced and seek accommodation at the eleventh hour. As far as possible, only those who have prior reservations shall be admitted to the hostels.

(ii) As far as possible, the students who seek accommodation for guests arriving late in the night, shall collect the keys in advance from the hostel office after payment of guest charges so that the guest can collect the keys from the students concerned on arrival. The students concerned are, however, responsible to get the required entries made by the guest in the guest register maintained in the hostel office.

(iii) No guests shall be admitted normally between 10 PM and 7 AM, unless there is prior intimation about their arrival.

(iv) A uniform pattern shall be followed by fixing the check-in and check-out time at 12 noon. Room charges will be levied from 12 noon to 12 noon on the following day.

(v) Non-Indian guests shall be required to furnish information regarding their nationality, passport number, period of stay in India etc.
(vi) The guests should furnish clearly all the relevant information prescribed in the guest register.

18.5.10 Women are not allowed in the hostel room occupied by men and men are not allowed in the rooms occupied by the women. Such visitors (women/men) may, however, be received in the visitors room or reception room ear-marked separately in each hostel. The Hostel Attendant shall call for the persons whom the visitor wishes to meet to the visitor's room itself. In the case of ladies hostel, men are not permitted to visit between 8.00 PM and 8.00 AM. A register may be maintained at the gate of each hostel and necessary entries relating to guests shall be made in this register. The hostel attendant shall be strictly instructed to enforce these rules. Any departure from these rules shall require prior approval of the Master of Halls of Residences. Any violation of these rules shall result in disciplinary action on the student(s) concerned.

Note: Lady guests should not normally be allowed to enter common rooms and dining hall of boys hostel and if any student wants to invite lady guests for lunch or dinner, prior permission of the Master of Halls of Residences should be obtained by him.

18.6 Electricity

18.6.1 Students are required to make their own arrangement for electric bulbs for their rooms. Use or possession of electric heaters or other electric appliances in the hostel rooms is not permitted. A fine of ₹ 500/- (under revision) shall be levied, the appliance confiscated for violation of this rule and cancellation of allotment.

18.6.2 Fans and lights in the rooms must be switched off before leaving the rooms.

18.7 Bicycle

18.7.1 Student shall be issued numbered tokens corresponding to their room number and no student shall be allowed to take out his/her bicycle without presenting the token at the gate. A limited supply of tokens for guests shall also be maintained and issued to bonafide guests.

18.7.2 Riding of bicycles, Scooter/Motor cycles in the corridors of the hostels is forbidden. Breach of this regulation shall render and offender liable to disciplinary action.

18.7.3 All bicycles shall be kept properly locked.

The watchmen on duty are instructed to take possession of unlocked bicycles, which shall be released only with permission of the Master of Halls of Residences.

18.8 Telephones

18.8.1 Telephones are provided in each hostel for making local calls only during specified hours which shall be notified by the Master of Halls of Residences from time to time. The use of telephone for making trunk calls is not usually permitted.

18.8.2 Students wishing to make local telephone call would be required to pay the prescribed local charges to the attendants on duty. Coupons shall be available with the telephone attendants against payment.

18.8.3 The students are not allowed to get personal telephones in their rooms.

18.9 Common Room

18.9.1 Hostel common room shall remain open from 6.00 AM to 11.00 PM.

18.9.2 Furniture and other articles from the common rooms shall not be removed under any circumstances.

18.10 Boarding Arrangements

Norms, Guidelines and Rules for Boarding Arrangement in the Hostels

I. Membership

a) The membership of the different messes run in the Post Graduate Hostel will be open to the resident students of the Post Graduate School. On admission, they will be required to pay an entry fee of not less than ₹ 30/- (non-refundable) and an advance equal to monthly charges accruing in the concerned mess (refundable after adjustment).

b) On recommendation of the Mess Secretary, the Master of Halls of Residences after
satisfying himself that inclusion of an outsider will not jeopardise the interests of the existing members, may permit non-resident IARI PG students and IARI staff members only to take their meals in the particular mess.

c) Each resident student is absolutely free to join any mess he/she likes; provided facilities are available in that mess to accommodate him. In case of difficulty, the Master of Halls of Residences should be approached. Any student who wishes to join a new mess should not have any arrears in any mess and will have to produce ‘No-Due Certificate’ from all existing messes, before the case is considered for membership in the new mess.

Note: (i) In case the mess has attained the maximum number, a priority list would need to be maintained by the Hostel office. All such applications will be submitted to Master of Halls of Residences and a copy endorsed to the Secretary of the concerned mess for priorities in the waiting list.

(ii) If a member leaves the mess in the middle of the month, the advance paid will not be disbursed pending finalisation of the accounts for the month.

d) A student will cease to be a member of the mess when:

(i) ‘No Dues’ certificate has been issued by the mess. The rules governing the mess are not abided by.

(ii) Payment is in default.

II. Organisation of the Messes

a) There will be one Mess Secretary to supervise the mess. The tenure of the Secretaryship will be only one calendar month who will act as liaison between the Master of Halls of Residences and the members and shall be competent to issue “No Dues” certificate to members. The selection of the Secretary will be made by drawing lots in the General Body Meeting which will be called every six months and except in very special circumstances such as appearing in qualifying examination or proceeding on tour, no member will refuse to accept the responsibilities.

b) The Secretary will furnish the list of members to the Master of Halls of Residences by 10th of each month.

c) The Secretary will arrange to collect the mess charges, effect purchases, ensure supply of food to members maintain the accounts and prepare the final monthly account.

d) The Secretary will also intimate the Master of Halls of Residences at the end of the month, the average charges per month for the meals. The secretary will have to display the accounts for the information and scrutiny of the members who will have free access to the vouchers for inspection, till the 10th day of the following month.

e) The Secretary will be responsible to call and preside over the general body meetings, prepare the proceedings for display or the circulation amongst the members and implement them as desired by the general body. In case, there is any vital issue or departure from the set rules, the Secretary will forward a copy of the proceedings to Master of Halls of Residences for information and necessary action.

f) General Body Meeting will be convened by the Secretary either on the last day of the month or on the first day of the following month to present the final account by the outgoing Secretary. The incoming Secretary will get the menu for the current month approved in the meeting.

g) If the term of the Secretary is to be discontinued in the middle, the general body may elect by drawl of lots any other member as Secretary.

h) (i) The cleanliness of the kitchen, stores and dining premises, will be the direct responsibility of the Secretary of the mess who will take suitable action against defaulter/mess staff.

(ii) The Secretary of the mess will be responsible for the maintenance and upkeep of the furniture and other items of stores belonging to the Institute and loaned out for the use of mess concerned. In case it is observed that
stores items issued on loan have been carelessly handled, the mess will have to bear the repairing charges. In case of closure of the mess, the facilities loaned to the mess will be handed over immediately to the Hostel office by the Secretary in whose tenure the closure of the mess comes up. Damages, if any, to stores belonging to the Institute will be evaluated and realised from all the members of the mess including the non-residents if they happen to be the members.

i) Each member of the mess shall abide by the mess rules. In case of violation, the Mess Secretary may terminate the membership of any member in consultation with the general body and the Master of Halls of Residences. The Master of Halls of Residences or his representative should be present at such general body meeting.

j) In the event of any dispute, the matter will be referred to the Master of Halls of Residences, whose decision will be a binding on all the members and employees.

k) (i) A list of employees together with their full particulars as to identity, address etc. will be maintained by the Mess Secretary in the prescribed form and a copy of this list will be supplied to the hostel office. The particulars of such employees should be got verified by the local police authorities. Any change in the employees of the mess will be reported to the hostel office immediately, and in any case not later than seven days. In case any mess servant is removed from a particular mess for some specific reason, the intimation about the same will be furnished to hostel office so that hostel administration can inform other messes and ensure that the concerned servant is not employed by any other mess. No servant will be allowed to entertain any guest in the hostels.

(ii) It will be compulsory for the mess servants to undergo quarterly medical examination to be conducted by the Institute’s Medical Officer.

(iii) All mess servants will be issued identity cards.

l) All employees of the mess will be required to abide by and obey a code of conduct prescribed by the Master of Halls of Residences and as such other instructions/orders as are issued from time to time by the hostel administration in the interest of well-being of the inmates of the various hostels.

III. General Rules

a) Each member will deposit the mess dues with Secretary by 10th of each month. The list of such members who fail to deposit the same by due date will be communicated by the Secretary to the Master of Halls of Residences who will in turn inform the Post Graduate School for taking steps to deduct the amount from the scholarship of the student/pay of staff members concerned.

b) The resident student member who obtains ‘No Dues’ certificate will not have any say in the management.

c) Persons absenting themselves for a month or more and not notifying their desire to discontinue as mess member shall continue to pay the establishment charges of the concerned mess.

d) No individual member or any group has any right on the permanent and the consumable property of the mess. Due to any reasons at any time if the mess completely dissolves, the valuation of the mess property will be done and equally distributed amongst the existing members only with the consent of the Master of Halls of Residences.

Cooking in rooms is prohibited except in the married student’s hostel. Defaulters shall be fined ₹ 100/-. 

18.11 Miscellaneous

18.11.1 Notices for the guidance of the student shall be displayed on the hostel boards. Students are advised in their own interest to read the notices regularly; ignorance of regulations and instructions shall not be an excuse for non-compliance.

18.11.2 No club or society shall be formed and no meeting, except those of the Student’s Union and
the Mess Committee, shall be held in the hostels nor shall outsiders be invited to such meetings without the permission of the Master of the Halls of Residences/Director. Facilities of the Institute and campus will not be available for meetings not approved by the Master of Halls of Residences/Director.

18.11.3 Parties or entertainment shall not be held in the hostels' premises without the permission of the Master of Halls of Residences.

18.11.4 No dogs or other pets or fire arms or personal telephone or air conditioner are permitted to be kept in the rooms.

18.11.5 The students shall keep their rooms clean and tidy. Strict cleanliness must also be observed in bathrooms, kitchen, common room and dining rooms.

18.11.6 Possession or consumption of liquor and alcoholic drinks within the hostel premises is strictly prohibited.

18.11.7 All cases of illness must be reported immediately to the Wardens/Assistant Warden/Caretaker/Assistant Caretakers. In case of serious illness, the Master of Halls of Residences must be informed at once.

18.11.8 Students must not incur any debts. The hostel authorities shall not be responsible for any debts or dues to hostel messes, canteens etc., incurred by the student.
Article 1. Name

The Union will be called “The Post Graduate School Students' Union” (hereafter referred to as PGSSU) after the name of the institution, the Post Graduate School of the Indian Agricultural Research Institute, New Delhi.

Article 2. Aims

The following are the aims and objectives of the PGSSU:

1. To inculcate a spirit of fellow-feeling and a mutual contact among the members.
2. To promote the social and cultural welfare of the members and to raise the tempo of athletic activities in the Post Graduate School.
3. To encourage the intellectual development of the members.
4. To arouse among the members a spirit of social service.
5. To provide an opportunity to the members to train themselves in the art of self-government and group leadership.
6. To promote the consciousness of the members regarding the aims and working of various national and international student organisations and to represent the Post Graduate School students' body on the national as well as international plane.
7. To find out immediate solution for all such problems as may jeopardise the common interest of the members by meetings, discussions and making suggestions, if necessary, to the concerned authorities.
8. To promote the establishment of close relations between the students and faculty of the Post Graduate School.
9. To maintain contacts with the ex-alumni of the Post Graduate School and Associates of the IARI, New Delhi.

Article 3. Activities

The above mentioned objectives shall be met by organising various literary and cultural activities, such as debates, film shows, essay writing competitions, educational trips, sports and games and any other items consistent with the objectives, provided that such subjects, which are likely to offend any member on religious and moral grounds and result in national and emotional disintegration or which have been disallowed by Patron shall not be discussed during the activities of the PGSSU.

Article 4. Clubs within PGSSU

With the concurrence of the General Body Meeting special groups like photography, drama, music clubs, etc. may be organised.

Article 5. Patron

The Director of the Indian Agricultural Research Institute, New Delhi shall be the Chief Patron and the Dean and Joint Director (Education) shall be the Patron of the PGSSU.

Article 6. Membership

1. Any person who is admitted to the Post Graduate School as an M.Sc./M.Tech. or Ph.D. student will automatically become a member of the PGSSU. “Departmental” students of the Institute are also eligible for the membership of the PGSSU.
2. Associate member: Any member of the staff of the Indian Agricultural Research Institute, New Delhi would be eligible as an associate member. Associate member shall not have the right to vote.

No person who is not a full member or an associate member of the PGSSU shall make use of the recreational and other amenities in the Post Graduate Students’ Hostel.

Article 7. Subscription

Each member shall pay a sum of ₹ 300/- and each associate member a sum of ₹ 40/- as annual subscription (subject to revision). For this purpose the year shall be the same as the academic year of the Post Graduate School. Full subscription shall be payable for an academic year.

Article 8. General Body

The members and the associate members of the Union shall constitute the General Body of the Union. The General Body shall be the supreme governing body of the Union.

Article 9. Executive Committee

The Executive Committee of the PGSSU will comprise the following elected officers:

(i) President
(ii) Vice-President (Girl)
(iii) General Secretary
(iv) Games and Sports Secretary
(v) Finance Secretary
(vi) Social and Cultural Secretary
(vii) The Student Representative to Academic Council will act as the ex-officio member and attend all the Executive Committee meetings as ex-officio member.
(viii) Five Class Representatives: One each from first and second year. M.Sc. students and one each from the first, second and third year Ph.D. students.
(ix) Literary Secretary (Girl)
(x) Alumni Secretary
(xi) Career Counseling and Placement Secretary

The President will, in addition, have the discretion to co-opt a maximum of two students on the Executive Committee, but the co-opted members shall not have right to vote.

The Executive Committee will function in collective manner with the members being responsible to the President in all matters. The General Secretary will function as the Principal Executive of the Committee in day-to-day management of the Union affairs. The duties assigned to the office bearers by the Executive Committee will be placed on record in the Union office for guidance.

Article 10. Functions of the General Body

1. Every member of the General Body, subject to article 9, shall have the right to vote at elections of the Union Executive and in all meetings where a vote is called for.

2. Every member of the Union shall have the right to contest elections for the Union subject to Article 6.

3. Every member of the Union shall have the right to examine the accounts, the minute books and record of the Union provided that he/she gives three days notice of his/her intention to do so to the General Secretary.

4. Every member shall have the right to ask questions in writing on any matter connected with Union and receive reply from the Union Executive.

All such questions shall be addressed to the General Secretary.

Article 11. Functions of the Executive Committee

The duties of the Executive Committee shall include:

(i) Preparation of programmes for the year, trimester-wise and to ensure their proper execution.

(ii) The programmes will be finalised after consideration of proposals made by individual
office bearers pertaining to their specific charges to pass the budget for these activities. The budget should be placed and passed in a special General Body Meeting by the simple majority of the members present. This special General Body Meeting will be called with at least three days notice.

(iii) To appoint Sub-Committee whenever necessary to help the Secretaries in the execution of their duties particularly on occasions of special importance.

(iv) To appoint delegations for representing the PGSSU in various national and international students activities.

(v) To assist the President in taking decisions on various matters so as to further strengthen the cause of the PGSSU.

Article 12. Defalcation of the Funds and the Union Property

In case a member of the Executive Committee is alleged to have committed a breach of the constitution or is charged with a serious offence, such as defalcation of funds or misappropriation of the Union property, the Union Executive shall, after investigation and with its own findings and option, forward the case to the Patron through MoHR for such action as he/she may deem fit. The member so accused will be given full opportunity to defend himself/herself. The decision of the Patron shall be the final.

Article 13. Election

1. The members of PGSSU shall elect the office bearers from among themselves for the term of a year as provided in Article 9.

2. The votes shall be non-transferable and each member will have the right to cast single vote. Associate members will have no right to vote.

3. The Patron will appoint an Election Committee headed by the Chairman (MOHR) which will conduct elections under the supervision of the Patron. The Chairman of the Election Committee shall issue notice inviting nominations at least 72 hours before the last date of accepting nomination papers. Each nomination shall be duly proposed and seconded by two separate members. The Election Committee may co-opt members to help them in the conduct of elections.

4. Only the Ph.D. students may be permitted to contest in the Election exclusively for the posts of President, Vice President and General Secretary of the PGSSU. The candidates for offices of the President and General Secretary will be students of at least one year standing in the preceding year.

5. The Chairman of the Election Committee may arrange a meeting to provide an opportunity to all the contestants to express their views before the general body. Those desirous of speaking should convey their wish in writing to the Chairman of the Election Committee at least 48 hours before the polling commences.

6. The Chairman of the Election Committee shall notify along with the date, time and place for polling, the names of the qualified candidates for the various offices as mentioned in Article 9 at least 48 hours but not more than 72 hours before the polling commences.

7. The Election shall be by secret ballot system and the candidates shall be elected by an ordinary majority. In case of a tie the decision will be made by a toss/lot.

8. The election shall be over within one month of the start of the academic session.

9. Any conflicts regarding the election shall be resolved by the Election Committee whose decision will be final.

11. After discussions, the Academic Council resolved that if no nomination is filed for any of the positions notified for PGSSU election, the Chief Patron is authorised to nominate, on the recommendation of the Dean, a student for that position in order to avoid supplementary election and for making PGSSU functional.

12. Any office falling vacant within the first trimester shall be filled on the same lines as the regular election.
13. After the first trimester if any office falls vacant the following procedure will be adopted.

(i) In case of the office of the President, the Vice-President will automatically take over as President.

(ii) For the rest of the offices of the Executive Committee, the Executive Committee shall fill up the vacancy by appointing one of the class representatives. The vacancy of class representative shall, however, be filled up by re-election from that particular class.

14. The Executive Committee shall hand over the complete charge of PGSSU accounts, goods and record to the new Executive Committee on the expiry of its tenure.

15. If no nomination is filed for any of the position of the PGSSU, the Patron is authorised to nominate on recommendation of the MoHR for their position in order to avoid supplementary election and for making PGSSU functional.

**Article 14. Meetings**

1. A meeting of the Executive committee shall be called by the President at least once a month and 33% of the membership on this Committee shall constitute the quorum, provided that the date, time and place of such meetings are notified to each member at least three days in advance.

2. An extraordinary meeting of the Executive Committee can be called at any time if at least 33% of members of this Committee give requisition for the same to the President. The quorum of such a meeting shall be 50% of the total membership of the Executive Committee.

3. A General Body meeting of PGSSU may be called if at least 25% of the members send a requisition to the President to that effect, who will call such a meeting within a week of the receipt of such a requisition. The quorum for ordinary general body meeting shall be constituted by 40% of the membership.

4. All the members of the Executive Committee shall be present in all its meetings and in the meetings of General Body of the PGSSU. If they have to be unavoidably absent, they shall always inform the President in writing before the commencement of a meeting. If a member absents himself from two successive meetings of the Executive Committee without informing the President in writing he/she shall cease to be a member of the Committee.

5. Any member shall have the right to ask questions about any matter concerning the PGSSU during the General Body meeting. All questions shall be addressed to the President who may refer them to the officers concerned. If need be, the President may demand time to give answer to any particular question in the next meeting.

6. Any member of the Executive Committee shall be free to ask questions in the Executive Committee meetings and the questions shall be addressed to the President

7. A motion, if allowed by the President, shall be carried by simple majority vote.

**Article 15. Finance and Audit**

1. The Students’ Union fees paid annually by the members, associate members and any occasional donations shall contribute towards the finances of the PGSSU. The subscription shall be payable to the Dean’s Office, Post Graduate School towards the PGSSU funds.

2. The money shall be drawn by the Finance Secretary for making payments for the approved items of expenditure only when the withdrawal order is counter signed by the President or any other member of the Executive Committee appointed by the President for this purpose.

3. The President shall be entitled to incur, at a time, an expenditure of ₹ 2,000/- under extra-ordinary circumstances without the prior approval of the Executive Committee which will be absolutely essential for any expenditure exceeding the sums mentioned
above. The expenditure so incurred should be regularised by the Executive.

4. The account of the annual expenditure of the PGSSU shall be audited by a Chartered Accountant at the request of the Executive Committee towards the end of the term.

5. The Chartered Accountant shall not question the budget allocations approved by the Executive Committee.

6. The Chartered Accountant shall hand over the audit report to the Executive Committee. It shall be displayed on the notice board and published in the Post Graduate School Journal.


1. Adjournment Motion

Any adjournment motion can be moved at any time and, if duly seconded, it shall be immediately put to vote. If such a motion is duly carried, the meeting shall be adjourned.

2. Vote of No Confidence

(i) A vote of no confidence may be brought against any member of the Executive Committee (except class representatives) for violation of constitutional provisions, neglect of duty or unbecoming conduct if 20% of the members of PGSSU requisition for the same to the Patron and if the latter agrees to the validity of the grounds on which the requisition is based, he shall allow it to be moved. It shall be considered effective only when a simple majority of the members present in the General Body of the PGSSU approve it in an extraordinary meeting. The notice for such a motion shall be issued at least a week in advance of the meeting of the General Body of the PGSSU.

(ii) In case of class representatives, lack of confidence may be expressed by the class itself. In such a case at least 25% of the students of that class shall be required to send a requisition to the Patron intimating their desire for the recall of the representative. If the Patron agrees to its validity and allows the motion, he will arrange to call a class meeting and decide the issue by a simple majority vote. At least three-fourths of the members of that class shall constitute the quorum of such a meeting.

3. Amendments

The provisions of this Constitution may be amended in an extraordinary meeting of the General Body of the PGSSU by the simple majority of the members present.

4. Interpretation of the Constitution

Any dispute relating to the interpretation of the constitution shall be settled by the Chief Patron whose decision shall be final.

(Adopted in the General Body Meeting of the Post Graduate School Students' Union held on the 19th September, 1964 and amendments made from time to time)
20 The Students’ Welfare Fund

20.1 Objectives

(i) To advance loan to individual students in case of necessity arising due to delayed payment of their salary, scholarship etc.

(ii) To grant loan for purchase of a cycle /books or for any other special purpose approved on merits by the Dean and Chairman of the Students’ Welfare Fund.

(iii) To grant loan to meet the railway fare on study tour.

(iv) To grant loan in emergency conditions while the student has to go to his/her home suddenly.

(v) To grant loan to any other student’s activity deemed desirable by the Administrative Body.

(vi) To grant aid / re-imbursement to student in the event of distress/illness like accident, sudden illness, for treatment in the CGHS recognized Hospitals.

20.2 Administrative Body

The Fund will be administered by a Committee henceforth to be known as Students’ Welfare Committee and will comprise:

(i) Dean, Post Graduate School - Chairman

(ii) Registrar, Post Graduate School - Secretary and Treasurer

(iii) Officer-in-Charge, AIM Cell, PG School

(iv) Master of Halls of Residences, Post Graduate School

(v) President, Post Graduate School Students’ Union

(vi) Finance Secretary, PGSSU

(vii) AAO, PGS-II “ Treasurer

20.3 Sources

(i) Every student will pay a sum of ₹200 towards this fund at the beginning of each academic year.

(ii) Contribution from other sources acceptable to the Students’ Welfare Committee.

20.4 Operation of the Fund

(a) Sanction of the Loan

(i) Students desirous of availing this loan will have to submit their applications to the Registrar through the Master of Halls of Residences (MoHR) on a prescribed form.

(ii) Ordinarily, the amount of the loan to meet the objective 20.1 (i to v) shall not exceed ₹25,000/- for any individual student. However for objective 20.1(vi) the maximum amount of the aid / reimbursement will be determined and sanctioned by the Chairman of the Students Welfare Committee on the basis of merit of the cases and subject to availability of funds.

(iii) Normally, not more than one application for loan will be entertained from the same student during a trimester unless all the previous dues have been paid.

(iv) The Students’ Welfare Committee would ordinarily meet in the beginning of each trimester to consider the formal approval of the expenditure and loan given to the students during the previous trimester.

(v) The sanction of the loan will be initiated to the student concerned who will collect the money from the Treasurer, PG School after due acknowledgement.
(b) Deposits and withdrawals

(i) All the contributions to the fund will be deposited in any branch of a nationalised bank as Savings Bank Account.
(ii) All money transactions will be made by the Treasurer, Students’ Welfare Committee. The Bank account will be operated jointly by the Chairman and the Treasurer.

(c) Refund of the loan

(i) The students will be required to refund the loan granted as per item 20.1 (i to v) within three months from the date of receipt of the loan. In any case the student must refund the loan within six months from the date of receipt of the same, however loan must be refunded before one month submission of the thesis.
(ii) No interest will be chargeable on the loan granted.

Explanatory Note

Chairman of the Fund may, at his discretion, grant the continuing students loans, subject to the maximum and the other restrictions provided in the rules, to cover expenses on payment of mess dues and railway fare for undertaking a journey to home town at the commencement of / during the vacation.

20.5 General

(i) Abuse of the facilities granted by the Students’ Welfare Fund will render the student liable to severe disciplinary action.
(ii) Any item not covered by the above rules will be decided by the Students’ Welfare Committee whose decision will be final and binding.
21 Co-curricular and Extra-curricular Activities

21.1 Sports, Recreation and Cultural Activities

21.1.1 The Post Graduate School encourages co-curricular and extra-curricular activities outside the classroom that enrich the cultural, physical and social life of the students.

21.1.2 Spacious playgrounds are provided near the students’ hostels and necessary facilities exist for various outdoor games and athletic events like Tennis/Badminton courts and Gymnasium are also available for the students in the ladies’ and men's hostel separately. There are facilities also for indoor games in each hostel.

21.1.3 There is a Students' Sports Fund to which every student subscribes at the beginning of each year a sum of ₹ 200/-. Besides the students also subscribe annually ₹ 100/- as PGSS Union Magazine fee. The amounts so collected are used for improving sports facilities and promoting literary activities amongst the students. These funds are administered by the Sports Fund Committee consisting of the following:

(i) Master of Halls of Residences  Chairman
(ii) All Wardens  Member
(iii) President, PGSSU  Member
(iv) Literary Secretary, PGSSU  Member
(v) Sports Secretary, PGSSU  Member-Secretary

The accounts and records of this Committee will be maintained by the Assistant, (Post Graduate Hostel Office) and the accounts of the fund would be audited by a nominee of the Chief Finance and Accounts Officer of the Directorate.

21.2 Matching Grant

A matching grant of ₹ 50,000/- per year will be made available for sports, cultural and literary activities of the students to the Master of Halls of Residences.

21.3 Health

A qualified Medical Officer-in-charge of the Institute's Dispensary looks after the health of the students. The Medical Officer is assisted by another qualified Doctor and a staff nurse. The Medical Officer resides in the Institute’s campus and is thus available not only during the day, but in terms of emergency during the night as well. The medical service is provided free to all students. Two Doctors, one male and one female are essentially deployed to cater the need of the students.

21.4 Lady Students’ Adviser

An honorary “Lady Students’ Adviser” is nominated by the Dean to look after the welfare and needs of lady students.

21.5 Foreign Students’ Adviser

An honorary “Foreign Students' Adviser” is nominated by the Dean to look after the special problems of foreign students including general advise regarding Post Graduate School procedures, and social and cultural life. A Hospitality Committee functions under the Chairmanship of the Foreign Students’ Adviser to look after the comfort of foreign students.
22 Short-term Training Courses

22.1 Besides the regular post-graduate courses leading to the award of M.Sc./M.Tech. and Ph.D. degrees, the Institute also offers facilities for refresher courses and short-term training courses in specific specialised subjects in Agriculture for the benefit of Agricultural Scientists and Extension workers coming from State Departments, Research and Educational Institutions and other official and autonomous organisations.

*Note*: Ordinarily requests for providing training to undergraduate students of other Institutions at IARI are not accepted.

22.2 Roaster of Training programmes to be Conducted during the Year

The tentative dates and duration of the courses to be conducted by the Institute during the ensuing financial year are finalised by the first week of March every year and circulated by 15th March every year.

22.3 The Institute organises the following programmes on a regular basis.

i) Soil testing: One month duration during September in the Division of Soil Science and Agricultural Chemistry.

ii) Mushroom cultivation during October in the Division of Plant Pathology.

In addition to the above, adhoc training programmes are organised under the auspices of Centre of Advanced Studies in the Disciplines of Plant Pathology, Biotechnology, Agricultural Economics, Agricultural Extension and Biochemistry. Winter Schools and Summer Schools are also organised with financial support from ICAR and other organisations. Several short-term training programmes are organised in the various disciplines sponsored by State/Central Government departments and autonomous bodies.

22.4 Exercise for Conducting Training Programmes (as per the ICAR Guidelines based on Johl Committee’s Recommendations)

Once the subject matter(s) of the training programme(s);

(i) to define clearly the objectives of the training programme(s);

(ii) to identify the Course Director or Course Coordinator for each training programme.

The Course Director could be Director of the Institute himself or any other Principal Scientist/Senior Scientist. The selection of Course Director should be made keeping in view the aptitude of such an officer for conducting training and his competence in the subject matter of the training. Success of a training programme largely depends on the choice of a suitable Course Director.

22.5 Functions of Course Director

Upon the selection of a Course Director, he/she shall be charged with the responsibility of:

(i) Preparing a resource paper and selecting suitable team of experts/trainers for developing course content. The experts/trainers may be drawn either from the Institute, where the training programme is to be conducted or from other Institutes or even from outside the ICAR System. Merit of the candidate for training assignment shall be the sole criterion for selection. However, no expert/trainer shall be allocated more than 3 lectures.

(ii) Entrusting each trainer/expert with the developing of specific course contents pertaining to his part of the training.
(iii) Preparing a schedule of training programme in consultation with fellow trainers/experts and fixing time for each item included in the training programme.

(iv) Getting prepared from the fellow trainers/experts the assignment and evaluation papers for getting proper feedback from the trainees.

(v) Preparing a tentative budget for the training course. This estimate shall also include overhead charges.

(vi) Preparing a brochure of the training programme outlining its objectives, salient features, faculty members, course fee, eligibility conditions for admission, duration of the course, date of commencement of the course, medium of instruction, and arrangements for boarding and lodging of the trainees.

(vii) Selection of suitable candidates for admission from amongst those who are nominated.

(viii) Submission of course material, list of trainees, brochure, etc. for approval of the Director.

22.6 Conditions of Eligibility for Admission

Minimum level of academic attainments and experience or official status of the trainee should be decided in advance. This is necessary to ensure that the trainee understands the contents of the teaching and is able to interact not only with the fellow trainees but also with the trainers/experts imparting the training.

22.7 Trainees Should Form a Homogeneous Group

As far as possible, the trainees should form a homogeneous group with respect to basic qualifications, experience, knowledge base.

22.8 Number of Trainees in a Class

The number of trainees in a class should not exceed 20-30, with a minimum of 5.

22.9 Selection of Trainees

In case where the number of applicants for admission to the training course exceeds the prescribed maximum of 30, the selection of trainees should be made on the basis of fair, objective and unbiased criteria.

22.10 Selection of Training Centre

The selected training centre must have facilities of a classroom, laboratory, library, farm, etc. wherever necessary apart from hostel for boarding and lodging of trainees.

22.11 Boarding and Lodging

Boarding and lodging of trainees is compulsory in a hostel. This is necessary to ensure punctuality in attendance, informal discussion and interaction amongst trainees, or listen to special lectures as also to have enough time for completion of assignment.

22.12 Budget

A tentative estimate of training costs will be prepared by the Course Director subject to approval of the Institute's Director. The budget should be prepared keeping in view the model charges which are given in Para 1.5 and it should be ensured that all the expenses of the institution are fully covered.

The estimate should also include:

(i) Institutional charges

(ii) Honorarium for resource persons as per model charges (ICAR staff or outside experts) and honorarium to supporting staff.

(iii) Lumpsum remuneration to the Course Director as per model charges.

(iv) Boarding and lodging charges of trainees for the duration of training.

(v) Costs of transport facilities which may have to be arranged for the trainees as part of training programme and

(vi) Overhead management charges which is 30% of total costs.

22.13 Course Fee

The course fee should be worked out on the basis of estimates indicated in the preceding para
as per model charges. The course fee should be indicated clearly in the circular inviting nominations for the training. The course fee is payable in respect of each trainee in advance and in any case before the commencement of training by demand draft drawn in favour of Director of the Institute.

### 22.14 Model Training Charges

| For foreign nationals (US$)                                                                 | Actual subject to a minimum of |
| (i) Boarding and lodging                                                                  | $50/trainee/day                |
| (ii) Training material                                                                     | $100/trainee                   |
| (iii) Stationery                                                                          | $50/trainee                    |
| (iv) (a) Honorarium to resource persons                                                    | $50/lecture                    |
| (b) Honorarium to supporting staff                                                        | $10/trainee                    |
| (v) Travel costs                                                                          | $200/trainee                   |
| (vi) Honorarium to Course Director                                                        | $400/course                    |
| (vii) Institutional charges                                                                | $300/trainee                   |

The course should accommodate a maximum of 20 trainees for a duration of two weeks.

| For Indian clients                                                                          | Actual subject to a minimum of |
| (i) Boarding and lodging                                                                    | ₹ 200/trainee/day              |
| (ii) Training material                                                                      | ₹ 1,000/trainee                |
| (iii) Stationery                                                                           | ₹ 500/trainee                  |
| (iv) (a) Honorarium to resource persons (limited to three lectures only)                    | ₹ 1,000/lecture maximum        |
| (b) Honorarium to supporting staff                                                         | ₹ 200/trainee                  |
| (v) Travel costs                                                                           | ₹ 5,000/trainee                |
| (vi) Honorarium to Course Director                                                         | ₹ 5,000/course                 |
| (vii) Institutional charges                                                                 | ₹ 1,000/trainee                |

The course should accommodate a maximum of 30 trainees for a duration of two weeks.

### 22.15 Costs of Training Programme to be Worked-out Case by Case

The model charges given in the preceding paras are bulk line charges. The Director may work out training costs case by case. However, such costs should cover fully all the expenses of the institution.
22.16 Institutional Charges

Amount generated by way of institutional charges may be utilized by the Institutes for enhancement of their capability further with an intimation to the ICAR Headquarters. A separate head of account will be maintained at the Institute. The Director would have power to utilize the funds keeping the above objective in view.

22.17 Participation by Foreign Nationals in Training Programmes

Foreign nationals sponsored by FAO, USAID, IDRC, British Council, Commonwealth Secretariat, UNESCO, World Bank, IFC, UNDP, IMF or other bonafide organisations and also the candidates sponsored by their home countries could be considered for admission to the training courses conducted by the Institutes with the prior approval of the ICAR Headquarters. In the case of the candidates sponsored by the Government of India under schemes like Colombo Plan, ITEC, Cultural Exchange Programmes, the prescribed fees will be suitably reduced by excluding institutional charges wherever considered necessary by the Council. Training charges in the case of candidates sponsored under bilateral agreements could be mutually agreed/negotiated, if necessary keeping in view the commitment of the Government of India.

Application for admission to a training course from a foreign national will not be entertained directly under any circumstances.

A copy of the proforma duly completed should be forwarded to Deputy Director General (DDG) administratively concerned with the Institute where the training course is to be organised for getting approval of Director General (DG), ICAR.

22.18 Issue of a Certificate at the Conclusion of Training

The performance of each trainee shall be watched through his/her participation in discussions in the classroom, assignments, etc. Each trainee will receive a certificate at the end of the training.

22.19 Evaluation of Training by Trainees

Evaluation of the training by the trainees in respect of course contents, practical exposure and trainers’ competence will be done at the end of the course. The evaluation made by the trainees should be analysed and discussed before distribution of certificates. Action wherever considered necessary should be taken on the basis of evaluation of the training course made by the trainees.

22.20 Distribution of Honorarium

The proportionate distribution of amount by way of honorarium to Course Director (other than Director himself), trainers/experts, supporting staff, if any, will be done by the Director. In case Director himself is the Course Director, sanction of honorarium in his case will be accorded by the Council for which a self contained reference should be made by the Institute to the DDG administratively concerned with the Institute.

The specimen of proforma prescribed for submission of proposals for short-term training course is placed at Annexure-XIX.
## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 501</td>
<td>INTRODUCTION TO AGROCHEMICALS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AC 502</td>
<td>GENERAL CHEMISTRY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 503</td>
<td>LABORATORY TECHNIQUES</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>AC 506</td>
<td>AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 603</td>
<td>ADVANCED ORGANIC CHEMISTRY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 511</td>
<td>AGROCHEMICAL DECONTAMINATION AND DISPOSAL</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 504</td>
<td>AGROCHEMICAL FORMULATIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 505</td>
<td>AGROCHEMICAL REGULATION, QUALITY CONTROL AND MANAGEMENT</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AC 507</td>
<td>AGROCHEMICALS FOR DISEASE AND NEMATODE MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 508</td>
<td>AGROCHEMICALS FOR WEED MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 509</td>
<td>SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 512/ENT 512/PL. PATH 521/NEMA 513/MB 512</td>
<td>NANOTECHNOLOGY IN CROP PROTECTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 602</td>
<td>CHEMISTRY OF BIOPESTICIDES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 601</td>
<td>AGROCHEMICAL FORMULATION TECHNOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 510</td>
<td>PESTICIDE RESIDUE CHEMISTRY</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>AC 604</td>
<td>AGROCHEMICAL DYNAMICS AND ENVIRONMENTAL IMPLICATIONS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AC 605</td>
<td>ADVANCES IN AGROCHEMICALS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
AGRICULTURAL CHEMICALS

Major Field : Agricultural Chemicals

Minor Fields : Ph.D student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own. M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AC 501 INTRODUCTION TO AGROCHEMICALS (3L+0P) I

Objective
To give an overview of pesticides with reference to their classification, structure, mode of action, synthesis and formulations and pesticide residue analysis.

Theory
UNIT I
Chronological development, classification, structures, toxicity, general properties and uses.

UNIT II
Synthetic and natural agrochemicals.

UNIT III
Plant production chemicals, nitrification inhibitors, chemical hybridizing agents and hydrogels

UNIT IV
Seed coats and soil conditioners

UNIT V
Formulation analysis, quality control, safety aspects, pesticide poisoning and antidotes. Production, consumption and trade statistics of pesticides

UNIT VI
Implications in the environment and general aspects of pest and pesticide management.

Suggested Readings
Rangasamy, Seeni and Dureja, Prem. Hand Book of Pesticides, SPS India.
Objective
To acquaint the students with atomic structure, stereochemistry, nomenclature of organic compounds, their chemistry and properties.

Theory
UNIT I
Organic compounds: nomenclature, isomerism - constitutional, configurational and conformational, chirality.
UNIT II
Chemistry of terpenoids, alkaloids, flavonoids and heterocyclic compounds, carbohydrates, amino acids, proteins, nucleic acids.
UNIT III
Chemical kinetics
UNIT IV
Solutions and colligative properties
UNIT V
Surface chemistry

Practicals
General aspects and Introduction, Detection of elements in organic compounds, Detection of functional groups and preparation of their derivatives, Separation and identification of organic compounds in binary mixtures.

Suggested Readings
Objective

To acquaint students with laboratory hygiene, upkeep and maintenance of laboratory, glassware and handling of chemicals, purification and drying of solvents, distillation and chromatographic techniques.

Theory

UNIT I
Acquaintance with laboratory glassware and apparatus and laboratory safety procedures
UNIT II
Solvent purification, drying and standard solutions
UNIT III
Extraction techniques, distillation, crystallization, sublimation, separation methods
UNIT IV
Functions of common equipments – water and oil pumps, heating and cooling baths, stirrers, rotary evaporators
UNIT V
Principles of chromatography: thin layer, paper and column chromatography.
UNIT VI
pH (Hydrogen ion concentration), electrical conductivity, electrophoresis, uv-vis spectrophotometry

Practicals

Introduction to Laboratory equipment and cleaning of glassware, Assembling of simple apparatus and finding density, Purification of solvents, Crystallization, identification and sublimation, Extraction, Chromatography: Paper, Column, TLC, Preparative TLC Column, Use of pH meters, electrical conductometer, electrophoresis, UV-Vis spectrophotometer, Steam Distillation, use of stirrer and vacuum pumps.

Suggested Readings


AC. 504 AGROCHEMICAL FORMULATIONS

Objectives

To acquaint students with general aspects/types of formulation, pesticide mixtures and application technology.
Theory

UNIT I
General aspects: definition, objective, process, product spectrum, classification, formulation codes etc.

UNIT II
Solid and liquid formulations: properties, specifications and uses.

UNIT III
Pesticide mixtures: formulations, properties and uses.

UNIT IV
Application: devices and quality of deposits.

Practicals

Release of active ingredient from controlled release formulations, determination of wettability and suspensibility of wettable powder, Determination of flash point and specific gravity, viscosity, stability of emulsion concentrate and application technology.

Suggested Readings


AC 505 AGROCHEMICAL REGULATION, QUALITY CONTROL AND MANAGEMENT
(3L+0P) II

Objective

To acquaint students about the insecticide laws, national and international guidelines, fertilizer control order, quality and quality control.

Theory

UNIT I
Laws, acts and rules governing registration and regulations of agrochemical production and use.

UNIT II
EPA, WHO, FAO, JMPR, Codex committee guidelines.

UNIT III
National / international guidelines on pesticide safety.

UNIT IV
Provisions of Insecticide Act and Rules

UNIT V

UNIT VI
Management and pesticide management
Suggested Readings


AC 506 AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT (3L+1P) I

Objective

A course to deal with the chemistry, mode of action and synthesis of different classes of pesticides like organochlorines, organophosphorus, neonicotinoids, acaricides and pyrethroids.

Theory

**UNIT I**
Preparation, properties, uses, structure-activity relationship (QSAR) and acaricides (organochlorines, organophosphorus pesticides, carbamates, pyrethroids and neonicotinoids).

**UNIT II**
Insecticide synergists

**UNIT III**
Mode of action of different groups of insecticides

**UNIT IV**
Synthetic IGRs

**UNIT V**
Fumigants and other chemicals for post-harvest storage of agricultural commodities

Practicals

Preparation and characterization of DDT, DDE, and Methoxychlor, Preparation of organophosphorus insecticide-Part A –phosphorodichloridite, and Part B -phosphonate, Preparation and characterization of oxime ether, Preparation of DDVP.

Suggested Readings


Objective
To teach students about the plant diseases causing fungi and nematodes and synthetic fungicides and nematicides.

Theory
UNIT I
Preparation, properties, uses, structure-activity relationships and mode of action of major groups of fungicides.
UNIT II
Inorganics: copper, mercury and sulphur compounds. Organometallics: compounds of tin arsenic, mercury etc.
UNIT III
Organophosphorus compounds and dithiocarbamates
UNIT IV
Polyhalogenalkanes, sulphenyl compounds, phenols, quinones, carboxamides, carboximides
UNIT V
Azoles and other heterocyclics compounds
UNIT VI
Nematicides: halocarbons, organophosphorus compounds, carbamates etc.

Practicals
Preparation of Zineb (Z), Preparation, purification and characterization of dichlorophen (D), Salicylanilide (S), an organophosphorus/heterocyclic fungicide (OP), Glyodin (G) and DBCP, a nematicide (DB) and fungicide bioassay (FB).

Suggested Readings
Objective
To teach classification, chemistry, synthesis and mode of action of different classes of herbicides, plant growth regulators.

Theory
UNIT I
Preparation, properties, uses, structure-activity relationship and mode of action of phenoxy alkanoic acids, carbamates and substituted phenylureas.
UNIT II
Preparation, properties, uses, structure-activity relationship and mode of action of triazines, pyridinium compounds and dinitroanilines.
UNIT III
Preparation, properties, uses, structure-activity relationship and mode of action of sulfonylureas, imidazolinones and phenoxy-phenoxy propionicacid (fop) herbicides.
UNIT IV
Herbicide safeners
UNIT V
Synthetic plant growth regulators

Practicals
Synthesis of 2,4-D. Its m.p, TLC, NMR, Preparation of nitrosomethyl urea, preparation of diazomethane and derivatization of 2,4-D, GC of methyl derivative, Introduction to Weeds: Field visit, synthesis of propionyl chloride and its distillation, TLC, NMR, synthesis of propanil, m.p, TLC, NMR, synthesis of maleic hydrazide, m.p, TLC, NMR, Educational Tour to some agrochemical factory/ laboratory.

Suggested Readings

Objective
To acquaint students with the techniques used in separation, estimation and structure elucidation of agrochemicals.
Theory

UNIT I
Principles of chromatographic techniques like high performance thin layer chromatography, high performance liquid, gas liquid chromatography

UNIT II
Principles of instrumentation and application of spectrophotometric techniques; UV and IR

UNIT III
Principles of instrumentation and application of spectroscopic techniques of $^{13}$C and PMR

UNIT IV
Principles of instrumentation and application Mass spectrometry

UNIT V
Principles of instrumentation and application of ion-exchange chromatography, gel chromatography, flash chromatography and supercritical fluid chromatography

UNIT VI
Tandem techniques like GC-MS, LC-MS, GC-MS-IR, MS-MS, etc.

Practicals


Suggested Readings


AC 510 PESTICIDE RESIDUE CHEMISTRY (3L+2P) III

Objective

To teach students the concept of pesticide residue, planning, layout and design of experiments, instruments and techniques involved data analysis and legal issues of pesticide residue analysis.

Theory

UNIT I
Pesticide residues-concepts and toxicological significance
UNIT II
Experimental design and sampling
UNIT III
Principles of extraction and clean up from different substrates
UNIT IV
Application of spectrophotometric and chromatographic techniques estimation / detection of micro level pesticides residue, ELISA and radiotracer techniques
UNIT V
Confirmatory techniques, bound and conjugated residues, multi residue methods
UNIT VI
Method validation: linearity, accuracy, precision, LOD and LOQ. Interpretation of data and statistical analysis and measurement of uncertainty.

Practicals

Suggested Readings

AC 511 AGROCHEMICAL DECONTAMINATION AND DISPOSAL (2L+1P) I
Objective
To teach students the concept of agrochemical / pesticide residue management, disposal and decontamination techniques.

Theory
UNIT I
General aspects of disposal and decontamination of agrochemicals.
UNIT II
Decontamination: techniques (physical, chemical and biological), soil, water, plant and agricultural produces.
UNIT III
Guidelines for pesticide disposal in the environment and effluent treatment plants.

UNIT IV
Disposal: methods of disposal of containers, obsolete. /out dated pesticides, industrial effluents and other xeno-biotics.

UNIT V
Sensors for monitoring contaminations

Practicals
Chemical detoxification of potential toxic xenobiotics, oxidative degradation and decontamination methods, decontamination of pesticides from water using different adsorbents, culinary methods for pesticide decontamination from fruits and vegetables, microwave induced decontamination of pesticides, photochemical decontamination of pesticides.

Suggested Reading

AC 512 NANOTECHNOLOGY IN CROP PROTECTION (2 L+1P)
(Multi-disciplinary: Agric. Chemicals, Plant pathology, Entomology, Nematology, Microbiology)

Objective
To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology.

Theory
UNIT I

UNIT II
Effect of bioactive nano-materials on insect pests and beneficial insects. (2 Lectures, Entomology)

UNIT III
Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi , bacteria and viruses with special reference to copper, sulfur etc. Interaction of bioactive nano- materials on plant pathogens including fungi, bacteria, virus etc (3 lectures, Plant Pathology).

UNIT IV
Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus. Identification and quantification of biotoxins effective in nano-doses. (3 lectures, Nematology).
UNIT V
Microbes: Microbes of agricultural importance. Life cycle: genesis, growth, reproduction, identification and quantification. Nanotechnological application in microbiology (3 lectures, Microbiology).

UNIT VI

Practicals
Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests.

Suggested Reading

AC 601 AGROCHEMICAL FORMULATION TECHNOLOGY (2L+1P) III

Objective
To teach general aspects along with latest developments of formulations, chemistry, classification and properties of formulants, machinery and equipment involved in preparation, packaging and labeling and bioefficacy of formulations.

Theory
UNIT I
Formulation ingredients: active ingredients and carriers/ diluents, surfactants, synergists, safeners, encapsulants, binders, anti-oxidants, stabilizers.

UNIT II
Formulant-toxicant interactions.

UNIT III
Preparation, properties, specifications and uses of solid and liquid formulations.

UNIT IV
Control release formulations: preparation, properties, specifications and uses.

UNIT V
Hydrogels: preparation, properties, specifications and uses.

UNIT VI
Equipments and machineries: formulation research. Basic considerations, absorption, penetration, translocation and activity for improvement of bioefficacy, industrial equipments and plants.

Practicals
Laboratory mills/ equipments used in formulation research, Preparation of standard hard water, Determination of acidity of a pesticide, Determination of alkalinity of a pesticide, Preparation of

Suggested Readings


AC 602 CHEMISTRY OF BIOPESTICIDES (3L+1P) III

Objective
To teach chemistry of conventional biopesticides, semiochemicals and allelochemicals, phytoalexins, pesticides of microbial origin and application of biotechnology in pest management.

Theory

UNIT I
Sources of biopesticides and extraction (ASE, SFE /solvent extraction

UNIT II
Isolation, characterization, properties and mode of action of important groups of naturally occurring insecticides (pyrethroids, nicotinoids, rotenoids, limonoids, microbial macrolides).

UNIT III
*Bacillus thuringiensis* and nuclear polyhedrosis virus based insecticides and other biopesticides.

UNIT IV
Semiochemicals, insect hormones, insect growth regulators, feeding deterrents and repellents etc

UNIT V
Natural nematicides, fungicides, mollusicides and rodenticides

UNIT VI
Allelochemicals. Anti JH / JH mimics and moulting agonists.

Practicals

Extraction by hydrodistillation, isolation of pure compounds, their characterization, Extraction of tobacco leaves, isolation of nicotine and its identification, Extraction of neem seed kernels, enrichment of azadirachtin, analysis of azadirachtin and its analysis.

Suggested Readings


AC 603 ADVANCED ORGANIC CHEMISTRY (3L+1P) I

Objective
To teach stereochemistry, mechanisms of stereospecific and stereoselective reactions, reagents in organic synthesis, elucidation of structure of organic compounds.

Theory
UNIT I
Stereochemistry, Cohn-Ingold-Prelog rules. Inductive, inductomeric, mesomeric and electromeric effects, Walden inversion, asymmetric synthesis, optical resolution, racemic modification.
UNIT II
Reaction mechanisms – substitution, elimination, addition and condensation reactions.
UNIT III
Important name reactions and rearrangements.
UNIT IV
Synthetic reagents and their applications.
UNIT V
Protective groups in organic synthesis.
UNIT VI
Photochemistry, pericyclic reactions and sigma tropic rearrangement.

Practicals
Friedal craft reaction (Alkylation/Acylation), Aldol/Claisen Schmidt reaction, Pechmann condensation/Perkin reaction, Methylation, acetylation, elimination, Oxidation, reduction, hydrolysis, Acid chlorides, amides, esters, Characterisation of Organic compounds (NMR and IR spectroscopy)
Suggested Readings


**AC 604 AGROCHEMICAL DYNAMICS AND ENVIRONMENTAL IMPLICATIONS (3L+1P) III**

**Objective**

To acquaint students with fate of pesticides in environment-their movement in plants and food chain, persistence, transformation and other metabolic fates.

**Theory**

**UNIT I**

Biotic and abiotic transformations of agrochemicals in the environment.

**UNIT II**

Soil: sources of contamination, microbial transformation, adsorption-desorption, leaching/mobility, volatilization.

**UNIT III**

Aquatic bodies: sources of contamination, transformation processes, bioaccumulation etc.

**UNIT IV**

Air: sources of contamination, transformation and transport processes.

**UNIT V**


**UNIT VI**

Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms.

**Practicals**

Preparation of metabolites, photodegradation of pesticides, leaching and volatilization of pesticides, biological degradation in soil.
Suggested Readings


AC 605 ADVANCES IN AGROCHEMICALS (3L+0P) III

Objective

To develop proficiency of the student in his/her area of specialization.

Theory

UNIT I
Recent advances in pesticide development, formulation, and analysis and safety evaluation.

UNIT II
Combinatorial chemistry, modeling etc for development of new molecules, mode of action and metabolism.

UNIT III
Innovations in pesticide formulation and delivery systems

UNIT IV
Application of biotechnology in developing herbicide tolerant and insect resistant transgenic plants.

UNIT V
Recent developments in botanicals and bio-pesticides

UNIT VI
Sanitary / phyto-sanitary issues, accreditations of testing laboratories

Suggested Readings

Selected topics from review books and journals.
## Agricultural Economics

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 014</td>
<td>FUNDAMENTAL OF ECONOMICS AND BUSINESS MANAGEMENT</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 501</td>
<td>MICROECONOMICS I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 520</td>
<td>AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS I (FARM MANAGEMENT)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 530</td>
<td>AGRICULTURAL MARKETING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 541</td>
<td>AGRICULTURAL FINANCE II</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 560</td>
<td>RESEARCH METHODS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 602</td>
<td>MACROECONOMICS II</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 621</td>
<td>AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-IV (AGRICULTURAL PRODUCTION UNDER RISK)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 630</td>
<td>AGRICULTURAL PRICE ANALYSIS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 632</td>
<td>QUANTITATIVE ANALYSIS FOR MARKETING AND BUSINESS DECISIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 641</td>
<td>INSTITUTIONAL AND LEGAL ENVIRONMENT FOR AGIBUSINESS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 660</td>
<td>AGRICULTURAL PROJECT ANALYSIS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG ECON 502</td>
<td>MACROECONOMICS I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 510</td>
<td>AGRICULTURAL ECONOMETRICS - I</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 521</td>
<td>AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS II (PRODUCTION FUNCTION ANALYSIS)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG ECON 532</td>
<td>INTERNATIONAL TRADE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 550</td>
<td>AGRICULTURAL DEVELOPMENT AND POLICY ANALYSIS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 601</td>
<td>MICROECONOMICS II</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AG ECON 640</td>
<td>STRATEGIC MANAGEMENT FOR AGIBUSINESS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>AG ECON 642</td>
<td>MANAGEMENT OF R&amp;D AND INNOVATION</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>AG ECON 691</td>
<td>SEMINAR</td>
<td>1 0</td>
<td></td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG ECON 525</td>
<td>NATURAL RESOURCES MANAGEMENT AND ENVIRONMENTAL ECONOMICS</td>
<td>3 0</td>
</tr>
<tr>
<td>AG ECON 535</td>
<td>FUNDAMENTALS OF BUSINESS MANAGEMENT</td>
<td>3 1</td>
</tr>
<tr>
<td>AG ECON 540</td>
<td>AGRICULTURAL FINANCE I</td>
<td>2 1</td>
</tr>
<tr>
<td>AG ECON 650</td>
<td>ECONOMIC DEVELOPMENT</td>
<td>3 0</td>
</tr>
<tr>
<td>AG ECON 610</td>
<td>AGRICULTURAL ECONOMETRICS – II</td>
<td>3 1</td>
</tr>
<tr>
<td>AG ECON 620</td>
<td>AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-III (LINEAR PROGRAMMING)</td>
<td>2 1</td>
</tr>
<tr>
<td>AG ECON 631</td>
<td>MARKETING MANAGEMENT</td>
<td>3 1</td>
</tr>
<tr>
<td>AG ECON 691</td>
<td>SEMINAR</td>
<td>1 0</td>
</tr>
</tbody>
</table>

**Core Courses**

- **M.Sc.:** AG ECON 501, AG ECON 502, AG ECON 510, AG ECON 520, AG ECON 521, AG ECON 530, AG ECON 535, AG ECON 540, AG ECON 550, AG ECON 560,
- **Ph.D.:** AG ECON 650, AG ECON 601, AG ECON 602, AG ECON 610, AG ECON 620, AG ECON 630, AG ECON 660,
AGRICULTURAL ECONOMICS

Major Fields:  
- Farm Management and Resource Economics  
- Agricultural Marketing and Trade  
- Agricultural Finance and Project Analysis  
- Agricultural Development and Policy  
- Agri-business Management

Minor Fields:  
Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.  
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.  
The total minimum credit requirement of course work for M.Sc./Ph.D. in Agricultural Economics is 55/45 including Minor field(s).

DESCRIPTION OF COURSES

AGR 014 FUNDAMENTALS OF ECONOMICS AND BUSINESS MANAGEMENT  (1L + 1P) I

Objective
The objective of this introductory course is to familiarise students with the basic concepts of economics and management as related to agriculture. The course also attempts to inform the students about the latest global developments that have a bearing on trade, food products safety and quality and IPRs.

Theory

UNIT I  
Basic concepts in economics; micro- versus macro-economics; positive and normative economics; scarcity and choice; utility concept; production possibilities frontier; opportunity cost concept. Theory of demand and supply; laws of demand and supply; concept of elasticity and its estimation.

UNIT II  
Theory of production and costs; laws of returns; total average and marginal products and costs; profit maximisation.

UNIT III  
National income; concept of national income; estimation of national income.

UNIT IV  
Agribusiness and agribusiness management; major functions of managers – planning, organising, directing, and controlling. Major functional areas of a business and their management – production, marketing, finance, personnel.

UNIT V  
Global issues in business – WTO; tariffs; non-tariff barriers; international product quality / safety standards, intellectual property issues.
UNIT VI
Application of quantitative techniques in economics and management – concept of cost-benefit analysis; break-even analysis, network techniques for managing projects, optimization and allocation techniques; decision analysis.

Practicals

Suggested Readings

AG ECON 501 MICROECONOMICS I (3L + 0P) I

Objective
The objective of this course is to give students a thorough understanding of the principles of economics that apply to the decisions of individual consumers and producers within the larger economic system.

Theory
UNIT I

UNIT II

UNIT III
Suggested Readings

**AG ECON 502 MACROECONOMICS I**  
(3L + 0P) II

**Objective**
The course is designed to understand key concepts, basic macro-economic theories and role of government in the economy and policy making process.

**Theory**

**UNIT I: BASIC CONCEPTS AND MEASUREMENT**
Basic concepts and scope of Macro-economics, National Income Accounting and measurement of income, concepts and measurements of money, prices, unemployment and growth, Indian system of Macroeconomic data management.

**UNIT II: CLASSICAL THEORY**
Say’s Law, Quantity theory of money, aggregate supply and labour market, Classical theory of determining output, employment, wages and prices, Classical theory of saving, investment and interest rate.

**UNIT III: KEYNESIAN MACROECONOMICS**
Consumption function, theories of aggregate consumption and empirical studies of consumption, aggregate demand and its components, Simple Keynesian model, multiplier and their impact on output, fiscal policy and Keynesian dynamics. International trade and multiplier effect

**UNIT IV: KEYNESIAN-CLASSICAL SYNTHESIS**
Keynes theory of interest, liquidity preference, demand and supply of money, investment theories, IS-LM Model for output and interest determination, fiscal and monetary policies under different monetary assumptions, fiscal- monetary policy mix and their effectiveness, effects of government budget deficits.

Suggested Readings

**AG ECON 510 AGRICULTURAL ECONOMETRICS -I**  
(2L+1P) II

**Objective**
The purpose of the course is to provide an elementary knowledge of application of econometric techniques for analysis of economic phenomena.
Theory

UNIT I
Introduction – representation of economic phenomenon, relationship among economic variables, linear and non-linear economic models, methodology of econometrics.

UNIT II
The two variable linear regression model – assumptions, estimation and inference in the least squares model.

UNIT III

UNIT IV

UNIT V
Sources of non-spherical disturbances, heteroscedasticity and the generalized least squares estimators. Maximum likelihood estimators and their properties.

Practicals
Two variable model - specification and estimation – hypothesis testing - transformations of functional forms and OLS application-estimation of multiple regression model - hypothesis testing - testing and managing multicollinearity - testing and managing autocorrelation - estimation of regressions with dummy variables - testing and managing heteroscedasticity - GLS estimation methods

Suggested Readings

AG ECON 520 AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS I (FARM MANAGEMENT) (2L+1P)

Objective
This basic course in farm management discusses the various types and systems of farming and the basic economic principles as applicable to farm management. Methods of estimating costs and revenues, and farm planning and budgeting are discussed.

Theory
UNIT I
Farm management and farm business-nature, scope and objectives. Characteristics of farming and requirements of success in farming. Task of management, classification of decisions and the process of decision making in farming. Types and systems of farming and factors affecting types of farming.
UNIT II
Basic principles of farm management and farm business - principles of marginal returns, costs substitution in choice of practices, Equimarginal returns, combining enterprises and time comparison. Law of comparative advantage. Farm records and farm accounting. Concept of size of farm and business.

UNIT III

UNIT IV
Essentials of farm planning and budgeting, farm surveys, questionnaire preparation and pretesting, data collection and analysis, enterprise budgets, partial and complete budgets and whole farm planning.

UNIT V
Elements of risk and uncertainty in agriculture, measurement of risk and adjustments to risk, Review of farm management research, education and extension in relation to changing needs in India.

Practicals

Suggested Readings
Heady, E.O. Economics of Agricultural Production and Resource Use. Prentice-Hall.

AG ECON 521 AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS II
(PRODUCTION FUNCTION ANALYSIS) (2L+1P) II
(Pre-requisite: Ag Econ 501 )

Objective
This course deals with the production concept and the various types production functions. The dualities between production, cost and profit function is discussed. The derivation of supply and factor demand functions from profit functions is also covered.

Theory
UNIT I (PRODUCTION FUNCTIONS)
Production concepts. Resource product relationship in agriculture. Important historical background and characteristics of different forms of production functions-linear, quadratic, square root,
UNIT II (MANAGEMENT OF FARM RESOURCES)

UNIT III (COST AND PROFIT FUNCTIONS AND THEIR APPLICATIONS)
Dualities between production, cost and profit functions; Derivation of supply and factor demand functions from production and profit functions.

UNIT IV (RISK AND UNCERTAINTY)
Optimization under risk and uncertainty; optimisation over time.

Practicals
Different forms of production functions - specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap - incorporation of technology in production functions- measuring returns to scale, risk analysis through linear programming

Suggested Readings
Heady, E.O. Economics of Agricultural Production and Resource Use. Prentice- Hall.

AG ECON 525 NATURAL RESOURCES MANAGEMENT AND ENVIRONMENTAL ECONOMICS (3L + 0P) III

Objective
The course is designed to provide an understanding of the principles of economics as they are applicable to the management of natural resources and the environment. Issues of efficient allocation of resources and need and methods for ensuring sustainability of resources, protection of environment and regulatory aspects are included.

Theory
UNIT I
Meaning, nature and scope of environmental economics. Agricultural development and environment—ecology, natural resources and human health. Environmental problems in developing
and developed nations. Population and environmental sustainability. Environmental costs of technology advances. Natural resource accounting and inter-temporal use of natural resources.

UNIT II

UNIT III

UNIT IV
Food security and environmental protection. International trade and environmental protection. Natural resource management, forest management and management of common property resources. Agricultural policy for sustainable agriculture.

Suggested Readings
Tom Tietenberg, Environmental and Natural Resource Economics, McGraw Hill.

AG ECON 530 AGRICULTURAL MARKETING (2L +1P) I

Objective
The course will attempt to make students understand the basic functions performed by agricultural and food marketing systems and the behaviour of various participants in the marketing system. The problems associated with the marketing of agricultural products and the initiatives taken to mitigate these problems will be discussed. Emerging developments such as marketing reforms, revisions in regulatory process and futures trading which relate to emerging issues in agricultural marketing will be covered to provide a holistic view of agricultural marketing.

Theory
UNIT I
Review of agricultural marketing concepts - Characteristic of agricultural product and production; problems in agricultural marketing – demand, supply and institutions. Market intermediaries and their role; Need for regulation in the present context; Marketable and marketed surplus estimation. Marketing efficiency.

UNIT II
The competitive environment - market structure, conduct and performance analysis; Demand and supply of agricultural products. Determination of prices; administered prices.

UNIT III
Marketing co-operatives; APMC regulated markets; direct marketing; contract farming and retailing; supply chain management; state trading, warehousing; Government intervention; market infrastructure needs, performance and Government role; value chains.
UNIT IV
Role of information technology and telecommunications in marketing of agricultural commodities; Market research; Marketing information and intelligence services - electronic auctions (e-bay), e-Chaupals, Agmarknet; Market extension.

UNIT V
Theory of storage - Introduction to commodities markets and future trading; Basics of commodity futures, operation mechanism of commodity markets; price discovery; hedging; Role of Government in promoting commodity trading and regulatory measures.

Practicals

Suggested Readings

AG ECON 532 INTERNATIONAL TRADE (3L+0P) II

Objective
The aim of the course is to appraise the students with the basic theories of international trade and to show how these may be applied in planning for international trade.

Theory
UNIT I
The pure theory of international trade; absolute and comparative advantage; international trade equilibrium. Supply side analysis: opportunity cost; trade under increasing opportunity costs; factor endowments; trade and factor prices; factor price equalisation. Demand side analysis: community indifference curves; demand and international trade. Integration of demand and supply; offer analysis; general equilibrium; equilibrium in product and factor markets.

UNIT II
Application of trade theory; terms of trade; supply and demand shifts; technological change; factor supplies and trade; factor intensities; transport costs; location. Trade with many goods and countries; Leontief paradox; human skills; technological gaps; the product cycle; scale economies.

UNIT III
Trade policy: Protection; tariff and non-tariff measures; trade and market structure; trade liberalisation; factor mobility and movements; role of multinational enterprises. National competitive advantage – Porter's diamond.

UNIT IV
International finance: institutional money and credit markets; foreign exchange markets. Balance of payments analysis: funds flow; capital and current account. International adjustment
mechanisms; fiscal and monetary adjustments. The International Monetary System; Bretton Woods to WTO. Recent developments in the international trade system. Implications for developing countries. Trade Blocks. Measures of trade competitiveness. Concepts of trade creation and diversion.

Suggested Readings


AG ECON 535 FUNDAMENTALS OF BUSINESS MANAGEMENT (3L + 1P) III

Objective

This course attempts to explore the basic concepts of management and to familiarise the students with the application of the management concepts to agribusiness.

Theory

UNIT I

UNIT II
Planning: Nature and purpose of planning; setting goals and objectives; MBO (Management by Objectives); Different types of planning – short range and long range or strategic planning. Strategies policies and planning premises.

UNIT III
Organizing: Nature and purpose of organizing; organizational structure and design. Key elements in organizing – authority, responsibility and unity of command, span of control, centralization and decentralization, departmentalization, delegation. and organizational relationships. Responsibility. Actuating human resources; staffing and recruiting. Organisational structures- types of structures, formal and informal structures, matrix structure.

UNIT IV
Leading: Motivation – concept and theories of motivation; leadership behaviour and styles. Managing personnel – compensation, incentives, training, placing and personal development.

UNIT V

UNIT VI

Practicals

Suggested Readings

AG ECON 540 AGRICULTURAL FINANCE I (2L+1P) III

Objective
To inform students about the importance and scope of finance in Indian agriculture, credit structure, capital investment and optimum utilization of available financial resources.

Theory
UNIT I

UNIT II

UNIT III
Legal aspects of credit: Real estate mortgage; Title theory; Chattel mortgages: Livestock, crop, commodity, equipment, miscellaneous. Promissory note; sale contract; other credit instruments.
Risk in financing agriculture. Risk management strategies and coping mechanism. Crop insurance schemes-yield loss and weather based insurance and their applications. Financial instruments and methods-E-banking, Kisan Cards and Core banking. Concept of supervised credit; objectives of supervised credit; procedures, costs and sources of funds for supervised credit; supervised credit and extension agencies. Agricultural taxation; investment criteria (portfolio analysis). Brief review of institutional lending procedures in India.
Practicals

Suggested Readings

AG ECON 541 AGRICULTURAL FINANCE II (3L+0P) I

Objective
To appraise the students about various sources of credit. The evolution, objectives, and performance of the institutional sources of credit are covered in this course.

Theory
UNIT I
Evaluation of Agricultural Credit and Polices in India-history of rural financial market, relative importance of various credit institutions. Financial intermediaries, their role and importance in Agricultural Development. Review of various Committee Reports on Rural Credit and Investment-Rural Debt and Investment Surveys. All India Rural Credit Survey Committee Report, All India Rural Credit Review Committee Report, CRAFICARD report, Khusro Committee Report, Narasimham Committee Report, Vyas Committee report.
UNIT II
Cooperative Banking Institutions-Role of cooperatives in financing agriculture-Social control of credit: Bank nationalization, Lead Bank Schemes, Preparation of District Credit Plan, Group lending, Role of commercial banks in financing agriculture, Rural credit review panel report-Multi agency approach. Small farmers development agencies. Role of State Bank of India in financing agriculture.
UNIT III
AG ECON 550 AGRICULTURAL DEVELOPMENT AND POLICY ANALYSIS (3L+0P) II

Objective
The course is designed to make students understand the concepts of agricultural development and planning and the factors that influence development. The lessons learnt from the development strategies of other countries, particularly USA, Japan, and China are also discussed.

Theory
UNIT I
Role of agriculture in economic and rural development. Agriculture in economic development theories - growth stage theories, structural transportation leading sectors and dual economy models. Theories of agricultural development – conservation, urban industrial impact, diffusion, high-payoff input. Planning for agricultural development in developing countries.

UNIT II
Institutions and agricultural development; collective actions, property rights, transaction cost economics.

UNIT III
Need for separate/sound agricultural policy – resource polices, credit policies, input and product marketing policies – price policies.

UNIT IV
Models of agricultural development – induced innovation, biological and chemical processes for mitigating poverty, inequality and unemployment. Indicators of sustainability and its measurement. Measuring bias and technical change.

UNIT V
Agricultural development in the USA, Japan, China and India. Globalization and relevance of development policy analysis. The dilemma of free trade – free trade versus protectionism. WTO agreement on agriculture.

Suggested Readings


Objective

The objective of this course is to familiarise students with the basic methods of research in economics. The course explains all aspects of social research starting from hypothesis formulation to data analysis. The issue of ethics in research is also discussed in the course.

Theory

UNIT I
Importance and scope of research in agricultural economics. Types of research - fundamental vs applied. Concept of researchable problem, research prioritization, selection of research problem. Approach to research; Research process.

UNIT II
Hypothesis: meaning, characteristics, types of hypothesis. Review of literature. Setting of research objectives and hypotheses. Testing of hypothesis.

UNIT III
Sampling theory and sampling design, sampling error, methods of sampling, probability and non-probability sampling methods, criteria to choose. Project proposals: contents and scope, different types of projects to meet different needs, trade-off between scope and cost of the study. Research design and techniques; types of research design.

UNIT IV
Data collection: assessment of data needs, sources of data. Mailed questionnaire and interview schedule: structured, unstructured, open-ended and closed-ended questions. Scaling techniques. Preparation of schedule. Problems in measurement of variables in agriculture. Interviewing techniques and field problems. Methods of conducting surveys; reconnaissance survey and pre-testing.

UNIT V
Coding, editing, tabulation and validation of data. Tools of analysis – data processing. Interpretation of results. Preparing research report / thesis; Universal procedures for preparation of bibliography; Writing of research articles.

UNIT VI
Ethics in research. Meaning of ethics in research; principles and elements of ethical research; design, implementation and operationalisation of ethical research.

Practicals

of conducting surveys. Exercise on coding, editing, tabulation and validation of data. Preparing for data entry into computer. Hypothesis testing – parametric and non-parametric tests. Exercises on format for thesis / report writing. Presentation of the results.

Suggested Readings

Venkatasubramanian, V. 1999. *Introduction to Research Methodology in Agricultural and Biological Sciences*. SAGE

AG ECON 601 MICROECONOMICS II  
*(3L+0P) II*

**Pre-requisite: Ag Econ 501 Microeconomics I**

**Objective**

The objective of this course is to teach economic theories that are applicable to firm and also places primary emphasis on the nature and functions of product markets, study of factor markets and evaluation of government regulation of markets.

**Theory**

**UNIT I**


**UNIT II**


**UNIT III**

Pricing of factors of production and Income distribution- Demand/supply/ pricing of single and several factors- Factor pricing in perfectly and imperfectly competitive markets- Monopolistic power
in product market- monopsonistic power in factor market- Bilateral monopoly-elasticity of factor substitution- Technological progress and income distribution- Pricing of fixed factors- The adding-up and product exhaustion theorems- Euler’s and Walras theorems.

UNIT IV

Suggested Readings

AG ECON 602 MACROECONOMICS II (3L+0P) I
Pre-requisite Ag Econ 502 Macroeconomics I

Objective
The aim is to provide an analytical background to macro-economic issues and policy concerns such as inflation, trade cycles, stabilization policies and international financial markets.

Theory
UNIT I: INFLATION AND GROWTH
Introduction to dynamic macro-economic models, Inflation and stagflation: measurement and effects, demand side and supply side inflation, Inflation- unemployment tradeoffs, recent developments in Inflation theory, empirical policy aspects of inflation, productivity and inflation, supply side economics.

UNIT II: TRADE CYCLES
Classical and neo-classical theories of Investment, Acceleration principle, Trade cycles : its nature and causes, theories of capital and investment, Hicks model of trade cycles, role of economic policies

UNIT III: STABILIZATION POLICIES
The instruments and impact of monetary and fiscal policies as an instrument of development, incidence of tax and fiscal policies, extension of Keynesian model: investment and economic growth, review of economic policies in India, case studies

UNIT IV: INTERNATIONAL MACRO-ECONOMIC ENVIRONMENT
Internal and external borrowings, Deficit financing, International trade theories and exchange rates, International macro-economic policies and institutions.

Suggested Readings
Shapiro, E. Macroeconomic Analysis. Galgotia Publications, Delhi.

AG ECON 610 AGRICULTURAL ECONOMETRICS -II
(Pre-requisite: AG ECON 510) (3L + 1P) III

Objective
The course is designed to provide comprehensive knowledge of advanced econometric tools for better understanding of economic problems.

Theory
UNIT I
Review of classical regression model – review of hypothesis testing – estimation subject to linear restriction
UNIT II
Mixed estimation - use of instrumental variables in regression analysis, method of principal components, Errors in variables models.
UNIT III
UNIT IV
Simultaneous equation systems: Basic rationale, identification problems, Single equation methods of estimation-indirect least squares, two stage least squares, and K-class estimators, and limited information maximum likelihood, three-stage least squares, and full information maximum likelihood; Relative merits of these methods and their small and large sample properties. SURE estimates.
UNIT V

Practicals
Estimation of multiple regression model - estimation of LPM, Logit and Probit models - comparing two regressions - Chow test - Indirect least squares 2SLS, SURE, 3SLS, estimation of simultaneous equation models – unit root tests for stationarity, fitting of ARIMA and ARCH group of models - cointegration

Suggested Readings
Objective

This course is meant to familiarise students with the theory and application of various optimization techniques such as linear programming, variable resource programming; recursive programming, game theory, goal programming, in agriculture.

Theory

UNIT I (INTRODUCTION TO LINEAR PROGRAMMING)
Problem formulation for programming; preparation of input-output matrix, objective functions and constraint equations. Assumptions of linear programming; basic and non-basic solutions; feasible and infeasible solutions. Linear Programming: Graphical method; Simplex method; Simplex method and its application for solving agricultural problems; use of artificial factors; problems of degeneracy, inconsistency, infeasible and unbounded solutions. Generalised simplex method; dual simplex method; integer programming; recursive programming. Transportation models. Application of linear programming for solving practical problems in farming with the help of following: Variable resource programming; variable price programming

UNIT II (RISK PROGRAMMING)

Practicals

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings


AG ECON 621 AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS IV
(AGRICULTURAL PRODUCTION UNDER RISK)

Objective

This course deals with various types of risks in agriculture and their measurement. The concepts of probability, decision theory, Bayes’ theorem, risk programming are discussed.

Theory

UNIT I (CONCEPT OF RISK AND UNCERTAINTY IN AGRICULTURE)
Various types of risks in agriculture and their measurement.
UNIT II (DECISION THEORY)
Introduction to decision analysis; Concept of probability, subjective probability and its illustration, estimation of posterior probability in the application of Bayes’ Theorem. Selection of optimal action under risk with and without forecast device. Minimax and Maximin Criteria. General model of discrete decision analysis. Risk response analysis-Supply response risk, formulation of production function under risk, Optimum input decision under risk.

UNIT III (RISK PROGRAMMING MODELS)
Linear risk programming model, Portfolio selection or E-V model, Markowitz model, McInnerrey’s model, Hazell model, Kataoka model. Quadratic programming, Multi-objective programming

Practicals
Decision making for optimum cropping plans based on Bayes’ theorem, MOTAD, quadratic risk programming.

Suggested Readings

AG ECON 630 AGRICULTURAL PRICE ANALYSIS (2L + 1P) I
*(Pre-requisite: AG ECON 510 Agricultural Econometrics I)*

Objective
The objective of this course to develop the skills of students in modelling price behaviour and estimate demand and supply. Implications of prices, demand and supply for food security and management of food are also covered.

Theory
UNIT I

UNIT II

UNIT III
Market integration – concept and measurement.

UNIT IV
Food Security. Management of Food Stocks - Buffer stocks operations, PDS. Futures market and trading.

Practicals
Estimation of input and output demand and supply; estimation of price variability; forecasting demand and supply, measuring market integration.
Suggested Readings


AG ECON 631 MARKETING MANAGEMENT (3L+1P) III

Objective

This course aims to show how the principles of marketing management can be applied to improve the efficiency and effectiveness of food and agricultural commodities marketing.

UNIT I
The core concepts of markets, marketing and marketing management. Process of marketing management. Marketing mix. Strategic marketing management; Analysing marketing opportunities - Consumer behaviour and purchase process; Marketing information system. Marketing research. Researching and selecting target markets: Measuring and forecasting market demand; identifying market segments and selecting target markets.

UNIT II
Product management: Concept of a product; managing product lines and brands; differentiating and positioning the market offer; product life cycle; new product development. Designing product related competitive marketing strategies – branding, labeling, packaging decisions.

UNIT III
Pricing strategies, decisions and programmes. Pricing methods.

UNIT IV
Product distribution: Channel management and strategies; Managing wholesale, retail, and logistics.

UNIT V

UNIT VI

UNIT VII
Issues in global marketing

Practicals

Practicals will be based on real world situations and case studies and will involve a critical analysis of the marketing actions and strategies of companies.
Suggested Readings


AG ECON 632 QUANTITATIVE ANALYSIS FOR MARKETING AND BUSINESS DECISIONS

(2L+1P) I

Objectives

The main objective of this course is to familiarise students with the application of quantitative techniques to decision making in business and marketing.

Theory

UNIT I
Decision theory applications in managerial decisions: Decision making under risk, uncertainty and perfect information situations; Decision criteria: Maximax, maximin, minimax, regret, Laplace criteria; Decision Trees.

UNIT II
Optimization and allocation problems: Assignment problems; transportation problems; media selection problem; channel selection problem; product line selection problem; blending and product mix problems; machine allocation problems. Other competitive strategy related problems.

UNIT III
Waiting line models: Facility planning problems at market yards; service facility problems; customer servicing problems in retail and service industry.

UNIT IV
Network models: PERT/CPM. Problems of new product introduction; planning and management of projects related to facilities development; production; processing.

UNIT V
Competitive Strategy Models: Inventory control models for managing production and marketing functions; Markov chain models applied to problems of brand switching, market selection, market shares, etc.; Game theory applications in situations involving conflicts or cooperation

Practicals

Structuring and solving decision trees for optimal decisions. Using different criteria for arriving at optimal decisions under different situations. Formulating and solving transportation type problems; handling unbalanced problems and situations of degeneracy. Assignment problems as a special type of transportation problem. Solving deterministic and probabilistic queuing models Developing network (PERT/CPM) diagrams and determining the critical path. Crashing of projects; PERT cost problems. Determining economic order quantity, reorder levels and robustness of EOQ model; EOQ models under situations of price breaks, outages and planned shortages. Markov Chains: Estimating transition probabilities, predicting future scenarios and estimating steady state probabilities. Game theory: Two person zero sum games; determining saddle points; problems where no saddle point exists.
Suggested Readings


AG ECON 640 STRATEGIC MANAGEMENT FOR AGRIBUSINESS (2L+1P) II

Objective

This course aims to explain how strategy can be formulated and implemented to gain a competitive advantage in the market.

Theory

UNIT I
Strategy Formulation: Vision and mission; industrial appraisal; organizational appraisal; situational analysis and formulation of corporate and business level strategies.

UNIT II
Strategy implementation: Management and operational issues; marketing, finance, R&D, MIS issues in strategy implementation.

UNIT III
Strategy evaluation and control: Measuring performance – a framework for strategy evaluation; balanced scorecard approach; strategic audit; strategic incentive management.

UNIT IV
Total quality management as a strategic tool: Concept of total quality management; product quality management - statistical quality control; national and international quality standards (AGMARK, ISI, ISO, HACCP, CODEX) in relation to food products.

UNIT IV
Governance and strategic management issues; role of top management and board; ethics in management; corporate social responsibility.

Practicals

Environmental scanning; internal scanning; development of external and internal factory analysis summaries; strategic factor analysis summary; SWOT analysis BCG Growth share analysis; portfolio analysis; case studies relating to strategies in functional areas.

Suggested Readings


AG ECON 641 INSTITUTIONAL AND LEGAL ENVIRONMENT FOR AGRIBUSINESS (2L + 0P) I

Objective

The course provides an insight into the legal and institutional aspects that impact the efficiency and performance of agribusiness organisations.
Theory

UNIT I

UNIT II

UNIT III
Management systems for food quality and safety: Regulatory provisions and acts: Essential Commodities Act, APMC Act, Consumer Protection Act, RTI Act, MRTP Act. Regulations related to food safety, hygiene and quality: national (FPO (1955), PFA, Food Safety and Standards Act (2006), and other Acts related to fruits, meat, milk, grading and standardization (AGMARK) and international (sanitary and phyto-sanitary requirements, Codex, ISO, HACCP, Good Manufacturing Practices (GMP) and Good Agricultural Practices (GAP))

UNIT IV
Role of institutions in agribusiness: Ministry of Food Processing Industries, Ministry of Food and Consumer Affairs, Product Boards, Export Promotion Council, Food Safety and Standards Authority, India, etc. International institutions facilitating agribusiness. Provisions related to FDI in agriculture and food production and distribution;

UNIT V
Nature and importance of ethics and moral standards; corporations and social responsibilities, scope and purpose of business ethics; Ethics in business functional areas; industrial espionage; solving ethical problems; governance mechanism.

Suggested Readings


AG ECON 642 MANAGEMENT OF R&D AND INNOVATION (2L+1P) II

Objective

The aim is to help students develop conceptual foundations for management of innovations. It introduces the framework of evolution and growth of national and international agricultural R&D systems, discusses issues related to science and technology policy and assesses the approach of impact of innovations.
Theory

UNIT I
Innovation, productivity and economic growth; Nature, process and importance of technological innovation; Sources of technical change-induced technical change, evolutionary theory and path dependence; Measurement of productivity growth; Institutional innovations, case studies.

UNIT II
Institutions and investments in science and technology; Agricultural research systems-evolution and growth, selected case studies of major countries, investment trends, international comparisons, institutional details; Changing public-private roles in technology development; Measuring the effects of agricultural research: Ex-ante and ex-post methods.

UNIT III
Technology adoption, diffusion and transfer-theoretical models and case studies, technology, resources and environment; Science and technology policy—regulation, incentives; Technology and intellectual property rights-selected case studies.

Practicals
Measurement of productivity growth-total factor productivity; frontier production function, etc. Institutional structures and national and international agricultural research systems. Ex-ante and ex-post methods of estimation of R&D impacts in agriculture.

Suggested Readings

AG ECON 650 ECONOMIC DEVELOPMENT (3L + 0P) III

Objective
The course is designed to show how economic systems work and teach various models that explain the nature of economic development and growth and the welfare implications of development.

Theory
UNIT I
Concept of economic growth, development, welfare, etc. Traditional and modern measurement of economic growth and development. Measurement of income (GNP), poverty, inequality and unemployment. Recent measurement of economic development NEW (New Economic Welfare), MRW (Measurement of Economic Welfare), PQLI (Physical Quality Living Index), HDI (Human Development Index), Green GNP Index.

UNIT II
Evolution of economic thought: Mercantilism and Physiocracy; the Classical School; Marxian economic ideas; the Neo-Classical School; the globalization era.
UNIT III

UNIT IV
Introduction to development planning: Strategy of economic development – Balanced – unbalanced growth, choice of techniques, investment criteria; Education, health and gender in development, Trade and development.

Suggested Readings
Meir, Gerald M. Leading Issues in Economic Development.

AG ECON 660 AGRICULTURAL PROJECT ANALYSIS (21 + 1P) I

Objective
In this course the students will be taught about the types of projects and various methods to capture cost and value of project. It also deals with various methods used to assess the feasibility of the projects.

Theory
UNIT I
Definition of a project, identification and formulation of project, need for project, ex-post and ex-ante appraisal, basic data requirement, discounted cash flow analysis and measure of probability, choice of discount rate, consideration of alternatives, divergence of private and social profits, government action to bring out equality of social and private profits, social objectives and accounting price.

UNIT II
Allocation of scarce resources; land, labour, capital, foreign exchange; present and future consumption, optimum use of taxes and subsidy.
Public ownership and planning, relationship between plans and projects selection and investment programme; private sector projects, method of evaluation of private projects, social cost-benefit and switching values, uses and abuses of sensitivity analysis.

UNIT III
Accounting prices for traded and non-traded goods, marginal social costs and marginal social benefits, financing of projects, scale and fixing of projects, impact of project outputs on production and consumption elsewhere. Shadow wage rates and accounting rate of interest, uncertainty and investment criteria, external effects related to inputs and outputs of the project, indicators of economic worthiness in project appraisal; period of recovery, capital output ratio, accounting rate of return, benefit cost ratio, internal rate of return, net present value, economic rate of return, comparisons of indicators.
Practicals

Time value of money. Computation of interest rate using different methods. Case studies on project appraisal and evaluation using both methods of project evaluation; Undiscounted measures and Discounted measures. Social cost benefit analysis. Sensitivity analysis

Suggested Readings


## 3 Agricultural Engineering

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 510/ES 510</td>
<td>SOIL &amp; WATER CONSERVATION ENGINEERING</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AE 527</td>
<td>OPERATIONS RESEARCH</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AE 528</td>
<td>INSTRUMENTATION IN AGRICULTURAL ENGINEERING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 531</td>
<td>ENVIRONMENTAL ENGINEERING FOR PLANTS AND ANIMALS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AE 614</td>
<td>DYNAMICS OF FARM MACHINERY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 616</td>
<td>PRODUCTION TECHNOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 622</td>
<td>OPEN CHANNEL HYdraulics</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AE 623</td>
<td>SOIL MECHANICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AE 627</td>
<td>FLUID MECHANICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AE 630/PHT 630</td>
<td>HEAT AND MASS TRANSFER</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AE 632</td>
<td>DESIGN OF STORAGE STRUCTURES</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AE 655</td>
<td>TESTING AND EVALUATION OF AGRICULTURAL EQUIPMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 656</td>
<td>IRRIGATION ENGINEERING FUNDAMENTALS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 621</td>
<td>GROUNDWATER DEVELOPMENT AND MANAGEMENT TECHNOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 629</td>
<td>SIMULATION MODELLING IN ENGINEERING SYSTEMS</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE 609</td>
<td>ERGONOMICS AND SAFETY IN AGRICULTURAL OPERATIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 615</td>
<td>SOIL DYNAMICS IN TILLAGE AND TRACTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 619</td>
<td>TRACTOR SYSTEMS DESIGN</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 620</td>
<td>GIS AND REMOTE SENSING FOR LAND WATER RESOURCE MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 625</td>
<td>ADVANCED HYDROLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AE 626</td>
<td>FARM DRAINAGE SYSTEM DESIGN</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AE 629</td>
<td>IRRIGATION SYSTEM DESIGN</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>AE 631/</td>
<td>DRYING AND DEHYDRATION</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>PHT 631</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>AE 633</td>
<td>DESIGN OF PROCESSING PLANTS</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AE 642</td>
<td>FARM STRUCTURES AND ANIMAL HOUSING</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE 645</td>
<td>NUMERICAL METHODS IN FLUID FLOW AND HEAT TRANSFER</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE 657</td>
<td>COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE 659</td>
<td>ENERGY CONSERVATION AND MANAGEMENT IN AGRICULTURE</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE 691</td>
<td>SEMINAR</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR016</td>
<td>BASIC AGRICULTURAL ENGINEERING</td>
<td>1</td>
</tr>
<tr>
<td>AE 530/</td>
<td>ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS</td>
<td>2</td>
</tr>
<tr>
<td>PHT 530</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AE 543/</td>
<td>SEED PROCESSING</td>
<td>2</td>
</tr>
<tr>
<td>SST 543</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AE 554</td>
<td>ADVANCED FOOD PROCESSING ENGINEERING</td>
<td>2</td>
</tr>
<tr>
<td>AE 608/</td>
<td>RENEWABLE ENERGY CONVERSION SYSTEMS</td>
<td>2</td>
</tr>
<tr>
<td>ES 608</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AE 610</td>
<td>THEORY OF ELASTICITY AND STRESS ANALYSIS</td>
<td>3</td>
</tr>
<tr>
<td>AE 618</td>
<td>ADVANCED FARM MACHINERY DESIGN</td>
<td>2</td>
</tr>
<tr>
<td>AE 628</td>
<td>FLOW THROUGH POROUS MEDIA</td>
<td>2</td>
</tr>
<tr>
<td>AE 634</td>
<td>UNIT OPERATIONS IN AGRICULTURAL PROCESS ENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>AE 652</td>
<td>WATERSHED HYDROLOGY AND MANAGEMENT</td>
<td>2</td>
</tr>
<tr>
<td>AE 653</td>
<td>MODELING IN INTEGRATED WATER RESOURCE MANAGEMENT</td>
<td>2</td>
</tr>
<tr>
<td>AE 655</td>
<td>ADVANCED GROUND WATER HYDRAULICS</td>
<td>3</td>
</tr>
<tr>
<td>AE 656</td>
<td>MACHINERY SYSTEMS FOR PRECISION AGRICULTURE</td>
<td>2</td>
</tr>
<tr>
<td>AE 691</td>
<td>SEMINAR</td>
<td>1</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Tech.:** AE 528, AE 529, AS 501, AS 550 and CS 501

**Ph.D.:** AE 527
AGRICULTURAL ENGINEERING

Major Fields:  
- Farm Power and Equipment
- Soil and Water Conservation Engineering
- Agricultural Processing and Structures.

Minor Fields:  
- Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
- M.Tech. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 016 BASIC AGRICULTURAL ENGINEERING  (IL+IP) III

Objective
To acquaint with basic principles of agricultural engineering

Theory
UNIT I  
Scope and application of Agricultural Engineering

UNIT II  
Farm power, sources and scope of mechanization, use of farm engines, power tillers and tractors on the farm, Agricultural equipment and machines for seed-bed preparation, seeding, intercultural, plant protection, harvesting and threshing.

UNIT III  
Soil and water conservation engineering; soil erosion- types; causes and control; soil conservation structures; irrigation wells; irrigation equipment including micro-irrigation.

UNIT IV  
Agricultural processing and structures: cleaning, grading, drying, milling, storage structure and materials handling and greenhouses.

Practicals
Classification of farm equipment based on different criteria, calibration of equipment, familiarization with different type of soil erosion and control structures, irrigation and drainage system, post harvest processes and equipment.

Suggested Readings
Liljedhal et al. Tractor and Their Power Units. John Wiley and Sons.
AE 510/ES 510 SOIL & WATER CONSERVATION ENGINEERING (3L+0P) I

Objective
To acquaint and equip with the process of soil and water conservation design of erosion control structures.

Theory

UNIT I
Concepts of soil and water conservation; relevance of soil and water conservation in agriculture; productivity loss due to soil erosion; moisture stress and moisture excess.

UNIT II
Types of soil erosion; mechanics of water erosion of soil; effect of land preparation and cultivation practices on soil erosion; theories of sediment yield and sediment transport; bed load movement; measurement of sediment yield and sediment transport; effective life of dams and water detention structures; effect of soil erosion on the life of multi-purpose river valley projects; soil erosion loss and fertility; erosion in water conveyance systems.

UNIT III
Design of channel for erosion control; maximum permissible velocity; hill soil erosion; land slides; mechanics of wind erosion; types of wind erosion and soil movement; wind erosion control measures.

UNIT IV
Analysis of hydrologic data including rainfall, evapo-transpiration; watershed characteristics; overland flow; methods of estimation of runoff; peak rate and time distribution of hydrograph; synthetic hydrograph; infiltration process.

UNIT V
Hydrologic evaluation of land treatment; flood routing; erosion control; design of soil conservation structures; farm ponds and temporary storage reservoirs, drop structures; chute spill ways; temporary storage reservoirs; small earth dams.

UNIT VI
Aforestation and associated agronomic practices; the role of river valley projects; soil conservation department, CADA etc. in undertaking soil and water conservation work.

Suggested Readings

AE 527 OPERATIONS RESEARCH (3L+0P) I

Objective
To develop scientific skill for solving problems involving integrated systems of man-machine and material.
Theory

UNIT I
Introduction to methods of operations research, formulation of problems and construction of models.

UNIT II
Linear programming, solution to linear programming problems, sensitivity analysis, duality in linear programming.

UNIT III
Network analysis including flow, shortest route, minimal spanning tree, PERT and CPM

UNIT IV
Transportation and assignment problems; sequencing and scheduling, inventory control, replacement models.

UNIT V
Markov chains, dynamic programming

Suggested Readings


AE 528 INSTRUMENTATION IN AGRICULTURAL ENGINEERING (2L+1P) I

Objective

To acquaint and equip with the concept of instrumentation and measuring devices in Agricultural Engineering

Theory

UNIT I
Basic concepts of measuring systems, generalized measuring systems, classification of instruments, performance characteristics, errors and uncertainties.

UNIT II
Stress analysis, different types of transducers, application of electrical strain gauges.

UNIT III
Advanced techniques of measurement of force, torque, power and pressure, fluid flow rates, temperature, calorific value etc.

UNIT IV
Basic signal conditioning and monitoring devices, data acquisition system, data storage and their applications.
Practicals

Identification of components of generalized measuring system, Calibration of instruments, Experiment on LVDT, strain gauge transducer, force, torque, power and pressure, fluid flow rates, temperature, calorific value, vibration measurement, Use of data loggers and data storage devices

Suggested Readings

Beckwith, T.G. *Mechanical Measurements*. Addison-Wesley.

AE 529 SIMULATION MODELLING IN ENGINEERING SYSTEMS (2L) II

Objective

To acquaint and equip with the dimensional analysis, modeling and simulation in engineering systems

Theory

UNIT I
Scope of dimensional analysis and simulation modeling, transformation of units of measurement.

UNIT II
Dimensional homogeneity, Buckingham’s Pi theorem, simulation for system modeling, simulation models-formulation and testing.

UNIT III
Simulation modeling as applied to problems of stress analysis, fluid mechanics, and heat transfer.

UNIT IV
Mathematical modeling through ordinary differential equation of first order, second order and partial differential equation.

UNIT V
Application of simulation modeling to problems of agricultural engineering.

Suggested Readings

Langhaar HL. *Dimensional Analysis and Similitude*. McGraw Hill.

AE 530/PHT 530 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS. (2L+1P) III

Objective

To acquaint and equip with different techniques of measurement of engineering properties and their importance in the design of processing equipment.
Theory

UNIT I
Biological materials, uniqueness in relation to other materials; physical characteristics viz. dimensions, density, volume, porosity and surface area.

UNIT II
Concept of rheology; rheological equations for stress and strain; visco-elastic characteristics of food materials.

UNIT III
Aerodynamic and hydrodynamic properties; thermal, electrical and optical properties.

UNIT IV
Applications of engineering properties in design and operation of agricultural equipment and systems

Practicals
Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, firmness and hardness of grain, fruits and stalk.

Suggested Readings

AE 531 ENVIRONMENTAL ENGINEERING FOR PLANTS AND ANIMALS (3L+0P) I

Objective
To study environment engineering principles for enhanced productivity and health of plants and animals

Theory
UNIT I
Description of aerial environment near the earth's surface

UNIT II
Transport processes in soil; environmental interactions of biological systems and their physical surroundings emphasizing biological response of animals and plants
UNIT III
Design of efficient environmental control machines and systems to enhance productivity and health

Suggested Readings

AE 543/SST 543 SEED PROCESSING (2L+IP) III

Objective
To acquaint and equip with processing of seeds and the design features of the equipment used for their processing.

Theory
UNIT I
Introduction to seed processing; preparing seed for processing.
UNIT II
Seed drying; cleaning and grading; seed treatment; seed handling; weighing and bagging.
UNIT III
Seed storage; construction, layout and installation of seed processing plant.
UNIT IV
Economics of seed processing; management of seed processing plant.

Practicals
Study of various seed processing equipment such as pre-cleaners, scalpers, air screen cleaners, graders, spiral and pneumatic separators, seed treating equipment, and their performance evaluation, design and layout of seed processing plant; effect of drying temperature and duration of seed germination and storability.

Suggested Readings

AE 554 ADVANCED FOOD PROCESSING ENGINEERING (2L+1P) III

Objective
To acquaint and equip with different unit operations of food industries and their design features.
Theory

UNIT I
Thermal processing: death rate kinetics, thermal process calculations, methods of sterilization and equipment involved, latest trends in thermal processing. Evaporation: properties of liquids, heat and mass balance in single effect and multiple effect evaporator, aroma recovery, equipment and applications. Drying: rates, equipment for solid, liquid and semi-solid material and their applications, theories of drying, novel dehydration techniques

UNIT II
Non-thermal processing: microwave, irradiation, ohmic heating, pulsed electric field preservation, hydrostatic pressure technique etc.

UNIT III
Freezing: freezing curves, thermodynamics, freezing time calculations, equipment, freeze drying, principle, equipment. Separation: mechanical filtration, membrane separation, centrifugation, principles, equipment and applications, latest developments in separation and novel separation techniques.

UNIT IV
Extrusion: theory, equipment, applications. distillation and leaching: phase equilibria, multistage calculations, equipment, solvent extraction.

Practicals
Solving problems on single and multiple effect evaporator, distillation, crystallisation, extraction, leaching, membrane separation and mixing, experiments on rotary flash evaporator, humidifiers, reverse osmosis and ultra filtration - design of plate and packed tower, visit to related food industry.

Suggested Readings

AE 555 TESTING AND EVALUATION OF AGRICULTURAL EQUIPMENT (2L+1P) I

Objective
To acquaint and equip with the procedure of testing and performance evaluation of farm power and machinery as per test standards.
Theory

UNIT I
Types of tests, test procedures, national and international codes.

UNIT II
Test equipment, uses and limitations.

UNIT III
Laboratory and field testing of selected agricultural equipment.

UNIT IV
Analysis and interpretation of test data, case studies.

Practicals

Laboratory and field testing of selected farm equipment. Interpretation and reporting of test results.

Suggested Readings


*Indian Standard Codes for Agril. Implements*. Published by ISI, New Delhi.


Nebraska Tractor Test Code for Testing Tractor, Nebraska, USA.


AE 556 IRRIGATION ENGINEERING FUNDAMENTALS (2L + 1P) I

Objective

To understand the basics and development of irrigation for design of systems in different soil-crop and climatic conditions for efficient use of water.

UNIT I
Water resources and status, irrigation water availability; irrigation statistics and development, concepts of irrigation; irrigation principles.

UNIT II
Evapotranspiration fundamentals and measurements, estimation of water requirement in different methods of irrigation, water budgeting, principles of irrigation scheduling and water application in relation to soil-plant and climatic parameters, soil water measurements, water infiltration.

UNIT III
Design and installation of different irrigation structures; irrigation pumps, design of systems for direct pumping from flowing streams, small reservoirs, wells and tube wells, linking of reservoir with pressurized irrigation system.
UNIT IV
Canal network, planning and design of water course network; hydraulic design of the canal delivery system; lining of canal, irrigation water demand; design of canal capacities and distribution systems; pressurized irrigation in canal command, concept of equity in water distribution

UNIT V
Irrigation hydraulics, water advance and recession, water use efficiency and irrigation efficiencies; farmers’ participation in irrigation water management, surface irrigation operation & evaluation, underground water conveyance systems, water law & water rights.

Practicals
Water distribution network, irrigation structures, lining of canals, soil water content measurement, surface irrigation evaluation, evaluation of drip system, evaluation of sprinkler system.

Suggested Readings

AE 608/ES 608 RENEWABLE ENERGY CONVERSION SYSTEMS (2L+1P) III

Objective
To equip with engineering concepts on renewable energy conversions and uses.

Theory
UNIT I
Energy cycle of the earth, energy flow and storage, renewable energy sources,

UNIT II
Thermodynamics of energy conversion, conversion systems of solar energy, wind energy, biomass energy, hydraulic energy.

UNIT III
Concepts of hybrid and integrated energy conversion systems.

UNIT IV
Applications and economics of different renewable energy systems in agriculture.
Practicals
Experiments on concepts and processes mentioned in theory.

Suggested Readings

AE 609 ERGONOMICS AND SAFETY IN AGRICULTURAL OPERATIONS (2L+1P) II

Objective
To design machines, tools and work environment based on human capabilities and limitations.

Theory
UNIT I
Importance and scope of ergonomics in Indian agriculture; Assessment of occupational health hazards on Indian farms.
UNIT II
Anthropometry and biomechanics.
UNIT III
Work physiology, stress indices and their methods of measurement: mechanical efficiency of work and assessment of work performance; work physiology in various agricultural tasks, and sustainable limits.
UNIT IV
Ergonomics and safety considerations in the tools, equipment, controls and work space; injury concept and prevention methods, injury severity assessment, determination of postural discomfort, Farm safety legislation
UNIT V
Mechanical environment; noise, vibration, dust and illumination and their physiological effects;

Practicals
Assessment of occupational health hazards on Indian farms, measurement of static and dynamic anthropometric dimensions, postural discomfort and overall tiredness level, assessment of tractor layout, ergonomic evaluation of hand tools used on farm, noise exposure assessment, measurement of vibration, assessment of dust concentration in breathing zone of a worker, analysis of an injury using Haddon’s Matrix

Suggested Readings
Grand Jean, E. “Human Factors in Engineering Division.” Taylor and Francis


**AE 610 THEORY OF ELASTICITY AND STRESS ANALYSIS**  
(3L+0P) III

**Objective**

To acquaint and equip students with different techniques/methods of stress analysis and its application in agricultural machine design

**Theory**

UNIT I

Plane stress-strain relationships, Analysis of stress and strain in three dimensions torsion, bending of bars.

UNIT II

Thermal stresses, stress analysis in agricultural machine design.

UNIT III

Problem solving and case studies.

**Suggested Readings**


**AE 614 DYNAMICS OF FARM MACHINERY**  
(2L+1P) I

**Objective**

To acquaint and equip with dynamic force analysis for farm machinery component designs

**Theory**

UNIT I

Farm machine systems characteristics and evaluation.

UNIT II

Analysis of forces, motion and their equilibrium in the elements of farm machines.

UNIT III

Dynamic balancing and stability of farm machines, analysis of typical problems in tractor implement systems.

UNIT IV

Research reviews on design and analysis of farm machines and components.
Suggested Readings


AE 615 SOIL DYNAMICS IN TILLAGE AND TRACTION (2L+1P) II

Objective

To acquaint and equip with the dynamic properties of soil, soil failure and design of tillage tools, prediction of traction performance and dimensional analysis of different variables related to soil-tire system.

Theory

UNIT I
Dynamic properties of soil and their measurements.

UNIT II
Stress-strain relationship in soil, failure pattern.

UNIT III
Pulverization, effect of speed; relationship of soil parameters to forces acting on tillage tools.

UNIT IV
Design of soil working implements; mechanics and design of traction and transport devices.

Practicals

Relationship of soil parameters to the forces acting on tillage tools, wheel slippage and tyre selection, design and performance of traction devices and soil working tools.

Suggested readings


AE 616 PRODUCTION TECHNOLOGY

Objective
To acquaint and equip with advance techniques of production of agricultural machines

Theory
UNIT I
Reliability of engineering product, risk analysis, workshop planning and layout.
UNIT II
Theory of plastic properties and heat treatment of metals, workshop practices applied in prototype production.
UNIT III
Common tools, press operations: theory and practice of welding; welding processes; metal cutting and machining process; jigs, fixtures and gauges; casting and die casting processes.
UNIT IV
Non-traditional methods of machining.
UNIT V
Computer aided manufacturing system, CNC, DNC, robotics.

Practicals
Hands on practices on different aspects covered in the theory.

Suggested Reading

AE 618 ADVANCED FARM MACHINERY DESIGN

Objective
Design of power operated agricultural machines including computer simulated designs.

Theory
UNIT I
Principles of design and development of agricultural machines; hydraulic and mechanical power transmission systems; linkages on agricultural machines safety devices on farm equipment.
UNIT II
Design characteristics and force analysis of various soil working tools; design standards and operation of seed drills and planters; design and operation of machines for chemical plant protection.
UNIT III
Design of forage, root crops and grain harvesting equipment; design factors and equipment for threshing and winnowing of crops.
UNIT IV
Utilization efficiency and performance of various agricultural machines; introduction to computer simulated designs.
Practical
Design of power transmission system with case study of vertical conveyor reaper, design of seed metering devices, aqua-ferti seed drill, okra planter, raised bed planter and zero till drill, designs of threshing and feeding units, introduction to computer simulated designs.

Suggested Readings

AE 619 TRACTOR SYSTEMS DESIGN (2L+1P) II

Objective
To acquaint and equip with the latest design procedures of tractor and its systems.

Theory
UNIT I
Thermodynamic principles of I.C. engine, testing of I.C. engine, engine design principles, modern trends in tractor design.

UNIT II
Traction, drawbar performance, mechanics of 2WD & 4WD farm tractors, tractor stability analysis.

UNIT III
Mechanical and power Steering, tractor hydraulics, power transmission systems, tractor tests and performance.

UNIT IV
Tractor test codes, pollution control technologies, human engineering factors in tractor design, Indian tractor industry.

Practicals
Practicals on the systems mentioned in the theory.

Suggested Readings
Objective

To acquaint and equip the techniques of remote sensing and application of GIS for land and water resources management.

UNIT I
Introduction to the Geographic Information System (GIS) and Remote Sensing (RS); Advantage of GIS and RS in management of land and water resources.

UNIT II
Application of GIS and RS in preparation of land use, soil type, water resources maps.

UNIT III
Use of the delineated maps as input to different process based models for quantification of surface and ground water resources; Use of the tools in change detection studies; disaster management; delineation of waterlogged and degraded lands and their management; design of irrigation networks, targeting potential water harvesting zones;

UNIT IV
Development of optimal land use plan based on the land and water resources on watershed basis

UNIT V
Case studies on GIS and RS application for optimal use of land and water resources.

Practicals

Familiarization with remote sensing and GIS hardware, software and their principle of working, Methods of establishing ground truth, comparison between ground truth and remotely sensed data, application of GIS packages.

Suggested Reading


AE 621 GROUND WATER DEVELOPMENT AND MANAGEMENT TECHNOLOGY

(2L+1P) I

Objective

To acquaint and equip the students with the techniques of groundwater development and management

Theory

UNIT I
Occurrence of groundwater, temporal and spatial variability of groundwater, methods for groundwater exploration, determination of aquifer parameters, pumping tests, assessment of groundwater potential,
UNIT II
Groundwater structures, groundwater development and utilization, types of water wells, design and construction of water wells, drilling methods, well development, well maintenance and rehabilitation, groundwater monitoring, monitoring wells, design and construction of monitoring wells.

UNIT III
Groundwater development and quality considerations, groundwater contamination, sources and causes of groundwater pollution, contaminated systems and their rehabilitation, groundwater bioremediation, management of salt water ingress in inland and coastal aquifers.

UNIT IV
Management of declining and rising water table, Natural and artificial groundwater recharge, Groundwater recharge basins and injection wells.

UNIT V
Groundwater management in irrigation command, conjunctive water use, water lifting, different types of pumps, selection of pumps, pump characteristics curve, cost of groundwater pumping, comparative economics of surface and groundwater use for irrigation.

UNIT VI
Major issues related to groundwater development and management in India, Legal aspects of groundwater exploitation, Diagnostic survey of sick wells/tube wells and their rehabilitation.

Practicals
Pumping test analysis: determination of aquifer parameters, assessment of groundwater potential, groundwater monitoring, development of conjunctive water use plan, design of tubewell and selection of screen, pump characteristics curve and selection of pumps, construction and analysis of flow net and estimation of seepage flow, groundwater modelling: physical models, application of mathematical models, selection and design of artificial groundwater recharge structure.

Suggested Readings

AE 622 OPEN CHANNEL HYDRAULICS (3L+1P) I
Objective
To acquaint and equip with hydraulics of flow in open channel
Theory
UNIT I
Open channel flow and its classification: open channels and their properties; energy and momentum principles; critical flow-its computation and analysis; uniform flow and its computation.
UNIT II
Concepts of boundary layer; surface roughness; velocity distribution and instability to uniform flow.
UNIT III
Theory, analysis and methods of computations of gradually varied flow.
UNIT IV
Hydraulic jump; gradually varied and rapidly varied unsteady flow.
UNIT V
Hydraulic structures for on-farm application and use in energy dissipation and special applications.

Practicals
Extensive practices on different aspects covered in the theory.

Suggested Readings

AE 623 SOIL MECHANICS (3L+ IP) I

Objective
To acquaint and equip with engineering properties of soil with respect to design of soil structures.

Theory
UNIT I
Physical and engineering properties of soil, stress, deformation, shear strength, consolidation, stability and compaction, gradation, moisture content, compaction of soils for earth dams, embankments, piles, foundation and walls theory.
UNIT II
Pressure distribution diagram, earth pressure theory, retaining walls, forces acting on earth retaining structures, lateral earth pressure, Coulomb’s earth pressure theory, assumptions and deficiencies, active and passive earth pressures.
UNIT III
Bearing capacity of soils, stability requirements of a foundation, soil rating, soil loading tests, Housel’s bearing capacity method, perimeter-area ratio method.
UNIT IV
Settlement and lateral expansion of soils.
Practicals

Extensive practices on different aspects covered in the theory.

Suggested Readings


AE 625 ADVANCED HYDROLOGY (3L+1P) II

Objective

To impart advanced knowledge of hydrological processes and modelling

Theory

UNIT I
Mathematical modeling of hydrologic processes-precipitation, infiltration, evapo-transpiration, run-off, soil water balance.

UNIT II
Probabilistic analysis of rainfall for irrigation scheduling.

UNIT III
Rainfall-run-off relationships; analysis of hydrographs.

UNIT IV
Watershed modeling.

UNIT V
Frequency analysis for design of hydrologic systems; time series analysis for hydrologic design and forecasting.

Practicals

Hydrologic budget, Probabilistic analysis of rainfall for irrigation scheduling and Frequency analysis-I
Probabilistic analysis of rainfall for irrigation scheduling and Frequency analysis-II, Regression analysis Time series analysis for hydrologic design and forecasting-I, Hydrologic design, Analysis of Hydrograph, Modelling of hydrological Processes

Suggested Readings


AE 626 FARM DRAINAGE SYSTEMS DESIGN (3L+IP) II

Objective
To acquaint and equip with the importance and phenomenon of drainage system along with design consideration of surface and sub-surface drainage systems.

Theory
UNIT I
Hydrologic basis for drainage system design; occurrence of floods; analysis of rainfall for drainage system design; analysis of flow into and through soil upto effective root zone depth.

UNIT II
Drainage and crop production; types of drains; surface drainage systems; sub-surface drains in homogenous isotropic soils and anisotropic heterogeneous soils; drainage for salinity control.

UNIT III
Soil dynamics in a sub-surface drained soil; computational analysis for solution of flow and draw-down problems.

UNIT IV
Basics of drainage coefficients and degree of desirable drainage; drainage structures; design, layout and construction of farm drainage systems considering rainfall, topography, soil and crops; gravity-cum-pump drainage systems.

UNIT V
Drainage using tubewells (vertical drainage); macro-drainage system considerations in design; outlet considerations, drainage modeling; legislation involved.

Practicals
Measurement of in-situ hydraulic conductivity, estimation of drainage coefficient and leaching requirements, delineation of waterlogged areas through isobar, isobath and topographic maps, design of surface and subsurface drainage systems, design of filter and envelop materials.

Suggested Readings

AE 627 FLUID MECHANICS (3L+IP) I

Objective
To acquaint and equip with the latest knowledge in the field of fluid mechanics

Theory
UNIT I
Review of fluid properties and definitions.
UNIT II
Fluids flow concepts and basic equations; kinetics and dynamics of fluid flow; method of describing motion, velocity, acceleration.

UNIT III
Euler’s equation; stress and deformation components for general cases.

UNIT IV
Fundamental equations derived from principles of mass transfer and conservation of mass, momentum and energy.

UNIT V
Ideal fluid flow requirements; vortex, irrotational and rotational flow; velocity potential; stream function; flow net.

UNIT VI
Two and three dimensional flow; boundary layer theory; velocity distribution; transition from laminar to turbulent flow; Heleshaw models.

Practicals
Extensive practical on different aspects of fluid mechanics.

Suggested Readings
Burce R. Munson, Donald F. Young. Fundamentals of Fluid Mechanics, sixth edition
Robert W. Fox and Alan T. McDonald. Introduction to fluid Mechanics.

AE 628 FLOW THROUGH POROUS MEDIA (2L+IP) III

Objective
To acquaint and equip with the hydraulics and process of water flow in the water bearing formation under saturated as well as unsaturated conditions

Theory
UNIT I
Physical and chemical properties for the medium and the fluid.

UNIT II
Theories of saturated flows; confined and unconfined flow phenomena and analysis; steady and unsteady flow phenomena and analysis.

UNIT III
Classical capillary models; parallel, serial and branching types of models; Hogen, Poissenlls, Iberal and Gibb’s theories; Venzol’s model: diffusion theory; Philip’s equation and Muskat models.
Practicals

Experiments on concepts mentioned in theory.

Suggested Readings


AE- 629 IRRIGATION SYSTEMS DESIGN (2L +1P) II

Objective

To acquire knowledge about the advances made in irrigation for design of irrigation system for water and land management

Theory

UNIT I
Methods of irrigation, selecting an irrigation method, design, construction and layout of different surface water application methods.

UNIT II
Field measurements for evaluating and improving uniformity and efficiency, hydraulic simulation of surface systems.

UNIT III
Application of Computer Software for Surface Irrigation, Surface Irrigation System, Automation; Land levelling and its effect on irrigation efficiency.

UNIT IV
Pressurized irrigation methods, sprinkle and micro-irrigation systems; hydraulics of drip system, suitability of pressurized systems and their design considerations, layout and uniformity determination; application of software for design of sprinkler and micro-irrigation systems; modeling of water dynamics under different methods of irrigation; irrigation with poor quality water.

UNIT V
Design of sub surface drip irrigation system and software and hard ware of automated micro irrigation systems; case studies on enhanced water use efficiency using micro irrigation and its socio-economic evaluations and adoption by farming community.

Practicals

Land levelling; Software’s for the design of sprinkler and drip system , Automation of surface and pressurized systems, water quality, Repair & maintenance of pressurized irrigation systems, Selection of pressurized system components.
Suggested Readings


AE 630/PHT 630 HEAT AND MASS TRANSFER (3L+0P) 1

Objective

To acquaint and equip the students with the principles of heat and mass transfer and its applications in food processing.

Theory

UNIT I
Modes of heat and mass transfer: uni- and multi-directional heat conduction; principles of conservation; boundary layer and turbulence: momentum and energy equations.

UNIT II
Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods.

UNIT III
Radioactive heat transfer and its governing laws, its applications in food processing.

UNIT IV
Mass transfer; heat and mass transfer analogy; molecular diffusion of fluids; mass transfer operations; absorption; adsorption; extraction-exchange and leaching.

Suggested Readings


Objective

To acquaint and equip the students with drying and dehydration of grains and seeds and the design features of the equipments used.

Theory

UNIT I
Kinetics of moisture sorption and description, mechanism of moisture transport.

UNIT II
Theory of drying, drying rate calculation, methods of drying grains, seeds and forage crops, dehydration techniques for different food products.

UNIT III
Effect of drying and dehydration on physico-chemical compositions.

Practicals

Determination of moisture content by direct and indirect methods, determination of drying characteristics under sun, mechanical (tray type, fluidized bed type) of grains, seeds, study of different types of dryers (LSU, batch, RPEC etc)

Suggested Readings


AE 632 DESIGN OF STORAGE STRUCTURES (IL+IP) I

Objective

To acquaint and equip the students with the safe storage of food materials, design of storage structures and the design of different material handling equipments used in the industries.

Theory

UNIT I
Storage losses of food materials due to microorganisms, enzymes, moisture and insects.

UNIT II
Treatments of agricultural products for longevity in storage, equilibrium moisture content, moisture migration.
UNIT III
Different methods of storage, basic principles in design of grain storage structures, effect of friction, pressure distribution and flow characteristics, design of fans and aeration ducts,

UNIT IV
Salient features in design of cold storage structures.

Practicals
Quality evaluation of stored products, design of storage structures, cold storage, load estimation, construction, maintenance, static pressure drop, estimation of storage loss, and quality of stored products.

Suggested Readings
FAO. 1984. Design and Operation of Cold Stores in Developing Countries. FAO.

AE 633 DESIGN OF PROCESSING PLANTS (3L+0P) II

Objective
To acquaint and equip the students with the design features of different food processing equipment used in the industries, layout and planning of different food and processing plants.

Theory
UNIT I
Raw food materials, harvesting, handling and packaging of food materials.
UNIT II
Unit operations in processing plants, plant layout and its evaluation.
UNIT III
Salient features of processing plants for cereals, horticultural crops, poultry and meat products.
UNIT IV
Guidelines for design and cost analysis of processing plants.

Practical
Selection of a food processing plant system and development of a plant design report including product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.
Suggested Readings

AE 634 UNIT OPERATIONS IN AGRICULTURAL PROCESS ENGINEERING (3L+0P) III

Objective
To acquaint and equip the students with different unit operations of food industries.

Theory
UNIT I
Size reduction, sorting and grading after threshing.
UNIT II
Dehusking and milling, principles of cleaning, aspiration and ventilation.
UNIT III
Extrusion, materials handling devices and their operational features.
UNIT IV
Packaging machinery and materials.

Suggested Readings

AE 642 FARM STRUCTURES AND ANIMAL HOUSING (2L+0P) II

Objective
To acquaint and equip the students with the design of farm structures and animal housing.
Theory
UNIT I
Types of farm structures and animal housing,
UNIT II
Design of farm structures, environmental control in farms, livestock building and storage structures.
UNIT III
Green house, selection of material and equipment, cost estimation.

Suggested Readings

AE 645 NUMERICAL METHODS IN FLUID FLOW AND HEAT TRANSFER (2L+ 1P) II

Objective
To acquaint and equip with numerical methods and their application in problem solving in agricultural engineering

Theory
UNIT I
Review of governing equations and their classifications
UNIT II
Discretization procedures; stability; consistency; convergence;
UNIT III
Alternative methods; problem formulation;
UNIT IV
Applications for steady state and time dependent problems.

Practicals
Extensive practices on the methods mentioned in the theory

Suggested Readings
AE 652 WATERSHED HYDROLOGY AND MANAGEMENT (2L+1P) III

Objective
To acquaint and equip the students with the watershed management systems

Theory
UNIT I
Introduction to watershed hydrology, its management and agricultural sustainability issues; need of integrated watershed management in India; delineation of watersheds.
Hydrology of watershed systems; estimation of surface runoff and sediment yields; effect of precipitation and hydro-climatic conditions on watershed systems; watershed erosion processes and its prevention; instrumentation and measurement of watershed management indicators.
UNIT II
Mechanical and vegetative interventions for prevention of erosion and moisture conservation in watersheds; water quality issues in watersheds; optimal land use planning in watersheds.
UNIT III
Use of GPS, GIS, RS and Decision Support Systems (DSS) in watershed management; technologies for rain-fed farming; socio-economic evaluation of the watershed management projects.
UNIT IV
Peoples’ participation and livelihood analysis; cropping system and resource conservation techniques in watersheds.
UNIT V
Heuristics and indigenous technical knowledge (ITKs) in watershed management; watershed associations and groups in villages of India; Government policies, acts and schemes on watershed management

Practicals
Experiments on concepts mentioned in theory

Suggested Readings

AE 653 MODELLING IN INTEGRATED WATER RESOURCES MANAGEMENT (2L+1P) III

Objective
To acquaint and equip the students with the integrated resources management, modeling and modeling systems

UNIT I
Introduction to modeling, model types, models in soil and water resources; model selection techniques; database requirement, availability, generation and use for model development. Development of conceptual and physics based models.
UNIT II
Use of numerical methods in model development and use of Geographic Information System (GIS) tool. Advantage of model hybridization over individual model types, model calibration, validation and testing for accuracy, consistency and sensitivity.

UNIT III
Use of expert system techniques, heuristics in soil and water resources; development of expert watershed systems; use of artificial Neural Networks in modeling.

Practicals
Application of Models in integrated resources management. Application of watershed models.

Suggested Readings

AE 655 ADVANCED GROUND WATER HYDRAULICS (3L+0P) III

Objectives
To impart advance knowledge on groundwater flow and solute transport.

Theory
UNIT I
Aquifers and aquifer materials, aquifer parameters, homogeneity and isotropy, hydraulic head and fluid potential,

UNIT II
Principals of groundwater flow, Darcy's law, Darcy's experiment, potential flow, flow nets and seepage analysis, groundwater flow equation, solution of groundwater flow equation, Well hydraulics, steady and unsteady flow through fully penetrating and partially penetrating wells in confined, semi-confined and unconfined aquifers, multiple wells and interference between wells, initial and boundary conditions, flow into aquifer with different boundaries,

UNIT III
Solute transport, advection and dispersion, sorption and diffusive mass transfer, pollution dynamics, hydrodynamics dispersion,

UNIT IV
Introduction to groundwater models, analytical and numerical modelling of groundwater flow, Modeling regional groundwater flow and contaminant transport, Sea water intrusion in inland and coastal aquifers, Gyben-Herzberz principle of salt-water intrusion,

UNIT V
Groundwater recharge mechanism, Application emerging of techniques in groundwater investigation.

Suggested Readings
Princeton University Press, Princeton, NJ

AE 656 MACHINERY SYSTEMS FOR PRECISION AGRICULTURE (2L+1P) III

Objective
To acquaint and equip with the farm machinery used for natural resources management and
machinery for precision farming. Use of GIS and GPS in farm machinery

UNIT I

UNIT II
Variable rate technology. Precision chemical application. Crop yield monitors.

UNIT III
Decision support systems; artificial intelligence.

UNIT IV
Precision sowing and planting machines, laser guided leveler.

UNIT V

Practicals
Introduction to GIS and GPS, study of models vis-à-vis farm machinery usage. Precision farming
using GIS and GPS – case study. Study the mechanism of power shovels, drag lines, earth diggers,
clamshells etc. earth work estimation, unit cost of operation, work scheduling, machinery
maintenance, entrepreneurship

Suggested Readings
De Mess, M.N. Fundamental of Geographic Information System. John Willy and Sons, New
York
Lille Sand, T. and Kaiffer, R. Remote Sensing and Image Interpretation, John Willy and Sons,
London.
AE 657 COMPUTER AIDED ANALYSIS AND DESIGN OF FARM MACHINERY  (2L+1P) II

Objective
To acquaint and equip with the computer aided design, analysis and manufacturing of farm machinery with the help of CAD.

Theory
UNIT I
Computer aided design principles of machines. Computer representation of models and drawings.
UNIT II
Features of various solid modeling packages. Usage of packages for dynamic analysis of farm machines and its components.
UNIT III
UNIT IV
Solid and wire frame modeling of components of tractor, seed drills and threshers.
UNIT V
Structural analysis and fatigue analysis of tractor and machinery systems Graphic analysis of cutter bar mechanism.

Practicals
Practical on CAD software, its uses and application in design of farm machinery. Design procedures. Exercise on agricultural engineering system analysis. Description of the machinery scheduling problem in harvesting and transport system. Investigation of existing software models – cases studies.

Suggested Readings

AE 659 ENERGY CONSERVATION AND MANAGEMENT IN AGRICULTURE  (2L+0P) II

Objective
To acquaint and equip with the energy use pattern in agriculture production systems, conservation of energy, energy planning and economics.

Theory
UNIT I
Farm energy resources, their forms and uses, energy coefficients for agricultural inputs and products.
UNIT II
Energy consumption patterns in agricultural production and processing sectors, energy conservation and waste minimization methods, energy efficient machinery systems.

UNIT III
Energy management concepts, energy audit, energy costs, energy performance, system efficiencies, material and energy balance, financial analysis.

UNIT IV
Energy forecasting and demand-supply optimization, fuel and energy substitution, energy action planning.

Suggested Readings
## Agricultural Extension

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS 502</td>
<td>TECHNICAL WRITING AND COMMUNICATION SKILLS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PGS 505</td>
<td>AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>AG EXT 501</td>
<td>FUNDAMENTALS OF EXTENSION EDUCATION AND EXTENSION PROGRAMMES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 503</td>
<td>FUNDAMENTALS OF PSYCHOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 551</td>
<td>FUNDAMENTALS OF COMMUNICATION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 553</td>
<td>DIFFUSION AND ADOPTION OF INNOVATIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 557</td>
<td>TRAINING FOR HUMAN RESOURCE DEVELOPMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 601</td>
<td>ADVANCES IN AGRICULTURAL EXTENSION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 602</td>
<td>MONITORING, EVALUATION AND IMPACT ASSESSMENT TECHNIQUES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 604</td>
<td>ADVANCED MANAGEMENT TECHNIQUES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 605</td>
<td>DEVELOPMENT COMMUNICATION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 691</td>
<td>SEMINAR</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 008</td>
<td>ON FARM EDUCATION AND VISITS TO DIFFERENT INSTITUTIONS</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>PGS 502</td>
<td>TECHNICAL WRITING AND COMMUNICATION SKILLS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PGS 505</td>
<td>AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>AG EXT 502</td>
<td>RURAL SOCIOLOGY AND DYNAMICS OF PLANNED CHANGE</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 505</td>
<td>E- EXTENSION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 509</td>
<td>PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 552</td>
<td>EXTENSION METHODS AND COMMUNICATION TECHNOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 556</td>
<td>ORGANIZATIONAL BEHAVIOUR</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 559</td>
<td>METHODS OF SOCIAL RESEARCH</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG EXT 603</td>
<td>VISUAL AND GRAPHIC COMMUNICATION</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>AG EXT 691</td>
<td>SEMINAR</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
III TRIMESTER

AGR 015  BASICS OF EXTENSION EDUCATION  1  1
PGS 502  TECHNICAL WRITING AND COMMUNICATION SKILLS  1  1
PGS 505  AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES
AG EXT 504  DIGITAL PHOTOGRAPHY  1  2
AG EXT 510  GENDER SENSITIZATION FOR DEVELOPMENT  1  1
AG EXT 511  PERSPECTIVES OF DISTANCE EDUCATION  1  1
AG EXT 512  MARKET-LED EXTENSION MANAGEMENT  1  1
AG EXT 554  AGRICULTURAL JOURNALISM  3  1
AG EXT 555  FUNDAMENTALS OF MANAGEMENT IN EXTENSION  2  1
AG EXT 558  ENTREPRENEURSHIP DEVELOPMENT  2  2
AG EXT 606  TECHNIQUES OF MEASUREMENT IN BEHAVIOURAL SCIENCES  3  1
AG EXT 691  SEMINAR  1  -

Core Courses

M.Sc.: AG EXT 501, AG EXT 502, AG EXT 505, AG EXT 553, AG EXT 555 and AG EXT 559
Ph.D.: AG EXT 512, AG EXT 556, AG EXT 601, AG EXT 602 and AG EXT 606
AGRICULTURAL EXTENSION

**Major Fields**
- Agricultural Extension
- Agricultural Communication
- Agricultural Management

**Minor Fields**
- Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
- M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.
- The total minimum credit requirement of course work for M.Sc./Ph.D. in Agricultural Extension is 55 / 45 including Minor field(s).

**DESCRIPTION OF COURSES**

**AGR 008 ON FARM EDUCATION AND VISITS TO DIFFERENT INSTITUTIONS**

(0L+2P) II

**Objective**

The objective of this course is to acquaint remedial class students about socio-economic profile of farm families, identifying the village problems and preparation of action plan to solve them. The students will be also visiting KVKs, ICAR Institutes, SAUs and some agripreneurs to know their role in research, extension and development.

**Theory**

**UNIT I**
- On farm education: Analysis of socio-economic profiles of rural families and their farming situations, determination and prioritization of village problems, formulation of objectives, preparation of action plan, Orientation of IARI TOT and KVK activities, Educational Tour, Visit to different ICAR institutes and SAUs for orientation in agricultural research, education and extension programmes, Visit to IARI Regional stations, Understanding agro-ecological situation of the country.

**AGR 015 BASICS OF EXTENSION EDUCATION**

(1L+1P) III

**Objective**

The course is intended to orient the remedial class students with the concept of extension education and its importance in agriculture development, important extension programmes, fundamentals of communication, rural sociology and extension teaching methods.
Theory

UNIT I
Concepts and characteristics of education process, objectives, philosophy and principles of extension education, historical development of extension education and community development in India. Ongoing agricultural extension programmes at National level, KVK, IVLP, Kisan Call Centre, Front line Demonstration and ATMA.

UNIT II

UNIT III
Concept of rural sociology, social institutions, exposure to village institutions, rural value systems, culture, norms, process of socialization

UNIT IV
Concept and elements of communication, Media of Communication – mass, group, interpersonal and traditional.

Practicals
Preparation and use of visual aids – posters, charts, flash cards, flannel graphs etc., preparation of slides using powerpoint, handling of audio-visual equipments, effective presentation, exposure to village institutions, KVK, ATIC, Extension projects and Community Development Block Organisations, experimental exercise.

Suggested Readings
Van Den Ban, A.W. and Hawkins, H.S. 1998. Agricultural Extension. 2nd Ed. CBS.

PGS 502 TECHNICAL WRITING AND COMMUNICATION SKILLS (1L + 1P) I, II, III

Objective
This course is intended to expose the students about the basics skills needed for writing, reporting scientific data in the form of reports, research papers, manuals etc., and develop skill in preparing appropriate graphics to be used in such documents and presentations.

Theory

UNIT I
Basics of writing, writing style, art of clear writing: Readability and comprehension testing procedures, Principles of technical writing, purpose of technical reports, Preparing a documentation plan, Understanding information types, Gathering the data, Analyzing and sorting the results, Outlining the report
UNIT II
Use of charts, graphs, tables, diagrams and photographs, scientific photography, Graphic formats, typology, Presentation of scientific data, general and exact data, Editing, Proof reading, Bibliography

UNIT III
Role of visuals in Communication; Characteristics of visuals, functions of visuals and graphics; Theories of visual perception; Classification of visuals, visual formats, Selection of visuals, Preparing lecture slides – content, limitation and layout; its utility in preparing presentations for research papers and other publications, Public speaking.

Practicals
Writing technical reports, research papers, preparing graphics, preparing computer based presentations.

Suggested Readings

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES

Objective
The course intends to sensitize the scholars about the basic issues related with agricultural research, ethics in research as well as rural development. The scholars will be also educated about principles and philosophy of rural development and motivated towards practising and promoting ethics in research and developmental endeavours.

Theory
UNIT I
History of agriculture in brief; Agricultural Research System - NARS and CGIAR; Agricultural Revolutions; Food and Livelihood Security; Climate Change - Mitigation and Adaptation;

UNIT II
Principles and foundations of research ethics; Publishing and Authorship, Plagiarism, Intellectual Property Rights and Policy, Researchers’ responsibilities, Research participants’ rights- consent, Privacy and confidentiality; Interviewing ethics; Agricultural research and bioethics; Incentives, Regulation and Activism for ethics; Ethics in agriculture-social contract, socio-economic issues, environment etc; Indigenous knowledge and benefit sharing.
UNIT III
Ethics and development; Process and outcome of development; Vulnerable groups; Social justice and Equity; Gender sensitivity; Principles, policies and strategies for rural development, Overview of rural development programmes in India; Panchayati Raj Institution; Role of voluntary and non-governmental organisations in rural development.

Suggested Readings


Minakshi Bhardwaj, Fumi Maekawa, Yuki Niimura, Darryl RJ Macer*. 1999. Ethics in Food and Agriculture: Views from FAO.

Rivera, Roberto and David Borasky 2009. Research Ethics Training Curriculum, Family Health International. P.O. Box 13950 Research Triangle Park, NC27709. USA


AG EXT 501 FUNDAMENTALS OF EXTENSION EDUCATION AND EXTENSION PROGRAMMES (3L + 1P) I

Objective

The course is intended to orient the students with the concept of extension education and its importance in agriculture development and also to expose the students with various rural development programmes aimed at poverty alleviation and to increase employment opportunities and their analysis. Besides, the students will be learning about the extension system worldwide and new dimensions of Agricultural Extension in India.

Theory

UNIT I
Origin and growth of extension in India and World, Meaning and aims of education and their implication to extension education, andragogy and pedagogy, Principles and theories of adult learning, Concepts, meaning and objectives of extension education, Analysis of various definitions of extension education, Conceptual and philosophical similarities and differences between extension education and extension work, community development, TOT, Role of extension in agricultural development.
UNIT II
A brief history of development of Agricultural Extension System (AES) in India, Early efforts of community development in India/Pioneering extension efforts and their implications in Indian Agricultural Extension, Reorganized extension system (T&V system), Community Development Programme and National Extension Service, Approaches of rural development, Poverty Alleviation Programmes, Employment Generation Programmes, Women Development Programmes.

UNIT III
Agricultural Extension System of the following countries with brief history, approaches, organizational structure, linkage with research and extension methods used. Africa: Kenya, Zambia, Ethiopia, Tanzania Asia: China, India, Indonesia, Japan, and Sri Lanka Europe: Netherlands, Denmark, and United Kingdom Latin America: Brazil and Mexico North America: USA, The Near East: Egypt and Israel. Extension System in SAARC Countries. Successful extension approaches, brief account of methodology and reasons for success; FAO small farmers development projects: Masagana 99 Programme of Philippines; BIMAS programme of Indonesia; Social laboratory Experience of Philippines; and building self-help groups for extension in Philippines; Micro-finance in Bangladesh.

UNIT IV
Overview of reforms in extension, Analysis of different approaches, Systems and models of Extension, Farmers participatory approaches, Farmers' First and Farmers Last model, Farming system research and extension, Introduction to participatory techniques (RRA, PRA, PLA), Front line extension projects of ICAR, Extension role of SAUs and ICAR institutes. Innovations in extension, NATP, IVLP, TAR, ATMA, ATIC, Farmer Field School; Importance, principles and process in developing sound extension programmes; Need assessment and People's participation in extension programmes; Critical analysis of various agricultural and rural development programmes; Programmes for gender empowerment, Self Help Group approach for rural development.

Practicals
Analysing the organisational set up and functions of the Directorate of Extension, MOA, Extension Division of ICAR, Directorate of Extension, SAU, KVK, Corporate /Private / NGO, Experience in Technology Assessment, FSR, PRA techniques.

Suggested Readings
Van Den Ban, A.W. and Hawkins, H.S. 1998. Agricultural Extension. 2nd Ed. CBS.

AG EXT 502 RURAL SOCIOLOGY AND DYNAMICS OF PLANNED CHANGE (3L+1P) II

Objectives
The course is intended to orient the students with the basics of sociological principles and group dynamics for bringing planned change in a community. Understanding of rural society, values
and culture will entail better planning for extension change programmes. Besides, the students will be learning about group dynamics approach to bring about planned changes in rural community.

Theory

UNIT I
Rural Sociology and extension education–its significance for social researchers. Basic Concepts in Sociology – society, social structure, community, social institution, culture, social change, cultural change, social system, social process, social values, norms, folkways, mores, customs; cultural relativism, cultural integration, cultural lag, acculturation; Family, Kin and Clan – its relationship with group behaviour and rural development; Social Stratification: class and caste system, their impact on rural development.

UNIT II
Groups – concept, development and norms, process of group formation and mobilization. Self Help Groups for development, Group Dynamics – Concept, theories and impact on rural community, transactional analysis and interaction analysis T-group and L group, Group behaviour and patterns of action – some Indian experiences.

UNIT III
Leadership – concept, types and range of leadership behaviour and principles of leadership in community development work; Values, Folkways, Norms, Mores, Social Sanctions etc., Social Process and Social Interaction – Concepts, types, Competition, Conflict, Cooperation, Accommodation and Assimilation, and change in social process due to developmental programmes.

UNIT IV
Dynamics of change – concept, types and importance in rural community, people's institutions for development; Typology of change- planned, indoctrinational, technocratic, coercive, emulative, etc; Theories of social change – Immanency, Functionalism, Economic, Technological, Historical, Ideological, Evolutionary and Field Theory; Factors affecting change under rural settings; Stimulants and Barriers to change. Social Capital, Collectivism- Interdependence in larger groups, conformity and functional analysis of roles.

Practicals

Visit to a village to study rural institutions. Preparation of a social map of a village with the help of villagers. Focus group discussions to identify stimulants and barriers to changes existing in rural community, Exercises on transactional analysis, interaction analysis and mobilizing groups; Exercises on small group interaction i.e., T group and laboratory training method.

Suggested Readings

Objective

The course is intended to orient students with the applied aspects of psychology which are essential for extension professionals to enhance their understanding of human behaviour. It will equip them with the knowledge and skills to work effectively with rural people.

Theory

UNIT I
Psychology as a science and its importance in extension education, Perception- nature, selectivity & laws, importance of perception in extension work, Attitude- meaning, characteristics, studying attitudes of farmers in field situations, formation of stereotypes and prejudices and factors in attitude change.

UNIT II
Motivation- nature, characteristics and types of motives, techniques of motivating farm people, Emotion- its nature, types of emotional response, theories of emotion, self-motivation; harnessing emotions productively, empathy, reading emotions, role of emotion in regulating human behaviour, Psychosocial distress and coping mechanisms in farming situations.

UNIT III
Learning- indicators, principles and theories of learning and experiential learning. Personality - individual differences and theories of personality, Multiple Intelligences- IQ, emotional intelligence, social intelligence, managing emotions; relationship between IQ and EQ, handling relationships; social skills. Defence mechanisms- types and importance.

UNIT IV
Psychological dimensions of poverty and deprivation- self esteem, cognitive processes of deprived groups, motivational consequences, aspiration, achievement, aggression, attribution and coping with poverty; helplessness and powerlessness studies.

Practicals

Measuring motivation- TAT, sentence completion, etc., Exercise on Emotional Quotient. Role Play – Emotional Self-Management. Visit to Psychology Department of Delhi University/ JNU/ ICSSR. Knowing self and knowing others. Experiential Learning Exercise

Suggested Readings


Objective

The students need to have knowledge and skill to communicate with visuals. The knowledge and understanding of photography is essential in designing of messages and for preparing other communication materials used for extension work and scientific report writing. Documenting of research and extension activities, post intervention development monitoring are important areas where photography is extensively used. Students orientation in photography will improve the extension work they execute.

Theory

UNIT I
Basic Science of Photography; Camera: Evolution, its components, functions, uses and accessories, Digital Camera, its difference with conventional film camera; Lenses: Photographic lenses, Lens aberrations, Resolving power, Type of lenses, their application. Exposure: Light intensity and film speed, Exposure controls, Effect of aperture and shutter speed, over, correct and under exposures. Exposure meters

UNIT II
Light: Fundamentals, Lighting techniques, daylight and artificial light, creating different photographic setups to suit scientific samples; Depth of field: Sharpness, Variables controlling Depth of Field, Influence of aperture and shutter speed in picture making. Picture: Elements of a picture, Photographic composition, Forms, Feelings, Balance, Cohesion and aesthetics.

UNIT III
Electronic imaging: Digital photography, Photographing with digital cameras and its controls, capturing digital images using scanners and Digital Image Processing, Controlling brightness and contrast; Controlling tones dodging and burning tools; Colour controls -using hue, saturation and variations;

UNIT IV
Output: intricacies of printing digital images, Computer printing and photographic paper printing; Output for on-screen presentations and for web pages; Preparing lecture slides - content limitation and layout; its utility in preparing presentations for research papers and other publications; Applications: In Agriculture, Scientific Photography, Communication, Scientific presentation and Extension work.

Practicals


Suggested Readings

Longford, Michael 1986. Basic Photography, Focal Press
AG EXT 505 E-EXTENSION (2L+1P) II

Objective
Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. reaching the unreached.

Theory
UNIT I
ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities.

UNIT II
ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc.

UNIT III

UNIT IV

Practicals

Suggested Readings

AG EXT 509 PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER (2L+1P) II

Objective
This course is intended to orient the students with the key concepts, principles process of different participatory approaches for technology development and transfer and also to expose the students
with various participatory tools and techniques like space related, time related, relation oriented methods. Besides the students will be learning the preparation of action plans participatory monitoring and evaluation.

Theory

UNIT I
Participatory extension – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.

UNIT II
Participatory tools and techniques. Space Related Methods: village map (social & resource), mobility services and opportunities map and transect; Time related methods: time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods: cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis.

UNIT III
Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practicals

Simulated exercises on space related methods, time related method and relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

Suggested Readings


AG EXT 510 GENDER SENSITIZATION FOR DEVELOPMENT (1L+1P) III

Objective

In this course the students will learn about an overview of the concept of gender and gender balance on development and develop skills of identifying gender roles, rights, responsibilities and relationships on development. Besides the students will also learn the attitudinal change to internalize gender equity concerns as fundamental human rights and also enhance the capability for identifying and analyzing gender issues in agriculture and allied sectors.

Theory

UNIT I
Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques.
UNIT II
National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors – need and relevance; Gender budgeting – a tool for empowering women.

UNIT III
Women empowerment–dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights ; Action plans for gender mainstreaming.

Practicals
Visits to rural institutions of women for studying the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for Women Development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

Suggested Readings

AG EXT 511 PERSPECTIVES OF DISTANCE EDUCATION (1L+1P) III

Objective
The course is intended to orient the students with the concept of Distance Education, Characteristics of Distance Education, Evolution, Methods of Distance Education, Different Approaches in Planning Distance Education, Educational Technology in Distance Education, Management of Resources for distance education, Strategies for maximizing the reach and programme evaluation and quality assessment.

Theory
UNIT I
Distance Education – Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education – Evolution and Historical view of Distance Education – Theory, Methodology, and Epistemology. Dimensions of Distance Education, Scope and
difficulties. Open education – Non-formal education, Continuing education, Education by correspondence.

UNIT II
Forms and systems of Distance and Open Education, Modes of Teaching and Learning in Distance Education, Methods of Distance Education, Significance of Distance Education in Teacher Education.

UNIT III
Planning Distance Education – a Systems Approach, Student learning – Course planning, target groups – Barriers to learning in Distance Education – Planning and management of networked learning.

UNIT IV
Educational technology is Distance Education, Application of information and educational technologies in Distance Education, Development of course and course material, Management of resources, processes, Forms of instructional material in Distance Education and Media Development and Production in Distance Education - Video classroom strategy in Distance Education – Strategies for maximizing the reach – services to students, programme Evaluation - performance indicators and Quality assessment.

Practicals
Visit to the University which is implementing the Distance Education Programmes. Detailed Study of their programme in relation to Educational Technology, Methodology, Curriculum Development, Evaluation and Assessment. Exercise on development of curriculum for Distance Education exclusively for farming community.

Suggested Readings
Holmberg, B. 1995. *Theory and Practice of Distance Education*. Routiedge Publ..

AG EXT 512 MARKET-LED EXTENSION MANAGEMENT (1L+1P) III

Objective
The student will learn the significance of post harvest management & value addition in present market environment and the challenges and future strategy for market led extension management. Also identifies the information sources and develop strategy for market intelligence and the marketing infrastructure, multilevel marketing and linkages for market led extension. In addition the students would be learning the public private partnerships for market led extension management, the features of contract farming, WTO its implications on agriculture and Understanding the role of IT for market intelligence.
Theory

UNIT I
Agricultural extension at cross roads; Changing scenario of agricultural extension at the national level; Market led extension – emerging perspectives; Market-led extension – issues and challenges; Dimensions of market-led extension.

UNIT II
Agricultural marketing an overview; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Marketing communication and promotional strategies; The marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPRs agreements on agriculture; Agreement on SPS and TBT - an overview; Future trading of agricultural commodities.

UNIT III
Public private linkages in market led extension; Role of SHG in market led extension; Contact farming – a viable approach to meet market challenges; IT enabled approaches for market led extension and communication; Weather service and crop modeling – an effective tool in market led extension.

Practicals
Identification and analysis of different marketing sources for agricultural commodities. Development of strategy for an effective market intelligence system; Development of suitable marketing plan to suite rural situation; Visit to APEDA, Rythu Bazaars to study the processes and procedures related to market-led extension.

Suggested Readings

AG EXT 551 FUNDAMENTALS OF COMMUNICATION (3L+1P) I

Objective
In this course, students will learn about the concept, meaning and process of communication and elements of communication, models, theories and modern media of communication.

Theory
UNIT I
Meaning and nature of communication, Why study communication, Defining communication, Communication process, Nature of communication, Purpose of communication, Levels of communication, language, words and meaning, levels and degree of abstraction, Benefits of language, hidden meaning-Non verbal communication, Communicator, Role of communicator in Extension Education, Communication behaviour
UNIT II
Key communicator, Communication skills, Fidelity of communication, Communication competence and empathy, Communication effectiveness, Credibility, Improving oral and written communication, Selection effectiveness, Credibility, Improving oral and written communication, Audience or Receivers, Feedback, Barriers in Communication, Message - meaning and dimensions of message, characteristics of good message, message treatment and effectiveness – distortion of message, Channels of communication, meaning, dimensions, classification, Communication and social change, Homophily-Heterophily, Social network, Traditional media, Mass media of communication

UNIT III
Theories and models of communication, Intrapersonal, Interpersonal and Mass Media, Effect of media mix for rural people, computer technology and its implication. Modern communication media – modern ICT tools such as video, internet, electronic video, tele-text, teleconferencing, mobile technology, computer assisted instruction, Communicating with farmers and farm women in villages.

Practicals
Exercises in written and oral communication, Exercises on Communication Planning, Communicating with farmers and farm women in villages

Suggested Reading

AG EXT 552 EXTENSION METHODS AND COMMUNICATION TECHNOLOGY
(3L+1P) II

Objective
This course is intended to expose the students to the extension education process, teaching and learning, extension methods, its classification and usage. The course also covers the Audio-visual aid used in communication, their features, selection and preparing communication material and low cost instructional aid.

Theory
UNIT I
Concepts and characteristics of education process, extension teaching and learning, Basic principles and management of learning, Course outline, Lesson plans for theory and practicals. Teaching and learning styles, theories of learning, Cognitive levels, Experiential Learning – simulation exercises, practising an experiential lecturette; Instruction system design and methods, Instructional Course Objective. Effective instructional modes for science; Evaluating teaching effectiveness; Non-directive teaching methods for team effort and creativity;

UNIT II
Extension methods; classification, features and methodology, Role of media and audio-visual aids in making extension teaching effective; Appraisal of teacher performance, Review of research in instructional technology.
UNIT III
Communication technology and Media materials: Classification, uses, Media Planning – Essential & Optional characteristics, system approach; principles of selecting effective combinations of extension teaching methods, media; Cost benefit analysis of communication media, Concepts in instructional technology Methodological issues in communication research. Media-mix and multimedia presentation; Principles of production of different projected and non-projected media. Innovative instructional aid. Computer assisted instruction. Programmed instruction technique. Team teaching. E-learning

Practicals
Practising farm and home visits, method demonstration; Preparing, pre-testing of audio and video materials and modules; Handling and maintenance of audio-visual equipment and projectors, PC and peripherals, photography, reprography, Formulation of instructional course objective, Development and presentation of course outlines, Preparation & presentation of lesson plans for theory & practical with CAI design, Preparation of innovative low cost instructional aids

Suggested Readings

AG EXT 553 DIFFUSION AND ADOPTION OF INNOVATIONS (2L+1P) I

Objective
The course intends to provide understanding of traditions and limitations in diffusion research; conceptual framework of diffusion research paradigm; models of innovation decision making process and socio-economic and cultural dynamics involved in diffusion and adoption of innovations. The course will lead to development of insight and skills among the learners for making interventions for diffusion of innovations in a social system and also to take up adoption research studies.

Theory
UNIT I
Introduction to the field: Concept of diffusion, Elements of diffusion, traditions of research on diffusion, Typology of diffusion research, Contributions and short comings of diffusion research.

UNIT II
The generation of innovations: The innovation development process, tracing the innovation-development process, converting research into practice; The adoption process: The concept and stages, shades of agreement. The neglected element – the need, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation; Decision making – meaning, theories, process, steps, factors influencing decision – making
UNIT III
Adopter categories: Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories, predicting innovativeness, Simulation of innovation diffusion; Perceived attributes of innovations and their rate of adoption; Attributes rating of current farm and home practices, Shades of proposals on attributes, factors influencing rate of adoption.

UNIT IV
The diffusion effect and the concept of over adoption; Opinion leadership and multi-step flow of innovation: Concepts of homophily and heterophily and their influence on flow of innovations, measuring opinion leadership, characteristics of opinion leaders; Monomorphic and polymorphic opinion leadership; Type of innovation – decisions: Optional, collective, authority and contingent innovation decisions; Consequences of innovations: Desirable or undesirable, direct or indirect, anticipated or unanticipated consequences;

Practicals
Content analysis of recent adoption studies, Field visit to study recently diffused innovations; Case studies in process of adoption of innovations at individual, community and Organization levels, Assessment of farmers' perceived attributes of innovations, Identification of adopter categories and their characteristics in changing agricultural scenario, Identification of opinion leaders in a social system, Study of factors/ determinants of innovation diffusion and adoption, rate of adoption, presentation of reports on adoption and diffusion of innovations.

Suggested Readings

AG EXT 554 AGRICULTURAL JOURNALISM (3L+1P) III

Objective
This course is intended to expose the students to journalism, concept, history, relevance of journalism in disseminating farm information to the stakeholders. Basic skills required for writing news and feature articles and finding out the readability of such articles, editing, layout, designing and printing are covered in the course. The students can also learn the process of creating TV and radio programmes.

Theory
UNIT I
Journalism – Concept, Theories scope; Agricultural Journalism as means of mass communication, Its form and role in rural development Opportunities, strengths and limitations; Farm Journalism – meaning and development in farm journalism in India, Problems with farm journalism,
UNIT II
Basics of Writing – News stories, feature articles, magazine articles, farm bulletins and folders; Techniques of collection of materials for news story and feature articles, Success stories, writing style of success stories, Techniques of collecting material for news stories and feature articles, Art of clear writing: Readability and comprehension testing procedures;

UNIT III
Photo Journalism; communicating with pictures; Radio and TV journalism: Techniques of writing scripts for radio and TV; Agricultural advertisements: Dynamics, types, storyboard, designing aids, Promoting agricultural products in rural areas; Fundamentals of layout and design; Research in agricultural journalism and applications, Printing methods & processes of printing different extension publications, budgeting for printing jobs. Techniques in book publishing, Techniques of editing and proof reading; Interface with editors of journals and magazines

Practicals
Processes of printing extension literature, News collection & Interview, Writing for farm magazines & folders, Designing cover page of magazines and folders, Visits to printing press.

Suggested Readings

AG EXT 555 FUNDAMENTALS OF MANAGEMENT IN EXTENSION (2L+1P) III

Objective
The major objective of these courses develop basic managerial skills needed in managing extension organization. To help the students to understand and analyse different projects to management theory. To gain knowledge and insight including tools and techniques needed for planning, decision making, directing, controlling and budgeting.

Theory
UNIT I
UNIT II
Planning – various tools and techniques for planning, planning for future, system approach to the planning process, Decision making – steps, tools and limitations, Organizing-basic elements, process and methods in organization. Organisational structure and types of organisational structures, Project organization, Matrix organization, free form organization, top management structure, Concepts of authority and responsibility, Span of management, Centralisation and decentralization, line and staff organization, signs of a poor organization, Departmentation, basic factors to be considered for grouping of activities, Service units – placement, Coordination – concept, need, types and techniques, Delegating – meaning, nature, need, principles and limits
UNIT III
Staffing, need and importance, manpower planning, recruitment, selection, placement and orientation, training and development, Performance appraisal, meaning, concept, methods, Directing, nature, ways of giving direction, Consultative direction – merits and demerits. Techniques of direction. Leadership – concept, characteristics, functions, different approaches and theories of leadership, leadership styles. Managing work motivation, different theories and approaches of motivation, Supervision – meaning, qualities and functions of supervision, essentials of effective supervision. Groups and committees, characteristics of organisational groups, team building and conflict management, Organizational Communication, concept, process, types, net works, Barriers to communication; Controlling, concept, types, methods and designing control systems, Budgeting, purpose, types of budgets, budgeting process. Auditing, internal and external, Staffing – Human resource management, HRM process, recruitment, selection, placement and orientation, Training and Development, Performance appraisal, meaning, concept and methods, Problems of agricultural management in India, Organizational climate- concept and ways to improve climate of development organisations, Recent advances in management of agricultural research and development organisations;

Practicals
Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Suggested Readings
Objective

To understand and develop skills related to organisational behaviour related to cognitive processes, management of organization for high performance and organization climate. To experience the students to make a critical assessment of different organizational behavioural processes such as perspectives, attitudes, motivation, crop process, communication process, development of tools, decision making, job designing and goal setting leadership, conflict management and organizational climate. To facilitate experiential learning of major behavioural processes such as motivation, leadership, team building, etc. through simulation games and experiential exercises which will help the students to have internal realization.

Theory

UNIT I
Introduction to organisational behaviour, Environmental context of organisational behaviour-information technology and globalisation- reward system.

UNIT II
Cognitive Processes – Perception, Attitudes and values, Motivation and performance, satisfaction and stress; Interpersonal and Group Process: Communication - interpersonal communication – Interpersonal feedback. Groups and teams - Formation and development of groups, team building and collaborative process. Decision making- decision making process, participatory decision making, problem solving techniques, creativity and creative thinking;

UNIT III
Managing the organisation for high performance: Job-design and goal setting, Management for work motivation, Leadership- leadership processes, theories and approaches, leadership styles, Management of conflicts; Change proneness and resistance to change.

UNIT IV
Organizational climate; Organizational development- concept of and process of OD, different interventions for organisational development;

Practicals

Analysis of organization in terms of process - attitudes and values, motivation, leadership. Simulation exercises on problem-solving - Study of organizational climate in different organizations. Study of organizational structure of development departments; Study of individual and group behaviour at work in an organization; Conflicts and their management in an organization; Comparative study of functional and non-functional organisations and drawing factors for organizational effectiveness.

Suggested Readings

AG EXT 557 TRAINING FOR HUMAN RESOURCE DEVELOPMENT (3L+1P) I

Objective

The course contemplates to acquaint the students with conceptual understanding of Training Vs education and different types and models of training. Further how an effective training programme could be organized and the approach of experiential learning could be integrated therein shall be another focus of the course. Besides, students will also be exposed to different training modules to be devised for different clientele and all possible dimensions of Human Resource management in relation to training will be covered.

Theory

UNIT I
Training and Education – Concept, meaning and relationship, factors affecting training, Types of training, current trends in training – organizational development approach; Paradigm shift in training-learning scenario; Training Process - different phases of training; Conceptual models of training;

UNIT II
Designing an effective training session – the semantics involved; Openness in training transactions – managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees). Experiential learning through simulation games, Training Methods, their importance and classifications. Uses and limitations of case study, role play, lectures, programmed instruction, group discussion, brain storming, field methods, transactional analysis, business games etc., Participatory training methods,

UNIT III
Training strategy and designs, Training need assessment, characteristics of good training programme, Exercises on developing training design, training curriculum and training programme; Training programme for different clientele; Training Modules for extension personnel, farmers, farm women and youth empowerment, Training modules for Krishi Vigyan Kendras, and SAU/ICAR staff, Trainers’ training, Training Evaluation and follow up – methods and strategy;

UNIT IV

Practicals

Designing participatory training sessions through simulations and experiential learning, Techniques of participatory training need assessment. Formulation of Course Objective, design of training

Suggested Readings

AG EXT 558 ENTREPRENEURSHIP DEVELOPMENT (2L+2P) III

Objectives
The course is intended to orient the students with need for entrepreneurship development in agriculture in the present times of decreased landholding and increased competitiveness faced by farmers in the markets. It will equip the students with knowledge and skills to motivate rural people to take up agri-entrprises.

Theory
UNIT I
Concept and theory of Development, Self Employment; Concept, need, approaches, theories scope and prospects of Entrepreneurship Development; Entrepreneurship in Agriculture, Concept, characteristics, Nature and importance for sustainable Livelihoods. Agro-industries, scope, constraints and strategy; Approach and Experiences in Entrepreneurial Development in India and other Developing Countries;

UNIT II
Entrepreneurship Development Cycle and process, Training for Entrepreneurship Development; Training development professionals; Development of Entrepreneurial Characteristics and Motives, Motivation Theories; Arousal of Motivation, Achievement Motivation Syndrome; Simulation games and exercises for developing entrepreneurial competencies – risk taking, self efficacy, creativity, achievement planning, influencing process, problem solving; Entrepreneurship Development among youth and women, Empowerment of women entrepreneurs; Policy approaches for women entrepreneurship development; Identification of potential entrepreneurs.
UNIT III

UNIT IV
Enterprise launching, Planning Resourcing; Enterprise Management, Management skills, Production management, Financial management, Marketing Strategy – pricing, costing, break-even analysis, Accounts and book keeping; Growth, Survival and Sustenance; Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion Studies on Entrepreneurship Development in Agriculture.

Practicals
EMT lab – Achievement Motivation, Risk Taking, Understanding Strengths and Blocks, Achievement Planning and Syndrome. Field visit to successful enterprises, Study of Characteristics of successful entrepreneurs Development of Project Proposal , Case Studies of Success / Failure enterprises, Exercise on Market Survey, Field visit to Financial institutions.

Suggested Readings
V.G.Patel Entrepreneurship Development Programme in India and its Relevance to Developing Countries.

AG EXT 559 METHODS OF SOCIAL RESEARCH (3L+1P) II

Objective
The major objective of the course is to promote objectivity and empiricism in conducting research and to develop the competencies in learners about various research methods and designs. The course will enrich the knowledge and skills in formulation of research problems and hypotheses, development of projects, application of SPSS package for computation, research report preparation and evaluation.
Theory

UNIT I

UNIT II
Measurement: General theory of measurement-postulates of measurement, levels of measurement, Reliability: types of reliability, methods of testing reliability - Importance of reliability: Validity: Types of validity-a variance definition of validity-the variance relation of validity and -the variance relation of validity and reliability, factors influencing validity. Methods of observation and data collection:- Interviews and Interview schedules, Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations. Projective methods- Content analysis- Observation- Meaning, types, tips in observation, advantages and limitations in its use. Case studies – Meaning, types, steps in conducting, advantages and limitations in its use. Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations. Rating scales – Meaning, types, limits in construction, advantages and limitations in its use, Sociometry, The semantic differential, Use of documents records-and indices.

UNIT III
Design of social research: Meaning, purpose and principles (MAXMINCON) of research design; experimental and Ex-post-facto approaches, Faulty designs, criteria of research design. General designs of research: Different types of basic, experimental designs- Variants of basic experimental designs- Simple randomized subject design- Factorial design. Types of research: Ex-post facto research, Action research methodology- Participatory research. Recent advances in social research methodology, theory building.

UNIT IV
Sample and procedure of sampling, Advances in collection of data, Principles of analysis and interpretation, Use of computers in social science research; Data treatment by computer and use of SPSS for analysis of data, interpretation, Preparation of Research Report- style manuals- format of research report- the thesis or dissertation

Practicals

Formulation and statement of research problem, operationalisation of concepts. Development and testing of data collection instrument, Testing the reliability and validity of the instruments. techniques of interviewing, Hands on experience in data analysis with SPSS, tabulation, analysis, interpretation and report writing and presentation, Critical evaluation of research papers & thesis and their presentation.

Suggested Readings

AG EXT 601 ADVANCES IN AGRICULTURAL EXTENSION

Objective
To help the students to critically analyse different approaches in models of agricultural extension including the application of agricultural knowledge and information system in improving extension practices. To gain knowledge and insight into the recent developments in extension such as cyber extension, alternative of financing extension, private/public partnership and privatization of extension, implications of WTO for extension services. To make a service of different contemporary issues in extension related to rural poverty, environmental protection, diversity, biotechnology and GM crops.

Theory

UNIT I
Approaches of agricultural extension: critical analysis of different approaches of agricultural extension, Extension programmes of corporate sector, the concept importance and implications of livelihood extension. Technology base of agricultural extension: Importance and relevance of indigenous knowledge system, identification and documentation of ITK, integration of ITK system with formation research.

UNIT II

UNIT III
Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities limitations and experiences and cases; Implications of WTO - AOA for extension services, Intellectual Property Rights (IPRs) and implications for extension, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension.

UNIT IV
Agricultural Knowledge and Information System (AKIS), concept, targeting of AKIS, Significance of theories of social learning for extension practice.

UNIT V
Extension and contemporary issues: rural poverty, environmental protection of farm and home, bio-diversity, sustainable development, food and nutritional security, recent advances in...
biotechnology and GM crops, adoption and diffusion of Bt cotton. Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming system and situation based extension delivery system, Extension delivery through Commodity Interest Groups.

Practicals

Analysis of ITK system, cases on integration of ITK and formal research system, Recent extension reforms in India – an analysis of growth and development of ATMAs, Extension delivery through community based organisations, Organization innovations in Extension, a critical analysis of village knowledge and resource centres, kisan call centres and ICAR extension system-KVKs, ATIC, IVLP etc.

Suggested Readings


AG EXT 602 MONITORING, EVALUATION AND IMPACT ASSESSMENT TECHNIQUES (3L+1P) I

Objective

The course intends to orient the learners towards the importance, issues, concepts and methods of monitoring, evaluation and impact assessment. The course will equip them with theoretical as well as analytical understanding and conducting monitoring, evaluation and impact assessment of extension programmes/ development projects.

Theory

UNIT I
Definition of Monitoring, Objectives, tools, methods and approaches of monitoring; Major Components of project Monitoring: Special Diagnostic studies, Project Completion report, Project sustainability. Monitoring Standards: Past quality or performance, the quality of other systems, desired quality, Professional standards, the quality required, Planning targets and Optimal quality; Usefulness of monitoring: role of project Completion Reports in Monitoring (PCRs); New Approaches to participatory impact Monitoring: Participatory Monitoring: Project Management in Practice; Tips for monitoring and evaluation.

UNIT II
Concepts and models of programme evaluation; Difference between monitoring and evaluation; Types of Evaluation: Objective Oriented, Management Oriented; Context Evaluation, Input evaluation, Process Evaluation, Product Evaluation, Consumer oriented evaluation, Expertise Oriented Evaluation, Adversary Oriented Evaluation, Naturalistic and Principal oriented
evaluation, goal free evaluation and meta evaluation; Major activities involved in conducting
evaluation; Evaluation Standards: Utility Standards, Feasibility Standards, Propriety standards
and Accuracy standards; Development of evaluation plan; Tools and techniques in evaluation;
Dealing with political, ethical and interpersonal aspects of evaluation. Reporting and using
evaluation information; Meta Evaluation.

UNIT III
Concepts and processes in impact assessment; Domains of impact assessment- Technical, socio-
cultural, economic, institutional, environmental, human, periodic-short and long term; Levels of
impact assessment; Approaches in developmental projects; Criteria and indicators: typologies and
properties of indicators –goodness and exactness; internal and external validity, specificity, gender
sensitiveness, stakeholders’ orientation; Impact monitoring- concept, purpose and methods; Impact
evaluation.

UNIT IV
Designs in impact assessment; Participatory need and stakeholders’ perception assessment;
Quantitative and qualitative techniques for impact assessment, Social impact analysis; Economic
impact analysis cost- benefit analysis, social-cost benefit analysis, partial budget analysis;
Environmental impact analysis; Institutional impact analysis; Sustainability analysis; Concepts in
livelihood and social vulnerability, adaptation and mitigation; Framework and qualitative and
quantitative and tools for livelihood analysis, assessment of social vulnerability and adaptive
capacities of communities; tools for farming system and gender analysis. Stakeholders’ analysis;
Human impact assessment; Case study; Policy implications of impact assessment;

Practicals
Development of Monitoring and Evaluation framework; Field studies for identification and
ranking of criteria/indicators for impact assessment, Development and analysis of cases in
evaluation and impact assessment.

Suggested Readings
Conceptual and Methodological Advances. Edward Elgar, UK.
New Delhi.
Byrn, D. et.al. 1962. Evaluation in Extension. USDA.

AG EXT 603 VISUAL AND GRAPHIC COMMUNICATION (1L+2P) II

Objective
This course is intended to give a clear perspective about the importance of visuals and graphics
in communication. The course starts with the delineating about the characteristics of visuals and
graphics followed by its main functions, theories of visual perception and its classification and
selection. Further, the course deals with the designing the message, graphic formats and devices
and presentation of data. It makes the students to understand, prepare and present the scientific
data effectively by using low cost visuals. The course also exposes the students to various Digitized
video material in multimedia and also enable to design visuals for print, TV and know-how about
scanning of visuals.

Theory
UNIT I
Role of visuals in Communication; Characteristics of visuals, functions of visuals and graphics;
Theories of visual perception; Classification of visuals, visual formats, Selection of visuals; Graphic
formats & Devices, typology, Presentation of scientific data, general and exact data; Preparing
lecture slides – content, limitation and layout; its utility in preparing presentations for research
papers and other publications
UNIT II
Principles of production of visuals, low-cost visuals, photographs, reprographic visuals, Pre-testing
and evaluation of visuals. Designing message for visuals; Designing & layout of visual elements,
balancing
UNIT III
PC based visuals, and digitized video materials in multi-media production; Designing visuals for
print and TV/ video media; Publishing e-books, audio-visual slideshow presentations through
VCD/DVD player. Scanning: scanners, scanning reflective and transparent original, resolution
and output, post scanning image controls; Output: intricacies of printing digital images, laser
printing, inkjet printing and photographic paper printing; Output for on-screen presentations and
for web pages
Practicals
Preparation of low-cost visuals (projected & non-projected); Designing & Layout of visuals for
Charts, posters, headliners etc., Generating computer – aided presentation graphics, preparation
of visuals.

Suggested Readings
Willem Zip. 1994. Improving the Transfer and Use of Agricultural Information - A Guide to
McGraw Hill.
Hyderabad.

AG EXT 604 ADVANCED MANAGEMENT TECHNIQUES (2L+1P) I

Objective
The course is intended to expose the students to the advanced management techniques. Besides,
the students will also be developing management competencies in the practical classes.
Theory

UNIT I
Forecasting Techniques: qualitative and judgmental methods, Technological forecasting- the Delphi methods, scenario construction. Management Information System (MIS): basic concepts, types of information needed at various levels, designs of MIS in an agricultural extension organization. Scope for computerization, system alternatives and evaluation, implementation, operation and maintenance of the system.

UNIT II
Management By Objectives (MBO): elements, process, making MBO effective, evaluation of the MBO system–strengths and weaknesses.

UNIT III

UNIT IV
Decision Support Systems (DSSs), Basic information about Artificial Intelligence (AI) and Expert Systems (ESs), their applications in an extension system.

Practicals
Exercises on forecasting techniques, Management Information System (MIS), Management by Objectives (MBO) and Transactional Analysis (TA), Team building processes, skills in coping with organizational stress, Creativity and Logical Framework Approach (LFA)

Suggested Readings

AG EXT 605 DEVELOPMENT COMMUNICATION (2L+1P) I

Objective
This course is intended to give the students an exposure to the concept of development communication and related issues like skills pertaining process of agricultural development, communication media and communication technology and networking mechanisms among various development agencies both at operational level and field level.
UNIT I
Concept and components of development; Theories of development and development communication; Approaches and development of communication media for development communication; Conceptual differences/similarities between development communication and development support communication;

UNIT II
Development communicators: characteristics and role demands; Process skills pertaining to process of agricultural development; communication media and technology; Networking mechanisms among various development agencies both at operational level and field level; Experiences generated from application of media for promoting development: case studies; participatory approach to integrated media development in extension and development projects

UNIT III
Developing information support for development communication projects; formulating and conducting development communication projects in India; Conventional mass media and traditional media used in development communication; Determinants of communication effectiveness of development projects. Critical evaluation of communication media and technology in development communication;

Practicals
Developing agricultural communication projects; Visits to mass media organizations engaged in development communication; Formulating communication plans and strategy; Cost benefit analysis of media use in development.

Suggested Readings

AG EXT 606 TECHNIQUES OF MEASUREMENT IN BEHAVIOURAL SCIENCES
(3L+1P) III

Objective
The course aims at development of conceptual understanding of psychometrics and its application in constructions of scales for measuring psychological characteristics/traits. The learners will be exposed to various methods of scale construction, scalogram analysis and testing the reliability and validity of scales. It is also intended to orient the learners towards other psychometric methods like Q-sort, semantic differential and rating scales besides multivariate techniques.
Theory

UNIT I
Role of measurement in Social Sciences; Levels of measurement; Theory of Scale development; Process and techniques of scale construction; Types of scales in social Research;

UNIT II
Scale Construction Methods: Paired Comparison Technique, Equal Appearing Interval, Successive Interval, Summated Rating; Scalogram Analysis; Scale Discrimination Techniques; Multi-dimensional scaling technique; Concept and application of H-technique and W-technique in scale construction; Development of knowledge test, Reliability and Validity of Scales.

UNIT III
Projective and non-projective techniques; Q-Sort Technique, Semantic Differential Technique; Case analysis; Use of multivariate analytical tools in extension research; Meta Analysis; Critical Incident Technique; Content analysis; Sociometry; Practicing participatory tools and techniques Utilization of these techniques in Extension Research; Advantages and limitations of these techniques.

UNIT IV
Concepts and approaches in theory construction in extension science, Testing of theory.

Practicals
Using different types of scales and techniques in the field and laboratory situation; Critical study of the scales constructed and used in Extension Education research; Development of attitude scales and knowledge tests; Testing reliability and validity of scales; Case analysis; use of various techniques (Q-sort, semantic differential, Content analysis, critical incident, project and non-projective tools and participatory tools) in field conditions.

Suggested Readings
## 5 Agricultural Physics

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP 500</td>
<td>BASIC CONCEPTS OF PHYSICS - I</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>AP 503/</td>
<td>FUNDAMENTALS OF SOIL PHYSICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 503</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP 504</td>
<td>MATHEMATICS IN AGRICULTURE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AP 530/</td>
<td>FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>WST 530</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP 613</td>
<td>ADVANCE SOIL PHYSICS II</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 632</td>
<td>SATELLITE AGROMETEOROLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP 501</td>
<td>BASIC CONCEPTS OF PHYSICS - II</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 505/</td>
<td>SOIL GENESIS, CLASSIFICATION AND SURVEY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 505</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP 520</td>
<td>PRINCIPLES OF BIOPHYSICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 540</td>
<td>PRINCIPLES OF REMOTE SENSING</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 610</td>
<td>PHYSICS OF SOIL AND WATER EROSION AND THEIR CONTROL</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 630</td>
<td>CROP MICROMETEOROLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 612</td>
<td>ADVANCE SOIL PHYSICS I - SOIL WATER AND NUTRIENT TRANSPORT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP 502/</td>
<td>SOIL FERTILITY AND NUTRIENT MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 502</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AG 502</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP 506</td>
<td>PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 507</td>
<td>PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AP 508</td>
<td>INTRODUCTION TO NANOTECHNOLOGY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>AP 511/</td>
<td>CROP ECOLOGY AND AGROMETEOROLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 511</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Contact Hours</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------</td>
<td>---------</td>
<td>---------------</td>
</tr>
<tr>
<td>AP 541</td>
<td>GIS AND GPS – PRINCIPLES AND APPLICATIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 611/</td>
<td>SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP 631</td>
<td>EVAPOTRANSPARATION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 640</td>
<td>REMOTE SENSING IN AGRICULTURE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

M.Sc.: AP 500, AP 501, AP 503, AP 504, AP 520, AP 530 and AP 540
AGRICULTURAL PHYSICS

Major Fields : Agricultural Physics

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AP 500 BASIC CONCEPTS OF PHYSICS-I (4L+1P) I

Objective
To impart knowledge on the concepts of physics and physics laws.

Theory

UNIT I
Linear, circular, relative motions, conservation of mass, energy and momentum, forces in nature, range of their operation, action at a distance, gravitational field, potential.

UNIT II
Elasticity, stress-strain relations – moduli of elasticity, Hooke’s law, molecular and structural basis of strengths of materials, hydrostatic pressure; surface tension, capillary rise, contact angle, hydrodynamics – laminar and streamline flow, Poiseuille’s equation, Stoke’s law.

UNIT III
Thermometry, measurement of heat, specific heat, transfer of heat - conduction, convection and radiation, Change of phase, equation of state, vapour pressure and relative humidity, laws of thermodynamics, free energy, chemical potential.

UNIT IV
Kinetic theory of gases, Brownian motion, mean free path, simple harmonic motion, concepts of phase, phase difference, interference and reflection of sound waves, ultrasonic, applications.

UNIT V
Wave theory of light, Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; electromagnetic theory of light, geometrical optics, aberrations, resolving power, principles of optical instruments, illuminated and luminous objects and light sources; luminescence, incandescence, fluorescence, auto-fluorescence, phosphorescence, bio-luminescence, qualitative and quantitative measurement of light, colour, optical spectrometry.

UNIT VI
Electric charges, potential, field, intensity and strength of electric field, current, Coulomb’s law, dielectrics, capacitance, electrostatic units, resistance, resistivity, Ohm’s law, steady currents in conductors, insulators and semi conductors, magnetic materials, induced magnetism, electromagnetism, measurement of magnetic field, geomagnetism, effects of the earth’s magnetic field on life, electromagnetic inductions and applications, electromagnetic units.
Practicals

Use of the instruments: Vernier/Screw Gauge/Spherometer, Sextant, Surface Tension, Viscosity, Interference Phenomenon, Optical Instruments (diffraction grating), Resistivity measurement (Potentiometer/Wheatstone bridge), Young’s Modulus

Suggested Readings

Any Graduate level Text book of Physics, Lecture notes/hand-outs given in selected classes.

AP 501 BASIC CONCEPTS OF PHYSICS- II

(3L+1P) II

Objective

To impart knowledge on the modern concepts of physics and physics laws.

Theory

UNIT I
Maxwell’s theory of electromagnetism, atomic structure, avogadro hypothesis and molecules, atomic and molecular weights, atomic sizes, quantum mechanics: uncertainty principle, De-Broglie hypothesis, wave function, Eigen state, Schrodinger equation.

UNIT II
Spectroscopy: atomic and molecular spectra, cathode rays; positive rays; radio activity; alpha-, beta-, and gamma-rays; detection and measurement of radiation; Rutherford’s theory of the scattering of alpha particles; X-rays, nature and properties; scattering of X-rays by atoms; diffraction of X-rays and Bragg’s law; characteristic X-ray spectra.

UNIT III
Planck’s quantum theory of thermal radiation; quantum theory and photo-electric effect; elements of special theory of relativity, atomic nucleus and its constitution, angular momentum of the nucleus; nuclear transmutation of elements; proton-neutron hypothesis; cosmic rays; elementary particles.

UNIT IV
Natural radioactivity, types of radiations, their interaction with matter and decay; isotopes; isotopic masses and abundances; mass spectrograph and mass spectrometers; stable isotopes; atomic masses,
packing fractions and binding energies, theory of radioactive disintegration; half life and mean life; Mass spectrometer.

UNIT V
Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power; production of artificial isotope.

UNIT VI
Physical principles of radiation detection; types of radiation detectors; efficiency of detectors; uses of radiation detectors, Elements of radioactive sources, handling, radiation protection and cardinal principles of radiation safety.

Practicals
Safe Handling of radioisotopes, Characteristics of GM counters, half life of a radioactive isotope, dead time of GM counter, Estimation of linear absorption coefficient of a material, Characteristics and Calibration of scintillation counter using CS-137 source, Determination of strength of gamma sources using multichannel analyzer

Suggested Readings
Any Graduate level Text book of Physics, Lecture notes/hand-outs given in selected classes

AP 502/ SSAC 502/ AG 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT  (3L+1P) III

Objective
To teach basics of soil fertility evaluation, techniques of soil fertility evaluation, plant nutrients, integrated approach of plant nutrition, and environmental quality.

Theory
UNIT I
Historical aspects of soil fertility, essential plant nutrients: criteria of essentiality, classification, functions, deficiency and toxicity symptoms, beneficial elements.
UNIT II
Carbon cycle in nature, carbon stocks, sequestration, greenhouse effects, different carbon pools in soil and their role in maintaining soil quality and productivity; soil organisms and their role in soil fertility.

UNIT III
Transformations and dynamics of major- and micro-nutrients in soils and their availability to plants.

UNIT IV
Nutrient interactions in soils and plants: Concept, different types of interaction, interaction among essential plant nutrients, law of minimum and maximum.

UNIT V
Commercial fertilizers, new fertilizer material and principles of their evaluation, crop response to fertilizer application and use efficiency, economics of fertilizer use, nutrient requirements of crops and cropping systems in sustainable agriculture and quality of the produce, foliar nutrition of crop plants.

UNIT VI
Soil fertility evaluation: Different approaches, soil and plant tests, biological tests, hidden hunger, critical nutrient concentration- concept and determination (graphical and statistical procedures), critical nutrient range, diagnosis recommendation and integrated system (DRIS)

UNIT VII

UNIT VIII
Fertilizer x water interactions, crop production under fertilizer / water constraints, site-specific nutrient management: concept and practices; summary of long-term fertilizer experiments

Practicals
Soil and plant sampling and processing for chemical analysis; determination of soil pH, total and organic carbon in soil; chemical analysis of soil for total and available nutrients (major and micronutrients); analysis of plants for essential elements (major and micronutrients)

Suggested Readings
Objective

To impart knowledge (both theoretical and practical) about the mechanism governing the behaviour of soil and its role in the biosphere for its proper management.

Theory

UNIT I
Basic principles of physics applied to soils viz. viscosity, surface tension, capillarity, stress-strain relations, gaseous diffusion, heat transport, thermodynamic principles; Properties of water in relation to porous media.

UNIT II
Physical characterization of soil; Soil as a polyphase system; Mass-volume relationships

UNIT III
Particle size distribution; soil texture; mechanical analysis; specific surface; clay-a colloidal surface; hydration of clays.

UNIT IV
Soil structure and aggregation: genesis, classification and evaluation; soil structural stability and indices; soil tilth; soil conditioners.

UNIT V
Geometry of pore space and pore size distribution; inter- and intra-aggregate pores; Soil consistency and its limits; consistency and deformation of cohesive soils; compaction and crusting in soils; soil strength and its measurement;
UNIT VI
Geometry of water phase; energy state of soil water; water content and potential and their measurement; different components of soil water potential; Soil water characteristic, hysteresis and available water;

UNIT VII
Flow of water in soil; Darcy’s law, hydraulic conductivity and water diffusivity; saturated and unsaturated flow and equations; Methods for saturated and unsaturated hydraulic conductivity measurement-both in situ and in laboratory; Capillary movement of water, contact angle.

UNIT VIII
Entry of water into soil and its redistribution; permeability; evaporation from bare soil; modification of soil surface affecting infiltration and evaporation; field water balance;

UNIT IX
Gaseous phase in soil, content and composition; renewal of soil air and gaseous diffusion measurement of soil aeration; factors affecting soil aeration.

UNIT X
Energy balance in bare soil; soil heat flux, heat capacity, specific heat and thermal diffusivity; soil temperature and its measurement, factors affecting; thermal regime in soil profile.

Practicals
Particle size analysis of soil, Determination of bulk density, particle density and mass-volume relationships of soil, Soil aggregate analysis, Measurement of soil moisture content and soil moisture potential, Determination of soil-moisture characteristic curve, Determination of saturated and unsaturated hydraulic conductivity of soil, Determination of Atterberg constants, Measurement of soil strength, Determination of infiltration characteristics of soil, Soil temperature measurement

Suggested Readings


AP 504 MATHEMATICS IN AGRICULTURE (3L+0P) I

Objective
To educate about the basic mathematical techniques which are used in agricultural physics studies.
Theory

UNIT I
Functions, limits, continuity, linear equations, non-linear equations, polynomials, infinite series and Taylor series.

UNIT II
Vectors, matrices and determinants, inversion of matrices, Eigen values and Eigen vectors, Orthogonality, Grahm-Schmidt processes, least square problems.

UNIT III
Differentiation, integration, areas, partial differential equations, applications, solutions to differential and integral equations.

UNIT IV
Systems of coordinates, cartesian, cylindrical, spherical and polar coordinates, three dimensional geometry, relative motion of frame of reference.

UNIT V
Probability, probability distributions and applications, Curve fitting, regression and correlation, linear and non-linear.

UNIT VI
Geo-statistics, averaging and scaling methods, Fourier analysis, numerical approximations, numerical analysis, finite element method, Monte Carlo analysis, stochastic methods, iterative and optimal techniques.

Suggested Readings
Advanced Engineering Mathematics by C. Ray Wylie
Advanced Mathematics for Engineers by H.W. Reddick
Any book on Mathematics for graduates
Mathematical Statistics by M. Ray & H.S. Sharma
Statistics for Geoscientists- Techniques and Applications by S.K. Pal

AP 505 / SSAC 505 SOIL GENESIS, CLASSIFICATION AND SURVEY (2L+2P) II

Objective
To teach the students concept of pedon, Pedology as a core discipline of Soil Science, factors and processes of soil formation, soil classifications systems, survey and cartography. Main emphasis is on enabling the students to conduct soil survey and interpret soil survey reports for sustainable land use and planning.

Theory

UNIT I
Historical developments in Pedology; characterization and classification of rocks and minerals; weathering of rocks and minerals, weathering sequences of minerals with special reference to Indian soils; soil forming processes and factors of soil formation.

UNIT II
Concept of soil as an individual entity; soil classification – principles and historical development; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy.
UNIT III
Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps; landform – soil relationships; application of remote sensing and GIS in soil survey and mapping; major soil groups of India.

UNIT IV
Land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystems.

Practicals
Morphological properties of soil profile in different landforms; classification of soils using soil taxonomy; calculation of weathering indices and its application in soil formation; grouping soils using available data base in terms of soil quality; aerial photo and satellite data interpretation for soil and land use; cartographic techniques for preparation of base maps and thematic maps; processing of field sheets, compilation and obstruction of maps in different scales.

Suggested Readings
Boul, S.W., Hole, R.D., McCracken, R.J. and Southard, R.J. 1997. Soil Genesis and Classification. Iowa State University Press, Ames, USA.

AP 506 PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE (3L+1P) III

Objective
To educate about different optical, electrical, colorimetric and nuclear techniques used in agriculture.

Theory
UNIT I
Physical principles of measurement of relationships, direct and indirect measurements, scale of operation, laboratory, field and regional scales, specificity of techniques to characterize objects, resolution, limitations and relative advantages.

UNIT II
Optical microscope, reflection, polarized microscopes, Colorimetric techniques, single and double beam instruments, reflection, transmission and absorption in relation to the properties of the object, UV and Visible spectrophotometry, applications.
UNIT III
Sensors and transducers, principles of operation of field-based instruments like leaf area meter, canopy analyzer, quantum sensor, spectroradiometer, laser land leveller etc., infrared thermometry, principles, emissivity, infrared spectroscopy, characteristics of agricultural materials.

UNIT IV
X-rays, crystal structure, applications, clay mineralogy, cotton fibres, small angle scattering, electron microscopy, electron optics, aberrations, contrast and image formation, specimen preparation techniques, transmission and scanning electron microscopy.

UNIT V
Morphological characterization of viruses, macromolecules, clay minerals and other material, atomic absorption spectroscopy, principle of operation, detection limits and sensitivity, polarography, applications.

UNIT VI
Nuclear techniques, detection and measurement of charged particles, types of detectors, counting systems, radiation monitoring instruments, radiation hazard evaluation and protection, tracer methodology, isotopes and their applications in different branches of agriculture, seed irradiation, γ chamber and γ irradiation for genetic variability, agricultural produce preservation, mass spectrometer, principle and applications.

Practicals
Photoelectric effect and measurements, Geiger-Muller counter: quenching time, thickness measurement of thin films/foils/paper sheets, half-life determination, tracer applications of artificial radio nuclides, multi-channel analyzer, neutron moisture meter, use of NMR spectrometer, seed irradiation with gamma rays, radiocarbon dating, hands on exposure to radiation safety

Suggested Readings
Objective
To educate students about different types of radiations, their principles, characteristics, interaction with matter and use in agricultural studies.

Theory
UNIT I
Electromagnetic spectrum, energy sources and their characteristics, spectral distribution of radiant energy, energy content in different radiations, radiation units, flux, intensity, emittance, inter conversion of radiometric units.

UNIT II
Radiation principles, resolution, geometry considerations, solid angle concept, inter conversion of photometric units, interaction of radiation with matter, scattering, reflection, transmission, absorption, diffuse and specular radiations, lambertian surface, different types of scattering.

UNIT III
Photosynthetically active radiation, Einstein, mole, photon units and their inter conversion, colour designations, conversion of optical to thermal and other forms of energy.

UNIT IV
Thermal radiations, blackbody radiation, Kirchoff’s law, Stefan-Boltzman law, Planck’s law, Wein's displacement law, Rayleigh-Jean's law, thermal properties of interacting materials, thermal emissivity, thermal inertia.

UNIT V
Microwave radiations, dielectric constant, microwave energy dissipation in interacting materials, isotropic and non-isotropic mediums, microwave transmission, reflection, polarization, microwave and radio wave heating, ionizing and non-ionizing radiations, applications in agriculture and biology.

UNIT VI
Energy balance of land surfaces, energy budget of leaf, energy budget of crop canopy, radiation interception, energy flow in ecosystems.

Suggested Readings
Objective
To impart basic knowledge about nanoscience, properties of nanoparticles and their applications in biology

Theory
UNIT I

UNIT II
Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nano wires, fullerenes (buck balls, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nano powders, electro deposition, important nano materials.

UNIT III
Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano particles, investigating and manipulating materials in the nanoscale: Electron microscopy, scanning probe microscopy, optical microscopy for nano science and technology, X-ray diffraction, scanning tunneling microscopy, atomic force microscopy.

UNIT IV
Nano-biology: Interaction between biomolecules and nano-particle surface, different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, application of nano in agriculture, current status of nano biotechnology, future perspectives of nanobiology, nanosensors.

Suggested Readings
Nanotechnology edited by Gregory Timp, New York : Springer Verlag. 1999
UNIT II

UNIT III
Physiological response of crop plants to weather variables (light, temperature, CO₂, moisture and solar radiation). Atmospheric pollution and its effect on climate. Global climate change and its impact on agriculture.

UNIT IV
Competition in crop plants, environmental manipulation through agronomic practices, agro-climatic indices. Improvement of unproductive lands through crop selection and management.

UNIT V

UNIT VI
Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

UNIT VII

Practicals

Suggested Readings
Objective
To impart theoretical and practical knowledge of different life forms, and interactive effects of various physical forces on life processes.

Theory
UNIT I
Introduction and scope of biophysics, weak and strong interactions in biological systems, structure and property of water, physical, chemical and biological origin of life
UNIT II
Experimental techniques used for separation and characterization of biomolecules: sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography, aminoacid and nucleotide sequence analysis
UNIT III
Spectroscopic techniques for biomolecular characterization: UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction & its application in biology
UNIT IV
Structure and function of biological molecules: Amino acids and peptides, protein structure, nucleic acids, protein synthesis, mechanism of genetic control, polysaccharides and lipids-structure and function
UNIT V
Biomembranes-structure and function of plant and animal cell membranes, basis for cell membrane voltages, bioelectricity of cell membrane and its measurement, artificial membranes, transport phenomena in biological systems, active and passive transport
UNIT VI
Structure and function of plant and animal cells and viruses, unicellular and multi-cellular life forms, types of specialized cells and their functions, cell to cell communication
UNIT VII
Bio-energetic- First and second laws of thermodynamics, heat, work, entropy and free energy, concept of negative entropy & its application in living systems, information theory.

Practicals
Spectroscopy-Verification of Beer-Lambert’s law, Spectroscopy-Absorption spectrum of chlorophyll a & b, Viscometer-Measurement of intrinsic viscosity and molecular mass, Polarimeter-Measurement of Molar rotation, Refractometer-Measurement of specific and molar refractivity, NMR spectroscopy- Relaxation time measurements, Isoliation of plant DNA
Melting point of DNA, Electrophoresis of DNA/Protein

Suggested Readings
Basic Biophysics for Biologists-M. Daniel, Agrobios, India
Essentials of Biophysics-P. Narayanan, New Age International Publishers
Objective
To impart theoretical and practical knowledge about basic physical processes in the atmosphere with an aim to apply in agriculture.

Theory
UNIT I
Atmosphere and its constituents, weather and climate; meteorology and climatology, meteorological elements, instruments for measurement of meteorological elements, meteorological observatory, weather satellites, websites of meteorological organizations – IMD, NCMRWF, IITM, WMO.

UNIT II
Sun and earth; seasons, solstices and equinoxes, solar radiation and laws of radiation, solar constant; radiation receipt on earth surface, heat balance of the earth and atmosphere.

UNIT III
Variation of pressure and temperatures with height; hydrostatic equation, atmospheric moisture; vapour pressure; saturation deficit; psychometric equations, lapse rates, atmospheric stability, tephigram, potential temperature.

UNIT IV
Climatic controls, seasonal distribution of climatologically elements (radiation, temperature, pressure and precipitation) over latitudes.

UNIT V
Clouds and their classification, precipitation processes; artificial rain making, thunderstorms and dust storms; haze, mist, fog and dew, introduction to evapotranspiration,

UNIT VI
Pressure gradient; coriolis force; cyclones and anti-cyclones, local wind systems; land and sea breeze circulation, mountain and valley winds, air masses and fronts,

UNIT VII
Weather charts, forecasting methods – short, medium and long range forecasting techniques, numerical weather prediction.

UNIT VIII
Climatic classification: Koppen and Thornthwaite systems, agroclimatic indices, agroclimatic zones; different agro ecological zones for India,

UNIT IX
Climatology of India; monsoons, rainfall variability; El Nino, La Nina and ENSO, disastrous weather events in different regions, drought climatology and drought indices, climate change and global warming, impacts of climate change on agro-ecosystems.

Practicals
Meteorological observatory, meteorological instruments, recording of weather parameters, daily, weekly and monthly means, meteorological websites, standard meteorological weeks and Julian days, classification of clouds, climatic normal, climatic chart, low and high pressure systems.
Suggested Readings


Journals

Journal of Climate
International Journal of Climatology
Mausam
Vayumandal
Weather

AP 540 PRINCIPLES OF REMOTE SENSING (3L+1P) II

Objective

To teach about basic principles and techniques of remote sensing.

Theory

UNIT I
Introduction, electromagnetic radiation, electromagnetic spectrum, interactions with the atmosphere, remote sensing system, passive versus active remote sensing, characteristics of images, radiometric quantities, BRDF.

UNIT II
Spectral signatures of natural targets in optical and thermal regions, physical basis of signatures, spectral indices.

UNIT III
Platforms, orbits, classification of sensors, satellite characteristics, pixel size, and scale, spectral, radiometric and temporal resolution.

UNIT IV
Cameras and aerial photography, imaging and nonimaging systems, multispectral imaging, hyperspectral imaging, thermal imaging.

UNIT V
Weather, land, ocean and other observation satellites, Indian remote sensing satellites, data reception, data products.

UNIT VI
Microwave remote sensing: principles, signatures, interferometry, radar basics, viewing geometry and spatial resolution, image distortion, target interaction, image properties.
UNIT VII
Image analysis: Visual interpretation, digital image processing, preprocessing, enhancement, transformations, classification, accuracy, integration, processing of hyperspectral and microwave images.

UNIT VIII
Overview of remote sensing applications in earth resource management: Agriculture, atmosphere, forestry, land cover/land use, water resources, geology, oceans and coastal zone.

Practicals
Use of Spectroradiometer, Spectral signatures of different, Derivation of spectral indices, Infrared thermometer and its applications, Stress indices derivation from IR thermometer Derivation and analysis of vegetation indices, GPS and ground truth collection, Digital Image processing: Introduction, preprocessing, enhancement, classification, accuracy assessment of satellite data, Analysis of High resolution data and time series satellite data

Suggested Readings

AP 541 GIS AND GPS – PRINCIPLES AND APPLICATIONS (2L+1P) III

Objective
To impart knowledge on dealing with spatial data and its applications in crop production and natural resource management.

Theory
UNIT I
Introduction; History of cartography and maps;

UNIT II
Basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS);

UNIT III
Geographical data structures; relational database management system; overview of MS Access;
UNIT IV
Maps and projections: principles of cartography; Basic geodesy: Geoid /Datum/Ellipsoid; cartographic projections, coordinate systems, types and scales; accuracy of maps;

UNIT IV
GIS data collection, linking spatial and non-spatial data; Errors and quality control, data output;

UNIT V
Raster based GIS: spatial referencing, definition and representation, data structure, advantages and disadvantages; Vector based GIS: Definition, concept, data structure, capture and Vector and raster formats, vector to raster and raster to vector conversion, advantages and disadvantages;

UNIT VI
Principles of graph theory, topology and geometry; spatial analysis: statistical analysis, measurement, proximity (buffering), overlay analysis, classification, network analysis, multicriteria analysis, site suitability analysis, nearest neighbour analysis;

UNIT VII
Surface modelling: Thiessen polygon, interpolation, DEM; geostatistical analyses, spatial and non-spatial query.

UNIT VII
Software and hardware requirements of GIS; Integrated image analysis and GIS; GIS for modeling;

UNIT VIII
Web GIS, 3D GIS, object oriented GIS, mobile GIS, knowledge based GIS; data warehousing, data mining; metadata, data interoperability, open GIS consortium, GIS customization, DSS and SDSS;

UNIT IX
Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

UNIT X
Basic Concepts, segments, working principles; Measuring distance and timing, errors in GPS data and correction; Differential GPS; Integration of GPS data with GIS data, use of GPS in remote sensing analysis; Past, present and future status of GPS; Applications of GPS in agriculture and natural resource management.

Practicals
Overview of current GIS software: ArcView/ArcGIS/IDRISI, Introduction to MS Access, Data input (spatial data); digitization and scanning, Data input: editing, Data input: non-spatial attributes and linking with spatial data, Database creation and map registration, Spatial analysis: Surface modelling, overlaying, buffering, neighbourhood analysis, Coordinate data collection through GPS and its integration with GIS

Suggested Readings


**Online useful materials (Tutorials)**

http://www.gisdevelopment.net/tutorials/tuman006.htm
http://www.colorado.edu/geography/gcraft/notes/datacon/datacon_f.html
http://egsc.usgs.gov/isb/pubs/gis_poster/
http://www.quantdec.com/SYSEN597/

**AP 610 PHYSICS OF SOIL AND WATER EROSION AND THEIR CONTROL (2L+1P) II**

**Objective**

To teach the physical factors and processes describing erosion, its estimation, measurement of soil loss and runoff and methods of erosion control in arable and non-arable lands.

**Theory**

**UNIT I**

Factor affecting soil erosion by water: Effect of climate: Rainfall erosivity- kinetic energy of rainfall, Wischmeir’s equation for its prediction, rainfall erosivity indices, isoerodent map of India. Effect of soil: Soil erodibility- soil physical parameters affecting soil erodibility and its measurement, various indices of soil erodibility. Effect of topography, crop cover and soil management on soil erosion.

**UNIT II**

Method of soil loss estimation and measurement; Universal Soil Loss Equation (USLE): Estimation of various factors affecting erosion by water, soil loss tolerance, applicability and limitations of USLE and its revision. Water erosion prediction programme (WEPP)- sediment transport equations: rate of sediment detachment, transport and deposition, sediment transport capacity, rill and inter rill erodibility and their measurement in field. Measurement of different types of soil erosion: Splash erosion and its measurement. Measurement of rill and gully erosion. Use of remote sensing methods for delineating different eroded areas according to their severity.

**UNIT III**

Runoff measurement & estimation: Gauges for long term/average prediction of stages of rivers and streams, stage level recorder for measuring short term variations of water levels, current meters for measurement of water discharge, hydrographs; Calibrated devices for runoff measurement: Theory of sub and super critical flow. Flumes, weirs and orifice - types, equations for calculating water head, suitable conditions for their use and their installation in field; Methods for runoff estimation: Rational formula, soil cover complex/curve number method;

**UNIT IV**

Sediment measurement: Multislot divisor, cshocton wheel sampler, point and depth integrated sediment samplers;
UNIT V
Soil and water conservation: Concept of watershed: need for implementation of soil and water conservation programmes on watershed basis, Size of watershed, understanding concept of integrated water shed management through case studies. Outline of steps of integrated watershed management plan. Characterization and management of watersheds using remote sensing and GIS, Land capability classification: land capability classes, sub-classes and units

UNIT VI
Methods of erosion control in arable and nonarable lands: contour farming, strip cropping, physical techniques of conservation forestry, bunds, terraces, ponds, gabion check dams, drop structures, trenches, retention walls and spurs. Problems of soil and water erosion in India & conservation techniques: Types of soil erosion by water in different parts of India & their control measures – Hill side erosion, ravines, erosion on black soils, torrents, landslides, erosion due to mining and seaside erosion, water harvesting & recycling: water harvesting techniques for alfisols, vertisols, inceptisols and arisols, methods for controlling seepage losses.

UNIT VII
Wind erosion-wind velocity, initiation and movement of soil particles, siltation, suspension and surface creep and mechanics involved, soil physical properties affecting wind erosion, wind erosion equation and its computation, control of wind erosion.

Practicals
Computation of Kinetic energy of falling rain drops and Wishmeir's formula, Measurement of Land slope, erosivity index (EI30) using rain gauge data, Determination of erodibility Indices, Land capability classification of a watershed, sediment discharge estimation from a river basin, sediment detachment and transport rates, transport capacity, rill and interrill erodibility from field runoff and soil loss measurements, soil loss estimation using RUSLE software.

Suggested Readings
Agricultural handbook AH703 – RUSLE Document from USDA
Training manuals on ‘Soil conservation and watershed management- vol.1 &2’by CSWCRT&I, Dehradun
Land and water resources by V.N.Murty
Watershed management by P.N. Bhatt (CSWCRT&I, Dehradun publication)
Watershed management by V.V.Dhruvnarayana
Water erosion prediction programme (WEPP) manual

AP 611/SSAC 611 SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH (3L+1P) III

Objective
To impart knowledge about characterization and management of soil physical environment in relation to plant growth and yield.

Theory
UNIT I
Introduction: Effect of soil physical properties on plant growth - soil water, soil air, soil temperature, mechanical impedance and tillage practices.
UNIT II
Soil water: Soil moisture – plant water relations, available water, newer concepts of water availability, least limiting water range, soil-plant-atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum.

UNIT III
Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.

UNIT IV
Soil Temperature – effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching, radiation – heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere.

UNIT V
Aeration – critical oxygen concentration and factors affecting.

UNIT VI
Field water balance – field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture

UNIT VII
Nutrient- nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, Integrated nutrient management in relation to soil physical condition.

UNIT VIII
Resource conservation technologies- bed planting & zero-tillage - types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term ) on soil health.

UNIT IX
Modelling: Interactions of soil, management and climatic factors on plant growth, development of sustainability indices.

Practicals

Suggested Readings
AP 612 ADVANCE SOIL PHYSICS I - SOIL WATER AND NUTRIENT TRANSPORT

(3L+1P) II

(Pre-requisite: AP 110 & AP 104)

Objective

To study the physical processes for transport of water and nutrients in soil.

Theory

UNIT I

Soil water transport: saturated flow equations: Poiseuille's and Darcy's equations, Laplace equation of steady flow and unsteady flow equation and their solutions, three dimensional saturated hydraulic conductivity and fluxes, hydraulic conductivity for layered soil, conductance coefficient, unsaturated flow equations: Buckingham-Darcy equation, Richards equation, dynamics of water flow, stationary water flux, diffusivity, Boltzmann transformation and a wetting front, unsaturated hydraulic conductivity, Infiltration, profile controlled and supply controlled infiltration, horizontal infiltration, vertical infiltration, Green-Ampt model, Philip model, homogeneous and layered soil infiltration, curve number method, preferential flow, measurement of unsaturated hydraulic conductivity: lab methods: direct method - constant head and falling head methods; indirect method- parameterization of hydraulic functions. Field methods- infiltrometers and permeameters, instantaneous profile and field inverse methods. Numerical models of water flow, finite element and finite difference methods

UNIT II

Root water uptake modeling: computation of root water uptake using Richard's equation; Ritchie's root water uptake model.

UNIT III


Practicals

Guelph Permeameter for field saturated hydraulic conductivity, Hydraulic conductivity by instantaneous profile method, Computation of dispersion and diffusion coefficients of CDE, Computation of solute (nonreactive) distribution in profile by analytically solving solute transport equation under different initial and boundary conditions

Suggested Reading

Advanced Soil Physics by Daniel Hillel.
Advanced Soil physics by Kirkham and Powers.
Soil Physics Companion by A.W. Warrick.

AP 613 ADVANCE SOIL PHYSICS II

(2L+1P) I

(Pre-requisite: AP 110 & AP 104)

Objective

To study the use of advanced mathematical tools in understanding the soil physical processes related to transport of soil heat and soil air.
Theory

UNIT I
Variability in soil physical properties: classical measures of variability, spatial variability of soil physical properties: spatial dependence, autocorrelation function and spatial structure studies: empirical semivariogram, semivariogram models, classical and geostatistical interpolation: IDW, spline, global polynomial, Kriging – stationarity, trend, solving kriging equations, type of kriging, GIS for geospatial analysis, Kriging for precision farming

UNIT II
Mathematical tools: Fourier series, Bessel functions, Infinite series of orthogonal functions, Numerical approximations: finite elements and finite difference model of applicability of numerical approximations, numerical simulations.

UNIT III

UNIT IV
Sediment transport by runoff: equations of sediment transport for rill and interrill erosion, measurement of inter-rill and rill erodibility, computation of sediment detachment, transport and deposition rates.

UNIT V
Movement and exchange of gases in soils: Darcy’s law for advective transport (nonisobaric system) of gas, deviation from Darcy’s law, gas transport by diffusion in isobaric system (Fick’s law). Multi component gas transport- Dusty Gas model, Stefan Maxwell equation. Gas permeability: laboratory and field measurement of gas permeability.

UNIT VI
Soil quality: definitions, selection of minimum data set of physical, chemical and biological characteristics for quality assessment, indices of soil quality-nonquantitative and quantitative systems, least limiting water range(LLWR) for assessment of soil physical health, soil conditioner: water soluble conditioners and soil hydrogels, their effects on soil structure, water and nutrient retention and other soil hydraulic properties

Practicals
Empirical semivariogram and fitting appropriate semivariogram model, Preparation of prediction map of a soil property by kriging, Computation of sediment detachment rate, sediment transport rate, interrill and rill erodibility, Computation of LLWR under different soil management practices, Computation of thermal properties using finite difference method

Suggested Readings
Advanced Soil Physics by Daniel Hillel
Advanced soil physics by Kirkham and Powers
Mathematical Physics by B.D.Gupta
Soil Physics Companion by A.W.Warrick
Objective

To impart advanced theoretical and practical knowledge about the physical processes in the atmosphere near the ground for growing crop plants.

Theory

UNIT I
Micro-, meso- and macro-climates and their importance, Atmosphere near the ground – bare soil and crop surfaces, exchange of mass, momentum and energy between surface and overlaying atmosphere, exchange coefficients, Richardson number & Reynold’s analogy, Boundary layer, frictional affects, eddy diffusion, forced & free convection.

UNIT II
Micrometeorological parameters; instruments and measuring techniques, agromet observatory.

UNIT III
Radiation, temperature, wind, humidity and carbon dioxide profiles in crops, radiation interception and utilization by crops – albedo, net radiation, PAR, LAI, biomass; photoperiodism, carbon dioxide and photosynthesis; net photosynthesis.

UNIT IV
Air, canopy and leaf temperatures and their biological effects – cardinal temperatures, thermal time, growing degree days, heat use efficiency and their application in field crops.

UNIT V
Wind profile near the ground; roughness and zero plane displacement, evapotranspiration – potential and actual; advection.

UNIT VI
Modification of microclimate by cultural practices, protection of crops from extreme weather.

UNIT VIII
Crop yield and weather parameters; climatic normal of crop plants, crop weather calendars, crop growth models, use of remote sensing for crop growth and yields estimation. Weather based insect pest and disease forecasting, Weather based agro-advisory.

Practicals

IPAR, FAPAR, PAR Extinction Coefficient, RUE, Temperate profile, Wind profile, humidity, Net Radiation profile of the crops at different stages. Thermal indices, albedo, canopy temperature, CATD, SDD and CWSI.

Suggested Readings

AP 631 EVAPOTRANSPARATION (2L+1P) III

(Pre-requisite 130)

Objective
To impart theoretical and practical knowledge about crop ET estimation and measurement

Theory

UNIT I
Radiation and its interaction with crop environment and radiation use efficiency, energy balance, its components and their estimation in crop canopy.

UNIT II
Theories of evapotranspiration – concept of evapotranspiration; potential, reference and actual evapotranspiration;

UNIT III
Estimation of potential evapotranspiration using different approaches – empirical, aerodynamic, radiation, Bowen ratio, combination and eddy correlation techniques, factors affecting evapotranspiration – meteorological, soil and cultural.

UNIT IV
Thornthwaite’s climatic water balance.

UNIT V
Measurement of evapotranspiration using various types of lysimeters, water use efficiency, irrigation scheduling and yield functions.

UNIT VI
Estimation of evapotranspiration using remote sensing technique.

Practicals
Radiation balance, Thornthwaite’s method, Blaney Criddle method, Radiation (Makkink’s) method, Bowen’s Ratio, Aerodynamic method, Combination (Penman’s) method, Combination (FAO 56) method, Pan Evaporation, Climatic Water Balance, Lysimeter
Suggested Readings


Journals

Agricultural and Forest Meteorology
Agricultural Water Management
Irrigation Science
Journal of Irrigation and Drainage Engineering
Water Resources Research

AP 632 SATELLITE AGROMETEOROLOGY (2L+1P) I

(Pre-requisite: AP 140)

Objective

To teach the use of satellite images for agro-meteorological purposes.

Theory

UNIT I
Scope and importance of agrometeorology from space, types of meteorological satellites – Geostationary and Polar orbiting.

UNIT II
International satellite systems and their payloads – NOAA, LANDSAT, SPOT, TERRA and AQUA, DMSP, METEOSAT, GOES, TRMM etc., National satellite systems and their payloads – INSAT, IRS, MEGHA-TROPIQUES, RISAT etc., Agromet parameter’s requirements and satellite data products available.

UNIT III
Retrieval of cloud type and structure in visible and infrared regions, estimation of rainfall by visible, infrared and passive and active microwave techniques.

UNIT IV

UNIT V
Retrieval of surface soil moisture by thermal and passive microwave, retrieval of crop biophysical parameters by empirical and physical techniques.
UNIT VI
Vegetation phenology and dynamics, crop yield modeling, linking Simulation models and remote sensing, crop growth monitoring system

UNIT VII
Drought monitoring, assessment and management, modeling net primary productivity of agroecosystems, agroecological zoning using remote sensing and GIS, remote sensing of air pollutants and green house gases.

Practicals
MODIS Products (Reflectance, LAI, fAPAR, LST), SPOT VGT Products, PROSAIL MODEL, Retrieval: LST, Albedo, Radiation, Crop Phenology, Drought indices, Drought assessment, Net Primary Productivity

Suggested Readings
Lecture Notes Module II : RS & GIS Applications in Agriculture & Soil Science, CCSTEAP, Indian Institute of Remote Sensing, Dehradun, India
Lecture Notes on Satellite Meteorology & Global Change, Vol 1, 2 & 3, CSSTEAP, Space Applications Centre, ISRO, Ahmedabad, India
Special Issue on Remote Sensing Applications in Meteorology, MAUSAM, Vol 54, No. 1, Jan 2003.

AP 640 REMOTE SENSING IN AGRICULTURE (2L+1P) III
(Pre-requisite: AP-140)

Objective
To impart knowledge about the remote Sensing techniques and their applications in agriculture.

Theory
UNIT I
Scope of remote sensing in agriculture, sensors and platforms, data availability for agricultural remote sensing.

UNIT II
Spectral characteristics of soils, differentiation and identification of soils, spectroscopy of soils, soil parameters by hyperspectral remote sensing, soil survey and resource mapping.
UNIT III
Interaction of EM radiation with plant components and crop canopies, spectral signatures, spectral and hyper-spectral indices, crop identification and acreage estimation, crop growth monitoring and yield modeling.

UNIT IV
Infra red thermometry, crop abiotic and biotic stress differentiation and assessment, retrieval of crop biophysical parameters – empirical and radiative transfer approach, advanced digital image processing and classification techniques for crops.

UNIT V
Land use/ land cover mapping, land planning with reference to different agro eco-regions, land degradation process and their evaluation by remote sensing.

UNIT VI
Role of remote sensing in water resource development and management, identification of ground water potential zones, generation of different thematic maps for integrated watershed management; utility of SAR data for crop inventory, salinity mapping, soil moisture mapping, flood assessment and management by remote sensing.

UNIT VII
Precision farming principles - VRT, Modern techniques and machines.

Practical
Use of Infrared thermometry and spectral data for crop stress monitoring, Hyperspectral data for soil and crop characterization, Computation of Spectral Indices for Soil and Vegetation, Processing of microwave Remote Sensing Data, Salinity mapping from remote sensing data, Pre-processing of time series satellite data, Crop discrimination and acreage estimation, Crop yield modeling from satellite data, Land use land cover classification and change detection

Suggested Readings
# Agricultural Statistics

## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS 504</td>
<td>BASIC STATISTICAL METHODS IN AGRICULTURE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 501</td>
<td>BASIC STATISTICAL METHODS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 550</td>
<td>MATHEMATICAL METHODS</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>AS 560</td>
<td>PROBABILITY THEORY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>AS 561</td>
<td>STATISTICAL METHODS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 567</td>
<td>APPLIED MULTIVARIATE ANALYSIS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 568</td>
<td>ECONOMETRICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 569</td>
<td>PLANNING OF SURVEYS / EXPERIMENTS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 572</td>
<td>STATISTICAL QUALITY CONTROL</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>AS 600</td>
<td>ADVANCED DESIGN OF EXPERIMENTS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS 601</td>
<td>ADVANCED SAMPLING TECHNIQUES</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS 602</td>
<td>ADVANCED STATISTICAL GENETICS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS 603</td>
<td>REGRESSION ANALYSIS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS 604</td>
<td>LINEAR MODELS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>AS 606</td>
<td>OPTIMIZATION TECHNIQUES</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS 504</td>
<td>BASIC STATISTICAL METHODS IN AGRICULTURE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 502</td>
<td>BASIC DESIGN OF EXPERIMENTS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 551</td>
<td>MATHEMATICAL METHODS IN STATISTICS</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>AS 562</td>
<td>ADVANCED STATISTICAL METHODS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 565</td>
<td>SAMPLING TECHNIQUES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AS 570</td>
<td>STATISTICAL MODELLING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AS 571/</td>
<td>BIOINFORMATICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MBB 509</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS 573</td>
<td>DEMOGRAPHY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Code</td>
<td>Course Title</td>
<td>Credit</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>AS 605</td>
<td>ADVANCED STATISTICAL INERENCE</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>AS 607</td>
<td>STOCHASTIC PROCESSES</td>
<td>3 0</td>
<td></td>
</tr>
<tr>
<td>AS 661</td>
<td>ADVANCED DESIGNS FOR SINGLE FACTOR EXPERIMENTS</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>AS 663</td>
<td>ADVANCED THEORY OF SAMPLE SURVEYS</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>AS 665</td>
<td>ADVANCED STATISTICAL METHODS FOR POPULATION GENETICS</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>AS 691</td>
<td>SEMINAR</td>
<td>1 0</td>
<td></td>
</tr>
</tbody>
</table>

**III TRIMESTER**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS 504</td>
<td>BASIC STATISTICAL METHODS IN AGRICULTURE</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 503</td>
<td>BASIC SAMPLING AND NON-PARAMETRIC METHODS</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 563</td>
<td>STATISTICAL INERENCE</td>
<td>4 1</td>
</tr>
<tr>
<td>AS 564</td>
<td>DESIGN OF EXPERIMENTS</td>
<td>3 1</td>
</tr>
<tr>
<td>AS 566</td>
<td>STATISTICAL GENETICS</td>
<td>3 1</td>
</tr>
<tr>
<td>AS 608</td>
<td>ADVANCED BIOINFORMATICS</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 662</td>
<td>ADVANCED DESIGNS FOR MULTIFACTOR EXPERIMENTS</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 664</td>
<td>INFERENTIAL ASPECTS OF SURVEY SAMPLING AND ANALYSIS OF SURVEY DATA</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 666</td>
<td>ADVANCED QUANTITATIVE GENETICS</td>
<td>2 1</td>
</tr>
<tr>
<td>AS 667</td>
<td>FORECASTING TECHNIQUES</td>
<td>1 1</td>
</tr>
<tr>
<td>AS 668</td>
<td>BAYESIAN INERENCE IN SURVEY SAMPLING</td>
<td>1 1</td>
</tr>
<tr>
<td>AS 691</td>
<td>SEMINAR</td>
<td>1 0</td>
</tr>
</tbody>
</table>

**Core Courses**


**Ph.D.:** AS 600, AS 601, AS 602, AS 603, AS 604 and AS 605.
AGRICULTURAL STATISTICS

Major Field : Agricultural Statistics

Minor Field : In addition to the major field, every student shall take not less than two minor fields of study (one for M.Sc. students) from disciplines other than Agricultural Statistics with at least 9 credits of course work in each.

The total minimum credit requirements of course work for M.Sc. (Ph.D.) in Agricultural Statistics is 55(45) including minor field(s). Courses AS 551, AS 560 to AS 567 and AS 569 are core courses for M.Sc. (Agricultural Statistics). AS 600 to AS 605 are core courses for Ph.D (Agricultural Statistics).

DESCRIPTION OF COURSES

PGS 504 BASIC STATISTICAL METHODS IN AGRICULTURE (2L+1P) I, II, III

Objective

This basic course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of statistical methods that would help them in understanding the importance and need of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, correlation and regression, tests of significance and multivariate analytical techniques. The students would also be exposed to basic design of experiments and sample surveys.

Theory

UNIT I

UNIT II
Correlation and regression: Correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, simple and multiple linear regression model. Estimation of parameters. Coefficient of determination. Introduction to multivariate analytical tools: Principal component analysis and cluster analysis.

UNIT III
Planning of an experiment and basic principles of design of experiments. Analysis of variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin square design (LSD). Randomization procedure, analysis and interpretation of results. Concept of factorial experiments.
UNIT IV
Planning of sample surveys. Sampling vs complete enumeration, Simple random sampling, Stratified sampling.

Practical
Descriptive statistics. Exercises on probability distributions. Correlation and regression analysis. Large sample tests, testing of hypothesis based on $\chi^2$, t and F. Exercises on non-parametric tests. Principal component analysis and cluster analysis. Analysis of data obtained from CRD, RBD, LSD. Analysis of data of factorial experiments. Selection of a random sample, estimation using simple random sampling. Exercises on stratified sampling.

Suggested Readings

**AS 501 BASIC STATISTICAL METHODS**

*Objective*
This course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance and need of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
Theory

UNIT I

UNIT II

UNIT III

UNIT IV
Introduction to multivariate analytical tools: dimension reduction techniques (Principal Component Analysis), cluster and discriminant function analysis.

Practicals
Descriptive statistics, Box- plots, Stem & leaf plot. Fitting of distributions: Binomial, Poisson, Negative Binomial, Normal. Large sample tests, testing of hypothesis based on exact sampling distributions: $\chi^2$, t and F. Confidence interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution, Correlation and regression analysis, fitting of orthogonal polynomials. Applications of dimensionality reduction, cluster and discriminant function analysis.

Suggested Readings
**Objective**

This course is meant for students of agricultural sciences other than statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to the concepts of design of experiments so as to enable them to understand the concepts involved in planning, designing experiments and analysis of experimental data.

**Theory**

**UNIT I**

Basic principles of design of experiments. Uniformity trials. Analysis of variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin square design (LSD), Balanced incomplete block (BIB) design, Resolvable block designs and their applications: Alpha design and Lattice design-concepts. Randomization procedure, analysis and interpretation of results.

**UNIT II**

Factorial experiments (symmetrical as well as asymmetrical). Confounding in factorial experiments - application in $2^n$ and $3^n$ factorial experiments. Factorial experiments with extra treatment(s). Split plot and Strip plot designs.

**UNIT III**


**Practicals**

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments without and with confounding, Analysis of Covariance, Analysis with missing data, Split plot and strip plot designs, Groups of experiments, Transformation of data, Fitting of response surfaces.

**Suggested Readings**


---

**AS 503 BASIC SAMPLING AND NON-PARAMETRIC METHODS**

(2L+1P) III

**Objective**

This course is meant for students of agricultural sciences other than statistics. The students would be exposed to basic sampling techniques and non-parametric tests. It would help them in
understanding the concepts involved in planning and designing surveys, analysis of survey data, presentation of results and applying non-parametric tests. This course would be especially important to the students of social sciences.

Theory
UNIT I
Concept of sampling, sampling vs complete enumeration, planning of sample survey. Sampling from a finite population, simple random sampling, inverse sampling, stratified sampling, cluster sampling, systematic sampling, multistage sampling, double sampling. Ratio and regression method of estimation. Non-sampling errors.

UNIT II
Concept and levels of measurement. Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal-Wallis test, Friedman two-way ANOVA by ranks. Kendall’s coefficient of concordance.

Practicals
Selection of a random sample, use of random number tables, estimation using simple random sampling. Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling. Estimation using ratio and regression estimators, Estimation using multistage design and double sampling. Exercises on various non-parametric tests.

Suggested Readings

AS 550 MATHEMATICAL METHODS (4L+0P) I

Objective
This course lays the foundation of all other courses of Statistics / Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of matrix algebra, real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory
UNIT I

UNIT II
Integration of rational, irrational and trigonometric functions. Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.
Applications of integration in agricultural research with special reference to economics, genetics, engineering etc.

UNIT III

UNIT IV

Suggested Readings

Narayan, S. 1962. *A Course of Mathematical Analysis*. S Chand and Company,

**AS 551 MATHEMATICAL METHODS IN STATISTICS**

(4L+0P)

**Objective**

This is another course that supports all other courses in Statistics / Agricultural Statistics. The students would be exposed to the advances in linear algebra and matrix theory. This would prepare them to study their main courses that involve knowledge of linear algebra and matrix algebra.

**Theory**

UNIT I
Linear Algebra: Group, ring, field and vector spaces, sub-spaces, basis, Gram Schmidt’s Orthogonalization, Galois field - Fermat’s theorem and primitive elements. Linear transformations.

UNIT II
Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D’Alembert’s Ratio - test, Cauchy’s n\textsuperscript{th} root test, Raabe’s test, Kummer’s test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes’ transformation, multiple integrals.

UNIT III

UNIT IV
Generalized inverses, Moore-Penrose inverse, applications of g-inverse. Spectral decomposition of matrices, Differentiation and integration of matrices, Quadratic forms. Graph theory: Concepts and applications. Fuzzy set theory.

**Suggested Readings**

Deo, N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India Pvt. Ltd.
Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

Theory

UNIT I
Elements of measure theory. Probability - classical and frequency definitions, axiomatic approach, laws of probability, conditional probability, Bayes theorem, Class of sets, field, sigma field, minimal sigma field, Borel sigma field in R.

UNIT II

UNIT III
Markov’s, Chebychev’s and Kolmogorov’s inequalities. Modes of stochastic convergence. Jenson, Liapounov, holder’s and Minkowsky’s inequalities. Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky’s theorem. Borel –Cantelli lemma and Borel 0-1 law.

UNIT IV
Weak and strong laws of large numbers, Central limit theorems (CLT). Demoviere- Laplace CLT, Lindberg – Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications. Definition of quantiles and statement of asymptotic distribution of sample quantiles.
Suggested Readings


**AS 561 STATISTICAL METHODS**

(2L+1P)

**Objective**

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation.

**Theory**

UNIT I

Descriptive Statistics- exploratory data analysis techniques. Random variable.

UNIT II

UNIT III
Exact sampling distributions. Central t, $\chi^2$ and F distributions. Bivariate normal distribution -
conditional and marginal.

UNIT IV
Correlation, rank correlation, correlation ratio, intra-class correlation. Regression analysis, partial
and multiple correlation and regression.

Practicals
Exercises on Descriptive Statistics and exploratory data analysis. Fitting of discrete distributions,
Fitting of continuous distributions, Computation of simple, multiple and partial correlation
coefficient, correlation ratio and intra-class correlation, fitting of regression equations.

Suggested Readings
Publishers.
University Press.
John Wiley.

AS 562 ADVANCED STATISTICAL METHODS (2L+1P)
(Pre-requisite: AS 561)

Objective
This course lays the foundation of probability distributions and sampling distributions and their
application which forms the basis of Statistical Inference. Together with probability theory, this
course is fundamental to the discipline of Statistics. The students are exposed to tests of
significance, non-central distributions, order statistics. Categorical data analysis is also covered
in this course.

Theory
UNIT I
Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsonian curves.
Categorical data analysis - loglinear models, Association between attributes. Variance stabilizing
transformations.

UNIT II
Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra-
class correlation coefficient.

UNIT III
Non-central t, $\chi^2$ and F distributions. Distribution of quadratic forms. Cochran's theorem. Tests
for normality. Large sample tests. Tests of significance based on t, $\chi^2$ and F distributions.
UNIT IV
Order statistics, distribution of $r$th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics, distribution of range, median etc.

Practicals

Suggested Readings

**AS 563 STATISTICAL INFERENCE**

*(Pre-requisite: AS 562)*

**Objective**
This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

**Theory**
UNIT I
UNIT II
Methods of estimation: maximum likelihood, least squares, minimum $\chi^2$, minimum distance, moments, maximum entropy.

UNIT III
Testing of hypothesis: randomized and non randomized tests, Neyman-Pearson lemma, power function, uniformly most powerful tests and their constructions, unbiased tests, likelihood ratio tests. Confidence-interval estimation.

UNIT IV
Sequential analysis, sequential probability ratio test. Elements of decision theory and bayesian inference.

UNIT - V
Nonparametric tests: run, sign, rank, median, Wilcoxon-Mann-Whitney, Kruskal-Wallis, Friedmann two - way ANOVA by ranks.

Practicals
Exercises on estimation of parameters using methods of maximum likelihood, minimum $\chi^2$ and moments. Obtaining confidence interval estimates, MP and UMP tests, Large sample tests, Non-parametric tests, Sequential probability ratio test, Decision functions.

Suggested Readings
Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

UNIT I

UNIT II
Completely randomized design (CRD), Randomized complete block design (RCBD) and Latin square design (LSD). Mutually orthogonal latin squares. Graeco Latin squares. Missing plot techniques.

UNIT III
Factorial experiments, Confounding in symmetrical factorial experiments (2^n and 3^n series), Balanced factorial experiment. Split plot and Strip-plot designs.

UNIT IV
Balanced incomplete block (BIB) designs - general properties and analysis with and without recovery of information. Construction of BIB designs, Youden square designs, Lattice designs. Cross-over designs. Groups of experiments.

UNIT V
Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays, potency estimation.

Practicals

Uniformity trial data analysis, Analysis of data obtained from CRD, RCBD, LSD. Analysis of factorial experiments without and with confounding; Analysis with missing data, Split plot and strip plot designs. Analysis of data obtained from BIB design.

Suggested Readings

www.iasri.res.in/design Design Resources Server.

**AS 565 SAMPLING TECHNIQUES (3L+1P) II**

**Objective**

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

**Theory**

**UNIT I**

Probability sampling, simple random sampling, estimation of proportions, confidence interval, determination of sample size, inverse sampling. Sampling with varying probabilities with replacement. Stratified sampling.

**UNIT II**

Ratio, difference and regression estimators. Cluster sampling, multi-stage sampling with equal probability, systematic sampling, double sampling, successive sampling.

**UNIT III**

Non-sampling errors: sources and classification, non-response survey techniques, imputation methods, measurement errors, repeated measurement techniques, interpenetrating sub-sampling.

**Practicals**

Determination of sample size and selection of sample. Simple random sampling, stratified random sampling, cluster sampling, systematic sampling. Estimation using Ratio and regression methods. Double sampling, multi-stage sampling.

**Suggested Readings**


Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT I
Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, Combined estimation, Disturbed segregation.

UNIT II
Gene and genotypic frequencies, Random mating and Hardy-Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes.

UNIT III
Forces affecting gene frequency: selection, mutation and migration, equilibrium between forces in large populations, polymorphism.

UNIT IV
Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning.

UNIT V
Correlation between relatives, Heritability, repeatability and genetic correlation. Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection. Restricted selection index, Inbreeding and cross-breeding, Changes in mean and variance.

Practicals

Test for single factor segregation ratios, homogeneity of the families with regard to single factor segregation. Detection and estimation of linkage parameter by different procedures. Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law, Estimation of changes
in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient. Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits. Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection. Combined estimation, Disturbed segregation.

Suggested Readings


AS 567 APPLIED MULTIVARIATE ANALYSIS (2L+1P)

(Pre-requisite: AS 560, AS 561, AS 562, AS 563)

Objective

This course lays the foundation of multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

UNIT I
Multivariate normal distribution, marginal and conditional distribution, Concept of random vector, its expectation and variance-covariance matrix. Marginal and joint distributions. Conditional

UNIT II

UNIT III
Concepts of discriminant analysis, computation of linear discriminant function (LDF), classification between $k$ multivariate normal populations based on LDF and Mahalanobis $D^2$. Cluster analysis: $k$-means and Hierarchical clustering. Canonical correlations, Principal components, Factor analysis, multi-dimensional scaling and Correspondence Analysis.

Practicals

Suggested Readings

AS 568 ECONOMETRICS

(2L+1P)

Objective
This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Theory

UNIT I
Study of single equation linear regression models: Maximum likelihood and ordinary least-squares methods of estimation, Statistical inference in linear regression, Estimation subject to linear restrictions.

UNIT II
UNIT III
Elements of time-series analysis-measurement of secular trend, seasonal fluctuations, cyclical fluctuations, periodogram analysis, harmonic analysis, serial correlation and correlogram. Index numbers – their characteristics and construction. Index numbers of wholesale and consumer prices.

Practicals

Suggested Readings

**AS 569 PLANNING OF SURVEYS / EXPERIMENTS**

*(2L+1P) I*

*(Pre-requisite: AS 502, AS 503 or AS 504, AS 565)*

**Objective**
The students would be exposed to concepts of Agricultural statistical system in the country, various surveys conducted at national level and planning and designing of experiments.

**Theory**
UNIT I
Agricultural statistical system in India. Organization of agricultural and livestock census. Nature of surveys: adhoc or repetitive, methods of data collection, problem of sampling frame, choice of sampling design.
UNIT II

UNIT III
Planning and designing of experiments, preparation of layout plans and field visits related to applications of designs. Sampling in field experiments. Quality of experimental data. Experiments on cultivators’ fields. Long-term and rotational experiments. Intercropping and agro forestry experiments.

Practicals
Designing of schedules and instruction manuals for conducting surveys, Demonstration of conducting crop cutting experiments, livestock surveys etc. Planning and designing of experiments, Preparation of layout plans and field visits related to applications of designs. Sampling in field experiments. Analysis of data from experiments on cultivators’ fields, intercropping and agro forestry experiments, long-term and rotational experiments.

Suggested Readings

AS 570 STATISTICAL MODELLING (2L+1P) II

(Pre-requisite: AS 550)

Objective
This is an advanced course in Statistical Theory that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of Mechanistic nonlinear growth models.
Theory

UNIT I

UNIT II
Formulation of nonlinear statistical model. Estimation of parameters using iterative procedures, like Taylor’s, Steepest descent, Levenberg - Marquardt’s. Choice of initial values. Examination of residuals and adequacy of a model. Fitting of nonlinear statistical models using nonlinear estimation procedures and software packages.

UNIT III

UNIT IV
Compartmental modelling: first and second order input-output systems, Dynamics of a multivariable system.

Practicals
Fitting of mechanistic nonlinear models. Application of Schaefer and Fox nonlinear models, Fitting of compartmental models.

Suggested Readings

AS 571/ MBB 509 BIOINFORMATICS (3L+1P) II

Objective
To provide information on basic principles of computational biology and statistical tools used for data analysis.

Theory

UNIT I
Basic molecular biology. Introduction to the basic principles of structure/function analysis of biological molecules. Genome analysis, different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.).

UNIT II
Statistical Techniques: MANOVA, cluster analysis, discriminant analysis, principal component analysis, principal coordinate analysis, multidimensional scaling. Multiple regression analysis.

UNIT III
DNA sequence retrieval system, various DNA and protein sequence file formats. Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools.

UNIT IV
Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools. Programming languages and their applications in bioinformatics.

Practicals
Different types of databases and database search and retrieval. DNA and protein sequence analysis, Similarity searching and multiple alignments, Gene annotation, Phylogenetic analysis, Sequence analysis, Protein structure prediction, Analysis of microarray data. Programming languages in bioinformatics.

Suggested Readings


**AS 572 STATISTICAL QUALITY CONTROL (2L+0P)**

**Objective**

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agri-business and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control.

**Theory**

UNIT I
Introduction to statistical quality control, control charts for variables – mean, standard deviation and range charts, statistical basis, rational subgroups.

UNIT II
Control charts for attributes- ‘np’, ‘p’ and ‘c’ charts.

UNIT III
Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

UNIT IV
Sampling inspection tables for selection of single and double sampling plans.

**Suggested Readings**


**AS 573 DEMOGRAPHY (2L+0P)**

**Objectives**

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.
Theory

UNIT I
Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, measures of fertility and mortality, period and cohort measures.

UNIT II

UNIT III
Stationary and stable populations, migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, measures of mortality and morbidity, period.

UNIT IV
Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays, quantal responses, probit and logit transformations, epidemiological models.

Suggested Readings


AS 600 ADVANCED DESIGN OF EXPERIMENTS (1L+1P) I

(Pre-requisite: AS 564)

Objective

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area. This also helps students for applications of this important subject to agricultural sciences.

Theory

UNIT I
Partially balanced incomplete block designs with two associate classes - properties, analysis and construction.
UNIT II
Resolvable block designs and their application: alpha designs, lattice designs. Multiple comparison procedures.
UNIT III
Fractional replication of symmetrical factorials. Asymmetrical factorials: construction and analysis of balanced confounded designs. Response surface designs, second order rotatable designs.

Practicals
Overview of MS-EXCEL, SAS, SPSS, SPBD Release 1.0, SPFE 1.0. Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorial structure. Analysis of second order response surface designs.

Suggested Readings
www.iasri.res.in/design Design Resources Server.

AS 601 ADVANCED SAMPLING TECHNIQUES (1L+1P) I
(Pre-requisite: AS 565)

Objective
This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares
students for undertaking research in this area. This also helps them for applications of this important subject to statistical system in the country.

Theory

UNIT I
Sampling with varying probabilities without replacement, Horvitz – Thompson estimator.

UNIT II
Ordered and unordered estimators, Sampling strategies, Midzuno-Sen, Rao-Hartley-Cochran, \( \pi \)PS Sampling: procedures such as Brewer, Durbin and Sampford, etc.

UNIT III
Super population concept - comparison of various sampling strategies.

UNIT IV
Post – stratified estimator, imperfect frames, multiple frames, randomized response techniques.

Practicals

Sampling with varying probability, Ordered and un-ordered estimators, Sampling strategies due to Horvitz-Thompson, Midzuno-Sen, Rao-Hartley-Cochran and \( \pi \)PS sampling: procedures such as Brewer, Durbin and Sampford etc., Imperfect frames, Randomized response technique.

Suggested Readings


Singh, D., Singh, P. and Kumar, P. *Handbook of Sampling Methods*. IASRI.


AS 602 ADVANCED STATISTICAL GENETICS (1L+1P)

(Pre-requisite: AS 566)

Objective

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps them for applications of this important subject in plant and animal breeding.

Theory

UNIT I
Genetic load, random genetic drift, effect of finite population size, Theory of path coefficients. Regular systems of inbreeding.
UNIT II
Effect of inbreeding on quantitative characters. Multiple allelism in continuous variation, sex-linked genes, maternal effects - estimation of their contribution.

UNIT III

Practicals

Suggested Readings

AS 603 REGRESSION ANALYSIS (1L+1P)

Objective
This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.
Theory

UNIT I
Simple and multiple linear regressions: Least squares fit, properties and examples. Polynomial regression: analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation. Use of orthogonal polynomials and their fitting.

UNIT II
Regression diagnostics: overview, non-normal errors, non-constant error variances and correlated observations, nonlinearity of the model. Distribution of residuals. Test of homoscedasticity and normality. Influential observations and outliers. Multicollinearity. Transformation of data. GLS. Ridge regression, principal component regression and robust regression.

UNIT III

Practicals

Suggested Readings

AS 604 LINEAR MODELS (2L+0P) I

Objective
The students would be exposed to the theory of linear models, estimation of variance components for unbalanced data and advanced techniques for analysis of data in agriculture.
Theory

UNIT I
General Gauss Markoff set up, Gauss-Markoff’s theorem, Aitken's transformation. Theory of linear estimation, test of hypothesis in linear models. Analysis of variance, partitioning of degrees of freedom. Restricted least squares. Special cases of one and two way classifications (including disproportionate cell frequencies and interaction, cross and nested classifications).

UNIT II
Analysis of covariance. Variance components models, estimation of variance components from unbalanced data. Unified theory of least-squares, MINQUE, MIVQUE. Mixed models. LAR, LASSO.

Suggested Readings

AS 605 ADVANCED STATISTICAL INFERENCE (1L+1P) II

Objective
This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base to undertake basic and applied research in Statistics.

Theory

UNIT I
Robust estimation and robust tests. Asymptotic techniques, Bayesian inference. Estimation of density function, Conditional inference, Detection and handling of outliers in statistical data.

UNIT II
Loglinear models, saturated models, hierarchical models. Analysis of multi-dimensional contingency tables.

UNIT III

UNIT IV
Practicals


Suggested Readings


AS 606 OPTIMIZATION TECHNIQUES

(1L+1P) I

Objective

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques, nonlinear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

UNIT I

Classical and numerical methods of optimization: constrained optimization, Lagrange multipliers, necessary conditions for an extremum. Statistical applications. Optimization and inequalities. Classical inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.
UNIT II

UNIT III
Linear programming techniques, simplex method, Karmarkar's algorithm, duality and sensitivity analysis, zero-sum two-person finite games and linear programming. Integer programming. Statistical applications.

UNIT IV

Practicals

Suggested Readings

AS 607 STOCHASTIC PROCESSES (3L+0P) II

Objective
This course aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area and helps them for applications of this important subject to agricultural sciences.

Theory
UNIT I
UNIT II

UNIT III
Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density. Statements of elementary renewal theorem and Key renewal theorem.

UNIT IV
Elements of queuing processes: queues in series, queuing networks. Applications of queuing theory.

UNIT V

Suggested Readings


Objectives
This is a course on Bioinformatics that aims at exposing the students to some advanced statistical and computational techniques related to bioinformatics. This course would prepare the students in understanding bioinformatics principles and their applications.

Theory
UNIT I
Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods. EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, Clustal W and others. Concepts in phylogeny. Gene prediction based on codons, decision trees, classificatory analysis, neural networks, genetic algorithms, pattern recognition, Hidden Markov models.

UNIT II

UNIT III
Markov Chains (MC with no absorbing states, higher order Markov dependence, patterns in sequences, Markov Chain Monte Carlo – Hastings-Metropolis algorithm, simulated annealing, MC with absorbing States). Bayesian techniques and use of Gibbs Sampling. Advanced topics in design and analysis of DNA microarray experiments.

UNIT IV
Computationally intensive methods (classical estimation methods, Bootstrap estimation and confidence intervals, hypothesis testing, multiple hypothesis testing). Evolutionary models (models of nucleotide substitution). Phylogenetic tree estimation (distances, tree reconstruction - ultrametric and neighbor-joining cases, surrogate distances, tree reconstruction, parsimony and maximum likelihood, modeling, estimation and hypothesis testing). Neural Networks (universal approximation properties, priors and likelihoods, learning algorithms - back propagation, sequence encoding and output interpretation, prediction of protein secondary structure, prediction of signal peptides and their cleavage sites, application for DNA and RNA nucleotide sequences). Analysis of SNPs and haplotypes.

Practicals
AS 661 ADVANCED DESIGNS FOR SINGLE FACTOR EXPERIMENTS (2L+1P) 1

Objective
This is an advanced course in Design of Experiments for single factor experiments for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area and also helps them for applications of this important subject to agricultural sciences.

Theory
UNIT I
General properties and analysis of block designs. Balancing criteria. m-associate partially balanced incomplete block (PBIB) designs and their association schemes including lattice designs - properties and construction. Properties and construction of mutually orthogonal latin squares.

UNIT II
Designs for two-way elimination of heterogeneity including lattice square designs. Designs for test treatment - control(s) comparisons. Nested designs, mating designs, cyclic designs, block designs with nested rows and columns.
UNIT III
Optimality criteria and optimality of designs, robustness of designs against missing observation, presence of outlying observation(s), presence of systematic trend, model inadequacy etc. Diagnostics in design of experiments.

Practicals
Analysis of data from block designs, PBIB designs, Lattice designs. Analysis of designs for two way elimination of heterogeneity, Analysis of augmented designs, Analysis of designs for test treatment - Control(s) Comparison, Analysis of mating designs. Diagnostic Study, Analysis of Lattice square designs.

Suggested Readings

AS 662 ADVANCED DESIGNS FOR MULTI FACTOR EXPERIMENTS (2L+1P) III

Objective
This is an advanced course in Design of Experiments for multi factor experiments and aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area.
Theory

UNIT I
Balanced factorial experiments: characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal and balanced arrays, Fractional replication, Regular and irregular fractions, minimum aberration in fractional factorials.

UNIT II

Practicals
Analysis of block designs with factorial treatment structure, Analysis of designs with orthogonal factorial structure, Analysis of factorial experiments with extra treatments, analysis of fractional factorial experiments. Analysis of response surface designs, Analysis of response surface with blocking, Analysis of experiments with mixtures.

Suggested Readings

AS 663 ADVANCED THEORY OF SAMPLE SURVEYS (2L+1P) II

Objective
This is an advanced course in the theory of sample surveys that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I
Design effect. Number of strata and optimum stratification. Controlled selection. Two way stratification, collapsed strata.

UNIT II

UNIT III
Multistage sampling with unequal probabilities. Self weighting designs. Integration of surveys - Lahiri and Keyfitz’s procedures.
UNIT IV
Variance estimation in complex surveys. Taylor's series linearisation, balanced repeated replication, Jackknife and bootstrap methods.

UNIT V
Use of software for survey data analysis.

Practicals
Estimation of parameters using unbiased ratio and regression type estimators, multivariate ratio and regression methods of estimation, ranked set sampling, systematic sampling in two dimensions. Applications of statistical packages for survey data analysis.

Suggested Readings
UNIT II

Practicals

Suggested Readings

AS 665 ADVANCED STATISTICAL METHODS FOR POPULATION GENETICS (2L+1P) II

Objective
This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in plant and animal breeding.

Theory
UNIT I
Hardy-Weinberg law with multiple allelic systems, auto-tetraploids and self-sterility alleles. Complex cases of selection with two or more loci.

UNIT II

Practicals
Exercises on Multiple allelism, Auto-tetraploid, Self sterility, Diffusion approach to inbreeding coefficient, Generation matrix approach to inbreeding.
Suggested Readings

**AS 666 ADVANCED QUANTITATIVE GENETICS (2L+1P) III**

**Objective**
This is an advanced course in Quantitative Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps them for applications of this important subject in plant and animal breeding.

**Theory**

UNIT I

UNIT II
Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), gene mapping and quantitative trait loci. Molecular manipulation for genetic variability.

UNIT III

**Practicals**
Prediction and estimation of genetic merit. Best linear unbiased prediction. Use of mixed model methodology in analysis of animal and plant breeding experiments.

**Suggested Readings**


**AS 667 FORECASTING TECHNIQUES**

(1L+1P)

**Objective**

The students would be exposed to concepts of forecasting techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

**Theory**

**UNIT I**

Forecasting techniques with special reference to agriculture. Forecast based on time series data: exponential smoothing, Box - Jenkins approach and non-linear models. Forecast models using weather parameters, crop-weather relationships and their use in yield forecast. Forecast using plant characters.

**UNIT II**


**Practicals**

Fitting of forecast models using weather parameters. Time series analysis: plots, decomposition, stationarity tests, exponential smoothing. Univariate Box - Jenkins ARIMA models and seasonal ARIMA models. Forecast models using plant characters, Agrometeorological models for crop forecasting, Markov chain models and ANN models.

**Suggested Readings**


**AS 668 BAYESIAN INFERENCE IN SURVEY SAMPLING**

*(1L+1P) III*

**Objective**

The students would be exposed to the advanced concepts of Bayesian Inference in Survey Sampling. This course prepares students for undertaking research in this area.

**Theory**

UNIT I


UNIT II

Time series approach in survey sampling. Dynamic Bayesian prediction, Kalman filter, empirical and hierarchical Bayes predictors. Robust linear prediction, Bayesian robustness.

**Practicals**

Stochastic parameter models, Bayes’ linear predictor, Kalman filter, Empirical and Hierarchical Bayes predictors, Robust linear prediction.

**Suggested Readings**


### 7 Agronomy

**TRIMESTER WISE DISTRIBUTION OF COURSES**

**I TRIMESTER**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 001</td>
<td>AGRONOMY OF RAINY SEASON CROPS</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>AG 503</td>
<td>PRINCIPLES AND PRACTICES OF WEED MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 505</td>
<td>DRYLAND FARMING AND WATERSHED MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 506</td>
<td>AGRONOMY OF CEREAL CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 510/SSAC</td>
<td>MANAGEMENT OF PROBLEM SOILS AND WATERS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>WST 510</td>
<td>MODERN CONCEPTS IN AGRONOMY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 601</td>
<td>FARMING SYSTEMS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**II TRIMESTER**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 002</td>
<td>AGRONOMY OF WINTER SEASON CROPS</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>AG 501</td>
<td>PRINCIPLES OF CROP PRODUCTION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 504/WST 504</td>
<td>PRINCIPLES AND PRACTICES OF WATER MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 507</td>
<td>AGRONOMY OF PULSE AND OILSEED CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 508</td>
<td>AGRONOMY OF COMMERCIAL CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 602</td>
<td>EXPERIMENTAL TECHNIQUES IN AGRONOMY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>AG 604</td>
<td>PRINCIPLES AND PRACTICES OF ORGANIC FARMING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**III TRIMESTER**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 003</td>
<td>AGRONOMY OF SUMMER SEASON CROPS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AG 502/SSAC</td>
<td>SOIL FERTILITY AND NUTRIENT MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 502</td>
<td>CROP ECOLOGY AND AGROMETEOROLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 509</td>
<td>AGRONOMY OF FODDER AND PASTURE CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 511/AP 511</td>
<td>CROP ECOLOGY AND AGROMETEOROLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Units</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>AG 606</td>
<td>CROP PRODUCTION AND SIMULATION MODELING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AG 607/</td>
<td>PHYSIOLOGY AND BIOCHEMISTRY OF HERBICIDE ACTION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PP 607</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AG 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Core courses

**M.Sc.**

Within the discipline: AG 501, AG 502, AG 503, AG 504 and AG 505

Outside the discipline: AS 501 and AS 502

Core courses for Ph.D.

Within the discipline: AG 601, AG 602 and AG 603
AGRONOMY

Major Field : Agronomy

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 001 AGRONOMY OF RAINY SEASON CROPS (1L+2P) I

Objective

To provide basic knowledge to non-agricultural graduates about the rainy season crops and their cultivation practices

Theory

UNIT I
Tillage in crop production, soil fertility management, weeds and their control, concept of cropping and farming system.

UNIT II
Agronomic practices for cultivation of rainy season cereals – rice, maize, sorghum, pearl millet and minor millets.

UNIT III
Agronomic practices for cultivation of rainy season pulses – pigeonpea, greengram, blackgram and cowpea.

UNIT IV
Agronomic practices for cultivation of rainy season oilseeds – groundnut, soybean and sesamum.

UNIT V
Agronomic practices for cultivation of rainy season fibre crops – cotton and jute.

Practicals

Suggested Readings


AGR 002 AGRONOMY OF WINTER SEASON CROPS (1L+2P) II

Objective

To provide basic knowledge to non-agricultural graduates about the winter season crops and their cultivation practices

Theory

UNIT I
Soil-water-plant relationship, irrigation scheduling, methods of irrigation and moisture conservation techniques.

UNIT II
Agronomic practices for cultivation of winter season cereals - wheat, barley, oats and winter maize.

UNIT III
Agronomic practices for cultivation of winter season pulses - chickpea, lentil and field peas.

UNIT IV
Agronomic practices for cultivation of winter season oilseeds - mustard, sunflower, safflower and linseed.

UNIT V
Agronomic practices for cultivation of sugarcane and potato.

Practicals

Suggested Readings


AGR 003 AGRONOMY OF SUMMER SEASON CROPS (1L+1P) III

Objective

To provide basic knowledge to non-agricultural graduates about the spring and summer season crops and their cultivation practices

Theory

UNIT I
Importance of summer ploughing, seed-bed and nursery management, green manuring, important pests and their control.

UNIT II
Agronomic practices for cultivation of summer season fodder crops – maize, sorghum and pearl millet.

UNIT III
Agronomic practices for cultivation of summer/spring season crops - greengram, cowpea, blackgram, sunflower as well as green manures.

Practicals

Summer ploughing, seed-bed preparation and moisture conservation techniques. Crop plants morphology, taxonomy, and nomenclature. Field preparation and sowing methods of different spring / summer season crops. Identification of summer season crops, their seeds and weeds. Calculation of seed and fertilizer requirements of summer / spring season crops. Cultivation practices including planting methods, nutrient and weed management, and irrigation scheduling for summer season crops. Biometric studies and yield determination of summer season crops. Plant herbarium preparation.

Suggested Readings


**AG 501 PRINCIPLES OF CROP PRODUCTION**

*(3L+1P) II*

**Objective**

To teach the basic concepts of soil and crop management along with quantitative agro-biological principles and crop growth analysis.

**Theory**

UNIT I

Historical aspects of crop production, genesis of scientific principles and modern concepts of crop production.

UNIT II

Quantitative agro-biological principles and their validity; Mitscherlich yield equation, its interpretation and validity; concept of inverse yield nitrogen law and Boule unit.

UNIT III

Conceptual development in tillage practices, resources conservation technologies, conservation agriculture, integrated farming systems, organic farming and precision agriculture.

UNIT IV

Theoretical concepts involved in growth analysis in relation to environment; validity and limitations in interpreting crop growth; different types of growth curves; root:shoot relationship; concept of plant ideotypes; physiological principles of dryland crop production; stress and strains - nature, injury, resistance and management.

UNIT V

Concepts of soil-plant relationships, yield potential of crops and cropping systems and their relationship to fertility status of soil; maximization of crop yields and the apparent limitations.

UNIT VI

Crop plants in relation to environment, competition between component crop plants in mixed crop and between crops and weeds; solar radiation, available moisture regime and crop production.

UNIT VII

Economics of crop production, law of diminishing returns in crop production, and crop response production functions.

**Practicals**

Plant sampling at different crop growth stages for dry matter and leaf area measurement. Calculation of growth indices using dry matter and leaf area, and interpretation of results in relation to treatments. Construction of crop growth curve based on growth analysis data. Measurement of
root:shoot relationship in crops at different growth stages. Computation of harvest index of different crops based on biomass and energy equivalent. Working out sustainability index of different cropping systems. Calculation of indices for assessment of cropping systems and input-use efficiency. Studying the effect of planting geometry on competition between crop plants, crop plants and weeds and input-use efficiency. Assessment of crop yield on the basis of yield attributing characters. Statistical analysis of fertilizer experiments to work out response equation, and optimum/economic dose of nutrients.

Suggested Readings

AG 502 / SSAC 502 / AP 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT (3L+1P) III

Objective
To teach basics of soil fertility, techniques of soil fertility evaluation, plant nutrients, integrated approach of plant nutrition, and environmental quality

Theory
UNIT I
Historical aspects of soil fertility, essential plant nutrients - criteria of essentiality, classification, functions, deficiency and toxicity symptoms, beneficial elements.

UNIT II
Carbon cycle in nature, carbon stocks, sequestration, greenhouse effects, different carbon pools in soil and their role in maintaining soil quality and productivity; soil organisms and their role in soil fertility.

UNIT III
Transformations and dynamics of major- and micro-nutrients in soils and their availability to plants.

UNIT IV
Nutrient interactions in soils and plants: concept, different types of interaction, interaction among essential plant nutrients, law of minimum and maximum.

UNIT V
Commercial fertilizers, new fertilizer materials and principles of their evaluation, crop response to fertilizer application and use efficiency, economics of fertilizer use, nutrient requirements of crops and cropping systems in sustainable agriculture and quality of the produce, foliar nutrition of crop plants.
UNIT VI
Soil fertility evaluation: different approaches, soil and plant tests, biological tests, hidden hunger. Critical nutrient concentration - concept and determination (graphical and statistical procedures), critical nutrient range, diagnosis recommendation and integrated system (DRIS).

UNIT VII

UNIT VIII
Fertilizer x water interactions, crop production under fertilizer / water constraints, site-specific nutrient management - concept and practices; summary of long-term fertilizer experiments.

Practicals

Suggested Readings
AG 503 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT (3L+1P) I

Objective
To provide basic and applied knowledge of weed science to the students, and to make them acquainted with weeds, herbicides, and weed management and research methods.

Theory
UNIT I
Weeds and their importance - harmful and beneficial aspects, weed characteristics and classification.

UNIT II
Weed multiplication/propagation – seed dormancy, viability, germination and dissemination of weeds; crop-weed competition/interference, allelopathy.

UNIT III
Weed management principles and methods/options – preventive, physical, cultural, biological, chemical and integrated weed management approaches.

UNIT IV
History and properties of herbicides, differences with other pesticides, classification of herbicides based on miscellany, chemistry (organic and inorganic) and physiology, structure-activity and selectivity.

UNIT V
Herbicide injury symptoms, physiology/biochemistry of mode/mechanisms of action, herbicide transformations in plants and soil, herbicide formulations and applications; herbicide mixtures; herbicide resistance and management, herbicide residues in environment.

UNIT VI
Weed management in major crops and cropping systems, and non-cropped situations; perennial, aquatic, parasitic and invasive weeds management.

UNIT VII
Biotechnological applications in weed management; herbicide tolerant crops - risks and opportunities.

Practicals
Suggested Readings


**AG 504 / WST 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT (3L+1P) II**

**Objective**

To teach the basic principles of water management and practices to enhance water productivity

**Theory**

**UNIT I**
Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

**UNIT II**
Soil-plant-atmosphere continuum, soil water movement in soil and plants, transpiration, soil-water-plant relationships, water absorption by plants, plant response to water stress, crop plant adaptation to moisture stress condition.

**UNIT III**
Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; micro-irrigation system; fertigation; management of water in controlled environments and polyhouses.

**UNIT IV**
Water management of crops and cropping systems, management of soil moisture stress and plant growth, strategies of using limited water supply, quality of irrigation water and management of saline water for irrigation, water-use efficiency.

**UNIT V**
Water stress – deficit and excess, its effect on growth and development, water stress injury and resistance, management of water stress through soil and crop manipulations, excess soil water and plant growth; water management in problem soils.
UNIT VI
Drainage - concept and classification. Field drainage systems with special emphasis on crop production and soil salinity. Inter-relationship of drainage with cropping patterns and types of farming. Drainage requirement of crops and methods of field drainage, their layout and spacing.

UNIT VII
Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer’s participation in command areas; irrigation legislation.

Practicals

Suggested Readings

**AG 505 DRYLAND FARMING AND WATERSHED MANAGEMENT** (3L+1P) I

Objective
To teach the basic concepts and practices of dryland farming and soil moisture conservation, and watershed management

Theory
UNIT I
Definition, concept and characteristics of dryland farming, delineation of dryland areas, desertification, dryland versus rainfed farming, significance and dimensions of dryland farming in Indian agriculture, types of drought, constraints limiting crop production in dryland areas.

UNIT II
Drought resistance in crops, mechanism for drought tolerance and crop adaptability to drought situations, drought tolerant crops and their varieties, plant ideotypes for dryland areas, shoot and root growth characteristics, mid-season contingent crop planning under erratic and aberrant weather conditions, seed and fodder bank.
UNIT III
Soil moisture conservation and utilization, moisture retention and availability concepts, water adsorption by plants under stress conditions.

UNIT IV
Water loss through evaporation and transpiration and its management under stress conditions, mulches, anti-transpirants and light reflectance – their kinds, effectiveness and economics.

UNIT V
Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

UNIT VI
Concept of watershed management - constraints, approaches and components. Water harvesting - concept and techniques (indigenous and modern), improved agro-techniques, conservation tillage, seed hardening.

UNIT VII
Nutrient and weed management practices, cropping systems, integrated farming systems and alternative land use systems for dryland areas.

Practicals

Suggested Readings
Dhruv Narayana V.V. 2002. Soil and Water Conservation Research in India. ICAR Publ.
AG 506 AGRONOMY OF CEREAL CROPS

(3L+1P) I

Objective
To teach the crop husbandry of cereal crops

Theory
UNIT I
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *kharif* cereals - rice, maize, sorghum and pearl millet.

UNIT II
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *rabi* cereals - wheat and barley.

UNIT III
Cereal-based cropping systems – their role in food security, productivity patterns. Physiological aspects of yield formation, approaches for breaking yield barrier and the role of agronomy.

UNIT V
Integrated nutrient, water and weed management in cereal-based cropping systems. Agronomic management in problematic soils. Recent advances in research on cereal crops.

Practicals

Suggested Readings


AG 507 AGRONOMY OF PULSES AND OILSEED CROPS (3L+1P) II

Objective
To teach the crop husbandry of major pulses and oilseed crops

Theory
UNIT I
Role of pulse and oilseed crops in Indian agriculture. Causes of low yields of pulse and oilseed crops, and strategies for improving productivity. Biofertilizers in pulses and leguminous oilseeds. Significance of BNF, mechanisms of residual effects, nutrient cycling and physical properties of soil.

UNIT II
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *kharif* pulses - pigeonpea, greengram, blackgram, cowpea, mothbean, field bean, horsegram and rice bean.

UNIT III
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *rabi* pulses – chickpea, lentil, peas, frenchbean, and grass pea.

UNIT IV
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *kharif* oilseeds - soybean, groundnut, sesamum, niger and castor.

UNIT V
Origin, history, production trends, adaptability, classification, varietal improvement, climate and soil requirements, cultural, nutritional, weed and water management, quality components for maximum production of *rabi* oilseeds – rape seed and mustard, sunflower, safflower, and linseed.

UNIT VI
Pulses and oilseeds in non-traditional areas and seasons. Physiological limitations for higher productivity in grain legumes; yield stability in pulses and oilseed crops. Non-monetary agro-techniques for augmenting productivity of pulses and oilseed crops.

Practicals
Sowing methods vis-à-vis germination pattern in pulses and oilseeds. Seed inoculation with *Rhizobium* and phosphate solubilizing bacteria. Cultural operations for higher productivity of pulses and oilseeds. Yield attributes of pulses and oilseeds, and estimation of yield. Estimation of biological nitrogen fixation by legume crops. Determination of oil content in oilseeds, and computation of

Suggested Readings

AG 508 AGRONOMY OF COMMERCIAL CROPS (3L+1P) II

Objective
To teach production techniques of commercial crops, and some knowledge of medicinal, aromatic and spice crops

Theory
UNIT I
Importance, origin, history, adaptability, production, distribution, constraints, growth and development, varietal improvement, water and nutrient requirements, weed management, cropping systems, produce quality and value addition in respect of cotton, jute and sugarcane crops.

UNIT II
Importance, origin, history, adaptability, production, distribution, constraints, growth and development, varietal improvement, water and nutrient requirements, weed management, cropping systems, produce quality and value addition in respect of potato, chilli and tobacco crops.

UNIT III
Importance of medicinal and aromatic plants in human health and national economy, classification according to botanical characteristics and uses, adaptability, climate, seed, water and nutrient requirements, cultural practices, plant protection, yield and important constituents, produce quality, processing and value addition in respect of mentha, lemon grass, aloe vera, celery etc.

UNIT IV
Importance, origin, history, adaptability, production trend, distribution, plant growth and development, varietal improvement, soil, water and nutrient requirements, weed management and crop protection, factors affecting produce quality, processing and value addition in respect of tea and coffee.
Practicals

Seed / seedling treatment in different crops. Delinting in cotton and visit to cotton gin. Estimation of seed rate in cotton and jute based on different parameters. Estimation of crop yield on the basis of yield attributes. Quality characteristics in medicinal and aromatic plants. Working out cost of cultivation of different crops. Raising of herbarium of medicinal, aromatic and under-utilized plants. Visit to the processing plant (medicinal and aromatic, sugarcane, potato etc.). Preparation of project report for commercial cultivation of crops. Field visits to acquaint the students about the plant growth and important cultural practices in the crops under study.

Suggested Readings


AG 509 AGRONOMY OF FODDER AND PASTURE CROPS (3L+1P) III

Objective

To teach the crop husbandry, conservation and utilization of different fodder crops, pastures and tree-forage crop-based systems

Theory

UNIT I
Introduction, origin, history, distribution, adaptation, classification, climate, soil, varieties, water, weed management and nutrient requirement of important cultivated fodder crops like maize, pearl millet, teosinte, cluster bean, cowpea, oats, barley, berseem, senji, lucerne etc.

UNIT II
Introduction, origin, history, distribution, adaptation, classification, climate, soil, varieties, water, weed management and nutrient requirement of important forage crops/grasses/legumes, like, napier and hybrid napier grass, guinea grass, Lasiurus, buffel grass, stylo etc.

UNIT III
Anti-quality factors of important fodder crops, forage grasses and legumes. Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting
quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.

UNIT IV
Seed production of important fodder, forage and pasture crops/ grasses/ legumes.

UNIT V
Natural grasslands of India. Establishment of pastures and their management with special reference to weed control and fertilization including micronutrients important to animals, defoliation and its effects, regeneration of infested pastures.

UNIT VI
Agrostolgy and agroforestry systems – definition, classification and importance. Crop production technology in agroforestry and agrostology system; silvipastoral system. Wasteland development - selection of species, planting methods and problems of seed germination in agro-forestry systems. Lopping and coppicing in agroforestry systems.

Practicals
Practical training of farm operations in raising fodder crops and canopy measurement. Yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops. Anti-quality components like HCN in sorghum and such factors in other crops. Hay and silage making, and economics of their preparation. Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry. Methods of propagation/planting of grasses, trees in silvipastoral system. Fertilizer application in strip and silvi-pastoral systems. Economics of agroforestry systems. Visit to IGFRI / NRCAF, Jhansi.

Suggested Readings

AG 510 / SSAC 510 / WST 510 MANAGEMENT OF PROBLEM SOILS AND WATERS
(3L+1P) I

Objective
To educate students about basic concepts of problem soils and waters, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.
Theory

UNIT I
Area and distribution of problem soils – acidic, saline, sodic and physically-degraded soils; origin
and basic concept of problematic soils, and factors responsible.

UNIT II
Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils
- soluble salts, ESP, pH, physical, chemical and microbiological properties.

UNIT III
Acid soils - nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement.
Management of acid soils, biological sickness of soils and its management.

UNIT IV
Management of saline and sodic soils; salt tolerance of crops - mechanism and ratings; monitoring
of soil salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

UNIT V
Agronomic practices in relation to problematic soils; cropping patterns for utilizing poor quality
ground waters.

UNIT VI
Quality of irrigation water; management of brackish water for irrigation; salt balance under
irrigation; characterization of brackish waters.

UNIT VII
Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in
plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Practicals
Characterization of acid, acid-sulfate, salt-affected and calcareous soils. Determination of cations
(Na⁺, K⁺, Ca²⁺ and Mg²⁺) in ground water and soil samples. Determination of anions (Cl⁻, SO₄²⁻,
CO₃⁻ and HCO₃⁻) in ground waters and soil samples. Determination of electrical conductivity and
gypsum requirement of salt-affected soils. Determination of soil pH and lime requirements of acid
soils. Demonstration of salt stress / injury on plants under laboratory conditions. Visit to salt-
affected / acid soil areas (CSSRI / CPRI).

Suggested Readings
New Delhi.
Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson W. L. 2006. Soil Fertility and Fertilizers (7th
Edn.) Prentice Hall, New Delhi.
Univ, Ames, USA.
ICAR, New Delhi.
Objective

To impart knowledge about crop ecology and agrometeorology

Theory

UNIT I
Concept of crop ecology, ecosystem characteristics, energy flow in ecosystem, succession and climax concept, adaptation of crops, agro-ecological regions.

UNIT II

UNIT III
Physiological response of crop plants to weather variables (light, temperature, CO$_2$, moisture and solar radiation). Atmospheric pollution and its effect on climate. Global climate change and its impact on agriculture.

UNIT IV
Competition in crop plants, environmental manipulation through agronomic practices, agro-climatic indices. Improvement of unproductive lands through crop selection and management.

UNIT V

UNIT VI
Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

UNIT VII

Practicals


Suggested Readings


AG 601 MODERN CONCEPTS IN AGRONOMY (3L+1P)  I

Objective
To acquaint the students about the recent developments in agronomy and resource management.

Theory

UNIT I
Environmental concerns related to intensive use of agricultural inputs. Sustainable agriculture - need, scope, practices and economic evaluation, holistic approach of farming systems. Agro-physiological basis of variation in yield, role of agro-biodiversity in sustainable food production, GM crops, crop diversification for improved food and nutritional security.

UNIT II
Conservation agriculture, modern approaches for improving resource-use efficiency, crop residue management in multiple cropping systems. Principles and practices of conservation tillage and watershed management, carbon sequestration.

UNIT III
Precision farming - current status and opportunities for adoption in India. GIS, GPS and remote sensing for crop management, global warming.

UNIT IV
Contract farming - concept, scope, partnerships, types, characteristics, management and administration, problems and advantages for farmers/ sponsors, WTO issues in agriculture.

UNIT V
Crop modeling, systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams information technology, elementary models for crop growth based on basic methods of classical growth analysis.

UNIT VI
Protected agriculture - concept, characteristics, types, scope and limitations in India. Plant nutrition - challenges and tasks ahead. Organic farming - importance, history, scope, principles and practices, limitations, export potential of organic products, certification, labeling and accreditation procedures.

UNIT VII
Climate change and crop adaptation. Stress crop production. Potential evapo-transpiration, water balance of the soil, and production with nutrient and moisture limitations.
Practicals


Suggested Readings


AG 602 EXPERIMENTAL TECHNIQUES IN AGRONOMY (2L+2P) II

Objective

To teach methodology of planning, layout, data recording, analysis, interpretation and report writing of agronomic experiments

Theory

UNIT I
Historical aspects, principles and practices of field experimentation

UNIT II
Identification of research problem and preparation of research project proposal. Presentation of data and report writing.
UNIT III
Planning of experiments, recording of data - before layout of experiment, during crop growth and after harvest. Selection of experimental design, layout of experiment, number of treatments / replications, plot size, border effect etc. Techniques for increasing the precision for an experiment.

UNIT IV
Interpretation of data from weed control, irrigation, fertilizer and cropping system experiments. Interactions in factorial experiments.

UNIT V
Contrast analysis, pooled analysis and data transformation. Evaluation of direct, residual and cumulative effects of treatments.

UNIT VI
Correlation and regression analysis, and their application. Energetics and economic analysis.

UNIT VII
Analysis of data of typical agronomic experiments. Nutrient and water balance sheets. Statistical softwares and their application.

Practicals

Suggested Readings
Objective

To appraise about cropping and farming systems, types of integrated farming systems under different agro-ecosystems, farming systems research and optimization methodologies.

Theory

UNIT I
Cropping systems – definition, indices, production potential, resource management in cropping systems, production potential under monoculture, multiple cropping, alley cropping, intercropping, multistoreyed cropping. Yield advantages in intercropping systems.

UNIT II
Farming systems - definition and importance; classification of farming systems, characteristics, objectives and principles. Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III
Production potential of different components of farming systems. Cropping systems as an important component of farming systems, remunerative cropping systems, crop diversification.

UNIT IV
Integrated farming systems for different agro-ecosystems, interactions and resource recycling among different enterprises.

UNIT V
Farming system research methodologies: on-farm research, on-station research and system modeling. Preparation of different farming system models; evaluation of different farming systems. Case studies on different farming systems.

UNIT VI
Multi-criteria decision making and optimization methodologies for designing integrated farming systems.

Practicals


Suggested Readings


**AG 604 PRINCIPLES AND PRACTICES OF ORGANIC FARMING**  
(2L+1P) II

**Objective**

To teach the principles and practices of organic farming for sustainable crop production

**Theory**

UNIT I

Definition, concepts, history and importance of organic farming; organic production scenario in the world, relevance and scope in India, principles, myths and constraints. Limitations of organic farming.

UNIT II


UNIT III

Package of practices for organic crop production – farm designing, crop planning, site selection, conversion period, selection of seed / seedlings, availability and use of organic inputs, viz. vermicompost, biofertilizers, compost, green manures for crop nutrition, water and weed management, crop protection, harvesting and post-harvesting processing / care.

UNIT IV

Production technology and availability of different organic inputs, viz. vermicompost, biofertilizers, improved compost, green manure, bio-pesticides and plant products, crop-specific package of practices for organic production of different food, vegetable and flower crops.

UNIT V

Changes in physical, microbiological and chemical properties of soil. Evaluation of soil and produce quality.

UNIT VI

Certification of organic produce and process, certification agencies, group certification, marketing, success stories, potential organic production areas/ crops of India.
Practicals

Technique of biofertilizers application and their response in crops. Technique of biopesticide and pheromones application and their response in crops. Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms. Techniques of growing green manure crops. Visit to National Centre for Organic Farming (NCOF). Visit to blue-green algae centre of IARI, vermicompost and biofertilizers production unit. Visit to biopesticide production units, Centre for Protected Crop Production, organic crop production farm.

Suggested Readings


AG 606 CROP PRODUCTION AND SIMULATION MODELING (2L+1P) III

Objective

To familiarize the students about systems approach and to simulate yields and growth of crops under varied soil and weather conditions with different management practices, and their optimization.

Theory

UNIT I

Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams.

UNIT II

Elementary models for crop growth based on basic methods of classical growth analysis.

UNIT III

Crop modeling methods for crop-weather interaction, climate change and variability components, DSSAT, APSIM, INFOCROP and Century models.

UNIT IV

Potential production: leaf and canopy CO₂ assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops. Estimation of generic coefficients.
Practicals


Suggested Readings


AG 607 / PP 607 PHYSIOLOGY AND BIOCHEMISTRY OF HERBICIDE ACTION (3L + 1P) III

Objective

To provide the students up-to-date knowledge on herbicide physiology and biochemistry, and recent approaches in weed management including biotechnological methods

Theory

UNIT I
Weed biology and ecology; allelopathy and allelochemicals; management options; weed economic thresholds; use of models for improved competition studies.

UNIT II
Recent concepts on entry, uptake, translocation and metabolism of soil and foliar-applied herbicides, and impact of environmental and plant factors.

UNIT III
Physiological, biochemical and molecular mechanism of action of different groups of herbicides. Metabolic pathway of herbicide degradation in plants and soil.

UNIT IV
Selectivity of herbicides - physiological and molecular mechanism; herbicide non-target toxicity. Herbicide residue and its management in cropping systems.

UNIT V

UNIT VI
Herbicide resistant crops - prospects, biotechnological and tissue culture approaches for development of herbicide resistant crops.
Practicals


Suggested Readings

# Biochemistry

**TRIMESTER WISE DISTRIBUTION OF COURSES**

## I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 501</td>
<td>BASIC BIOCHEMISTRY</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>BIO 502</td>
<td>NUTRITIONAL BIOCHEMISTRY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>BIO 601</td>
<td>NUCLEIC ACIDS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>BIO 603</td>
<td>GENETIC ENGINEERING-PRINCIPLES AND METHODS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>BIO 701</td>
<td>CURRENT TOPICS IN BIOCHEMISTRY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>BIO 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

## II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 503</td>
<td>PLANT BIOCHEMISTRY</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>BIO 602</td>
<td>PROTEIN BIOSYNTHESIS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 606</td>
<td>INTERMEDIARY METABOLISM</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 607</td>
<td>INORGANIC NITROGEN METABOLISM</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>BIO 608</td>
<td>BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

## III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 504</td>
<td>TECHNIQUES IN BIOCHEMISTRY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>BIO 604</td>
<td>GENE REGULATION</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 605</td>
<td>ENZYMOLOGY</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>BIO 609</td>
<td>BIOCHEMISTRY OF PLANT CELL ORGANELLES</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 702</td>
<td>PROTEOMICS,METABOLOMICS AND IONOMICS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BIO 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** BIO 501, BIO 502, BIO 503, BIO 504, BIO 601, BIO 605, BIO 606 and BIO 607  
MBB 501, PP 501  
**Ph.D.:** BIO 701, BIO 702
BIOCHEMISTRY

Major Fields : Biochemistry
Nutrition

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

BIO 501 BASIC BIOCHEMISTRY \((4L+1P) I\)

Objective
To provide basic knowledge/overview of structure and functional and metabolism of biomolecules.

Theory

UNIT I
Scope and importance of Biochemistry in Agriculture; Fundamental principles governing life; Structure and properties of water; Acid base concepts, pH and buffers; Intra- & inter-molecular forces in biomolecules; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II
Classification, structure and function of carbohydrates, lipids, amino acids, proteins, nucleic acids and vitamins.

UNIT III
Fundamentals of thermodynamic principles applicable to biological process, bioenergetics; respiration and oxidative phosphorylation.

UNIT IV
Classification of enzymes and their mechanism of action, regulation and kinetics.

UNIT V
Plant and animal hormones; Metabolism of carbohydrates, lipids & proteins, DNA replication, transcription and translation.

Practicals
Suggested Readings


**BIO 502 NUTRITIONAL BIOCHEMISTRY**

(3L+1P) I

**Objective**

To provide knowledge about the fundamentals of human nutrition and the significance of various nutrients, present in food and their role in preventing diseases.

**Theory**

UNIT I
Fundamentals of human nutrition; concept of balance diet; calorific value of foods, energy requirement, expenditure and basal metabolic rate.

UNIT II
Biochemical composition and utilization of carbohydrates, proteins and fats; Dietary requirements of carbohydrates, proteins and fats.

UNIT III
Nutritional significance of dietary minerals; Biochemical function and specific deficiency diseases associated with vitamins; Protein-energy malnutrition.

UNIT IV
Antinutritional factors; Role of diet and nutrition in the prevention and treatment of diseases. Antioxidants; Food allergy.

UNIT V
Biochemical composition, energy and food value of various food grains including cereals, pulses, oil seeds, fruits and vegetables. Biochemical changes during processing and storage of food grains, fruits and vegetables; Food additives and contaminants.

**Practicals**

Estimation of tryptophan; Estimation of starch; Estimation of amylose; Estimation of crude fiber; Estimation of oil content in oilseeds; Estimation of carotenoid pigments; Estimation of ascorbic acid (Vitamin C); Assessment of rancidity of oils and fats; Determination of phytin phosphorus; Estimation of Glucose; Protein Estimation.

**Suggested Readings**

Objective

To provide insight into various biochemical and molecular processes in plants and their regulation

Theory

UNIT I
Structure and function of plant cell organelles; Photosynthesis in higher plants; Light and Dark reactions; C₃, C₄ & CAM pathways and their regulation.

UNIT II
Biosynthesis of structural carbohydrates, storage proteins and lipids; Sucrose-Starch interconversion; Photorespiration.

UNIT III
Proteins: post-translational modifications, folding, stability, transport and degradation.

UNIT IV
Cellular metabolism of oligosaccharides and polysaccharides; Secondary metabolites- isoprenoids, alkaloids and phenolics, cyanogenic glycosides and glucosinolates

UNIT V
Biochemistry of Plant hormones; signaling pathways; Phytochromes.

Practicals

Soluble Protein Estimation by Lowry’s Method; Fractionation of Cell Organelles; Estimation of Starch; Assay of ADPG Pyrophosphorylase; Assay of Starch Synthase; Estimation of Amylolytic Activity; Assay of Isocitrate Lyase; Assay of Isocitrate Dehydrogenase; Assay of Ribulose-1,5-Bisphosphate Carboxylase; Assay of Phenylalanine Ammonia Lyase; Assay of Pectin Methyl Esterase; Assay of Superoxide Dismutase; Assay of Polyphenol Oxidase; Assay of Lipoxygenase; Estimation of Proline; Estimation of Carotenoid Pigments; Determination of Polyphenols in Pulse Grains, Fractionations of storage proteins

Suggested Readings


Objective

To impart theoretical and practical knowledge about various biochemical techniques used in biochemistry for isolation and characterization of cellular components.
Theory

UNIT I
Principles of enzyme assays and analysis of biomolecules; Centrifugation techniques-theory, types and applications.

UNIT II
Principles and applications of Spectrophotometry, Mass spectroscopy.

UNIT III
Chromatographic techniques-TLC, ion - exchange, gel - filtration, affinity, GLC and HPLC.

UNIT IV
Electrophoresis techniques – native and SDS-PAGE, Isoelectric focusing, capillary electrophoresis and agarose gel electrophoresis.

UNIT V
Concept of radioactivity, tracer techniques and their applications in biology, Scintillation counters, autoradiography, radiation hazards and safety measures.

UNIT VI
Polymerase Chain Reaction (PCR); Immunochemical techniques, MALDI-TOF.

UNIT VII
Ethical issues and professional responsibilities in research.

Practicals

pH and buffer preparation; Fractionation of cell organelles; Soluble protein estimation by Lowry's Method; Isolation, purification and distribution of polysomes; Gel Chromatography; polyacrylamide gel electrophoresis; Separation of proteins by iso-electric focusing. Isolation of plant DNA, Agarose gel electrophoresis; Estimation of fatty acids by gas-liquid chromatography, Radioisotope analysis by liquid scintillation counter, PCR.

Suggested Readings


BIO 601 NUCLEIC ACIDS

(2L+1P) I

Objective

To provide knowledge about structure and function of nucleic acids and the role of modification enzymes
Theory

UNIT I
History of nucleic acids; DNA as genetic material.

UNIT II
Chemistry of nucleic acids; Chromatin structure and function; Structure and conformation of DNA and RNAs.

UNIT III
DNA topoisomerases, nucleases, endonucleases and related enzymes.

UNIT IV
Biosynthesis of nitrogenous bases, nucleotides and their regulation.

Practicals
Isolation and purification of RNA and DNA from plant tissue; Spectrophotometric analysis and agarose gel electrophoresis; Restriction analysis of DNA; Isolation of total RNA and Ribosomal RNA; Spectrophotometric quantification; agarose gel electrophoresis; Isolation of messenger RNA.

Suggested Readings

BIO 602 PROTEIN BIOSYNTHESIS (3L+0P) II

Objective
To impart knowledge about the various components and processes involved in protein biosynthesis its regulation and the significance of post-translational modifications.

Theory

UNIT I
RNA world; Diverse RNA functions in living cells and its significance.

UNIT II
Structure and function of tRNA, rRNA, mRNA; Pre mRNA splicing, tRNA processing, modification and transport.

UNIT III
Structure and function of amino acyl tRNA synthetases; tRNA identity; recognition and charging; proof reading mechanisms.
UNIT IV
Protein synthesis: structure and function of ribosomes; Genetic code: Elucidation, nature and properties; Initiation, elongation and termination cycles in prokaryotes and eukaryotes, Protein synthesis inhibitors and regulation.

UNIT V
Secretion and maturation of polypeptides: Signal sequences and secretion; Spontaneous and Chaperone mediated folding and transport to organelles like chloroplast, mitochondria and nucleus; Post translational modifications and their significance.

Suggested Readings

BIO 603 GENETIC ENGINEERING – PRINCIPLES AND METHODS (3L +1P) I

Objective
To provide knowledge about the basics of recombinant DNA technology and its applications

Theory
UNIT I
Introduction and historical perspectives; Properties and applications of Restriction Enzymes; Characteristics of vectors; DNA cloning strategies.

UNIT II
Methods of gene isolation, Construction and screening of genomic and cDNA libraries, PCR; Site directed mutagenesis; Gene silencing Methodologies:–Anti-sense RNA Technology, Ribozyme technology; DNA sequencing.

UNIT III
Plant transformation methods and transgene analysis, Potential applications of genetic engineering in agriculture; Transcriptional and post transcriptional gene silencing, gene targeting and gene therapy.

UNIT IV
Bioethics and biosafety issues and IPR in Recombinant DNA research.

Practicals
Isolation of Plant, plasmid and phage DNA and purification; Restriction of Plant DNA; Southern blotting; Elution of DNA from agarose gel; Radioactive labeling of DNA; Southern hybridization, autoradiography. Preparation of vector for cloning; Ligation of vector with insert DNA; Preparation of competent cells; Transformation of E.coli cells and selection of recombinants by antibiotic or blue/white selection; PCR, Preparation of plant RNA, RT-PCR.
Suggested Readings


BIO 604 GENE REGULATION (3L+0P) III

Objective

To provide knowledge about the genome organization, gene expression and regulation in prokaryotes and eukaryotes.

Theory

UNIT I


UNIT II


UNIT III

RNA editing; RNA-interference; Signal transduction and gene regulation in plant development and stress responses.

UNIT IV

Epigenetic control of gene expression.

Suggested Readings:


Objective

To impart knowledge about the catalytic role of enzymes, their structure, Physico-chemical, kinetic and regulatory properties, mechanism of action and their importance in agriculture and allied sectors.

Theory

UNIT I
Enzymes: structure and conformation; classification, assay, isolation, purification and characterization.

UNIT II
Specificity, mechanism of action, steady state and pre-steady state kinetics; Active site mapping, regulation and enzyme activity.

UNIT III
Immobilized enzymes and their applications.

UNIT IV
Enzyme engineering in Agriculture and allied sectors.

Practicals

Soluble protein Estimation by Lowry’s Method; Estimation of Urease activity in Soybean; Crystallization of Urease from soybean meal; Alternate method for Urease extraction; Determination of pH optima for Urease ; Determination of the optimum temperature Q_{10} value and activation energy of Urease ; Study the effect of substrate concentration on enzymatic activity of Urease and determination of K_m and V_{max}; Study of the effect of inhibitor on the activity of Urease; Estimation of ADH and alkaline phosphatase activities; Purification of peroxidase from wheat seedlings.

Suggested Readings

Theory

UNIT I
Intermediary metabolism of carbohydrates and its regulation.

UNIT II
Bioenergetics; Electron transfer and oxidative phosphorylation; Mechanism of oxidative phosphorylation.

UNIT III
Lipid metabolism – degradation and biosynthesis of fatty acids, sterol biosynthesis, metabolic regulation.

UNIT IV
Amino acid metabolism – general reactions, degradation and biosynthesis of amino acids.

UNIT V
Metabolism of nucleic acids – degradation and biosynthesis of purines and pyrimidines.

UNIT VI
Metabolic pathway engineering.

Suggested Readings


BIO 607 INORGANIC NITROGEN METABOLISM (3L+1P)

Objective
To impart knowledge of biochemistry and molecular mechanism of biological nitrogen fixation mechanism and regulation of nitrate assimilation and denitrification processes.

Theory

UNIT I
Biochemistry of nitrogen cycle. Biological nitrogen fixation; Structure, function and regulation of nitrogenase; Structure, function and regulation of nif genes in Klebsiella pneumoniae and Clostridium.

UNIT II
Biochemical basis of legume-Rhizohium symbiosis; Genes involved in symbiosis. Different types of hydrogenases and role of uptake hydrogenase in N₂ fixation; Chemoautotrophy in rhizobia. Biochemistry of ferredoxin and other non-haem iron proteins.

UNIT III
Biochemistry of nitrate assimilation and mechanism of its regulation; GS/GOGAT and GDH pathways; Ureides and amides as nitrogen transport compounds.

UNIT IV
Practicals

Estimation of nitrate content by hydrazine sulphate reduction method; Estimation of protein by Lowry’s Method; In vivo assay of nitrate reductase activity; In vitro assay of nitrite reductase activity; In vitro assay of glutamine synthetase activity; In vitro assay of glutamate synthase activity; In vitro assay of glutamate dehydrogenase activity; Assay of nitrogenase activity by acetylene reduction method; Estimation of hydrogen evolved by legume nodules.

Suggested Readings


BIO 608 BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES (3L+0P) II

Objective

To provide knowledge about the biochemical basis of biotic and abiotic stresses in plants.

Theory

UNIT I
Plant- pathogen interaction and disease development, changes in metabolism of cell wall composition and vascular transport in diseased plants, Expression, structure and activity of gene products caused by genetic mutation, epigenetic phenomena and environmental agents leading to diseases.

UNIT II
Plant defense response, antimicrobial molecules, hypersensitive response and cell death, systemic and acquired resistance, pathogen derived resistance, antipathogenic principles.

UNIT III
Plant viruses, host virus interactions, disease induction, virus movement and host range determination; viroids.

UNIT IV
Biochemical basis of abiotic stresses namely: drought, salinity, temperature, heavy metals, and water pollutants, synthesis and function of proline and glycine betaine, stress tolerance, stress adaptation, interaction between biotic and abiotic stresses.

UNIT V
Reactive oxygen species, antioxidants, enzymes of defense system. Molecular strategies for imparting tolerance against biotic and abiotic stresses.
BIO 609 BIOCHEMISTRY OF PLANT CELL ORGANELLES

Objective
To impart knowledge about structure and function of plant cell organelles and various signaling pathways.

Theory
UNIT I
Cell wall - structure, biogenesis and expansion; Cell membrane - structure and functions, membrane trafficking; Cytoskeleton - Microtubules, microfilaments, and intermediate filaments.

UNIT II
Structure, functions and biogenesis of cell organelles- Endoplasmic reticulum, Golgi Body Complex, Mitochondria, Chloroplast, Ribosome, Lysosome, Peroxisomes, Nucleus (Nuclear envelope with nuclear pore complex, nucleolus, nucleoplasm & chromatin), vacuoles and protein bodies.

UNIT III
Cell division- mitosis, meiosis; cell cycle and its regulation; Cell senescence and programmed cell death; Organization, expression and manipulation of organellar genomes, and their cross-talk with nuclear genome.

UNIT IV
Cell-cell and inter-organellar signaling- Role of plasmodesmata in intercellular transport; intracellular trafficking; signal transduction pathways.

Suggested Readings
Theory

UNIT I
Advanced topics related to nutrition and metabolism.

UNIT II
Advanced topics related to enzymology and industrial biochemistry

UNIT III
Advanced topics related to molecular biochemistry

UNIT IV
Advanced topics related to metabolic engineering and bioprospecting.

Suggested Readings

Selected research articles from most recently published journals.

BIO 702 PROTEOMICS, METABOLOMICS AND IONOMICS
(3L+0P) III

Objective
To impart knowledge in the upcoming areas like Proteomics, Metabolomics and Ionomics and their applications.

Theory

UNIT I
Protein sequencing technologies.

UNIT II
Protein profiling and proteome analysis: Proteome technology, 2D PAGE, MSMS. MALDI-TOF, Protein microarray, comparative and structural proteomics.

UNIT III
Quantitative PCR, SAGE, MPSS, Micro array.

UNIT IV
Metabolomics: Elucidation of metabolic pathways, metabolic pathway engineering. Specific examples of pathway engineering.

UNIT V

Suggested Readings


## Bioinformatics

### Trimester Wise Distribution of Courses

#### I Trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Lectures</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI 501/MBB 503</td>
<td>MOLECULAR CELL BIOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CA 502</td>
<td>INTRODUCTION TO COMPUTER APPLICATION</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CA 551</td>
<td>MATHEMATICAL FOUNDATIONS IN COMPUTER APPLICATION</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MBB 501</td>
<td>PRINCIPLES OF BIOTECHNOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CA 561</td>
<td>PRINCIPLES OF COMPUTER PROGRAMMING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>BI 523</td>
<td>ADVANCED TECHNIQUES FOR SEQUENCE AND STRUCTURE ANALYSIS</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>BI 524</td>
<td>TOOLS AND TECHNIQUES FOR BIOLOGICAL DATA MINING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>BI 525</td>
<td>ADVANCED PROGRAMMING IN BIOINFORMATICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>BI 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II Trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Lectures</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI 506/CA 566</td>
<td>DATABASE MANAGEMENT SYSTEM</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>GP 540/MBB 509/AS 571</td>
<td>BIOINFORMATICS - I</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>BI 508/BIO 602</td>
<td>PROTEIN BIOSYNTHESIS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>BI 525</td>
<td>COMPARATIVE GENOMICS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BI 527</td>
<td>PHYLOGENETIC ANALYSIS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BI 528</td>
<td>CHEMOINFORMATICS AND IPR ISSUES</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BI 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
III TRIMESTER

BI 509/ GENOMICS AND PROTEOMICS 3 0
MBB 602
BI 510 BIOLOGICAL DATABASES AND DATA ANALYSIS 2 1
BI 511 RNA/PROTEIN STRUCTURE PREDICTION & MOLECULAR MODELING 2
BI 512/ BIOINFORMATICS – II 2 1
AS 608
BI 691 SEMINAR 1 0

Core Courses
M.Sc.: BI 501, BI 502, BI 503, BI 504, BI 505, BI 506, BI 507, BI 508, BI 509, BI 510, BI 511.
BI 501 / MBB 503 MOLECULAR CELL BIOLOGY (3L+0P) I

Objective
To provide insight into fundamentals of cell structure, organization and function.

Theory
UNIT I
General structure and constituent of cells; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, cell surface related function.

UNIT II
Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles

UNIT III
Organellar genomes and their manipulation; Ribosome in relation to cell growth and cell division; Cyto-skeletal elements; Water, protein and ion transport;

UNIT IV
Trafficking of biomolecules, Cell division and regulation of cell cycle; Signal transduction mechanisms.

Suggested Readings


BI 502/CA 502 INTRODUCTION TO COMPUTER APPLICATION (1L+1P) I

Objective
The course is aimed to provide fundamentals of networking and application protocols with emphasis on developing web based applications.
Theory

UNIT I
Computer organization; Software - System software and Application software.

UNIT II
Networking fundamentals, types of networking, network topology; File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP).

UNIT III
Internet basics; Hyper Text Markup Language (HTML).

UNIT IV
Web designing; Web servers.

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

Suggested Readings


BI 503/ CA 551 MATHEMATICAL FOUNDATIONS IN COMPUTER APPLICATION (4L+0P) I

Objective

This course is designed to give basic foundations in mathematics that are needed to complement and improve the understanding of courses based on algorithm and problem solving.

Theory

UNIT I
Matrix algebra: Basic operations on matrices, Rank and inverse of matrices.

UNIT II
System of linear equations, Characteristic roots and equations, Eigen values and eigen vectors; Basic Differentiation, Integration and Differential Equations; Vector algebra: Double and Triple Product of vectors.

UNIT III
Coordinate geometry: circles and conic sections; Three dimensional geometry: point, straight line, plane and sphere.

UNIT IV
Sets: Set theory, subsets, operations on sets, set cardinality and counting; Functions: Bijective functions, pigeon-hole principle, Boolean functions, permutation functions, Boolean algebra, recursion relations.
UNIT V
Number Theory: Binary arithmetic, exponentiation, induction, sequences, Fibonacci sequence, big-oh notation, GCD, Euclidean algorithm, partially ordered sets, congruence and equivalence relation, encryption scheme, linear homogenous recurrence relations with constant coefficients.

UNIT VI
Graph Theory: Graphs, trees, LAN, Eulerian cycles, Hamiltonian cycles, graph coloring, graph algorithms; Mathematical Logic: Propositional calculus, proposition, logic connectives and compound statements, conjunction, disjunction, truth tables, duality, tautologies and fallacies; Turing Machine: DFA, NFA.

Suggested Readings

BI 504/ MBB 501 PRINCIPLES OF BIOTECHNOLOGY (3L+0P) I

Objective
To provide insight into basics and application of general biotechnology.

Theory

UNIT I
The structure of DNA; Function of genes and genomes; Restriction enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; PCR and its applications.

UNIT II
Molecular markers and their applications; DNA sequencing.

UNIT III
Applications of gene cloning in basic and applied research; Genomics, transcriptomics and proteomics.

UNIT IV
Genetic engineering and transgenics; General application of biotechnology in agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics

UNIT V
Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual Property Rights in biotechnology.

Suggested Readings
BI 505/ CA 561 PRINCIPLES OF COMPUTER PROGRAMMING

Objective
The course is aimed to develop problem-solving strategies, techniques and skills, to help students develop the logic, ability to solve the problems efficiently using object oriented programming.

Theory
UNIT I
Techniques of problem solving, Algorithm development, Flowcharting, Stepwise refinement.
UNIT II
Structured programming; Object oriented programming, classes, objects, Abstract data types, Data types, Operators (Arithmetic, Logical and Comparison) and expressions.
UNIT III
Branching and iteration, Arrays, Object/Message paradigm.
UNIT IV
Data encapsulation- modules and interfaces; Polymorphism - Static and dynamic binding, Inheritance: class and object inheritance.
UNIT V
Object oriented software design; Generic and reusable classes, Debugging and testing of programs.

Practical
Programming constructs, control statements: branching and looping, file operations, Creation of classes with features - overloading, inheritance, data abstraction, polymorphism and a case study using and Object oriented language.

Suggested Readings

BI-506/ CA 566 DATABASE MANAGEMENT SYSTEM

Objective
Database systems are backbone of any information system, enterprise resource planning, research activities and other activity that require permanence of data storage. This course provides the basic
introduction to database system technologies; design, concurrency, security and backup/recovery issues of database management systems. The major focus in this course is the relational database model.

**Theory**

UNIT I
Database system - Operational Data, Characteristics of database approach, architecture.

UNIT II
Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification.

UNIT III
Entity Relationship model; Relational Data Structure- Relations, Domains and Attributes, Relational Algebra and Operations, Retrieval Operations.

UNIT IV
Relational Database Design - Anomalies in a Database, Normalization Theory, and Normal forms; Query processing and optimization; Security, backup and recovery.

UNIT V
Distributed Databases- concepts, architecture, design; Object Oriented databases; Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML), Query by example.

UNIT VI
PL/SQL - Stored procedure, Database triggers; Relational Data Base Management Package.

**Practical**

E-R diagram construction; SQL - Command Syntax, Data types, DDL Statements, DML Statements, integrity constraints; Triggers, creating stored procedures/ functions; Normalization of database and Case study on a database design and implementation.

**Suggested Readings**

Date, C. J. 2000. *Introduction to Database System*. Addison Wesley.


**BI: 507/ AS 571/ GP 540/ MBB 509 BIOINFORMATICS - I**

**Objective**

To provide information on basic principles of computational biology and statistical tools used for data analysis.
Theory

UNIT I
Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.).

UNIT II
Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling.

UNIT III
DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools.

UNIT IV
Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics.

Practicals
Different types of databases and database search and retrieval, DNA and protein sequence analysis, Similarity searching and multiple alignments, Gene annotation, Phylogenetic analysis, Sequence analysis, Protein structure prediction, Analysis of microarray data, Programming languages in bioinformatics

Suggested Readings

BI 508 /BIO 602 PROTEIN BIOSYNTHESIS (3L+0P) II

Objective
To impart knowledge about the various components and processes involved in protein biosynthesis its regulation and the significance of post-translational modifications.

Theory
UNIT I
RNA world; Diverse RNA functions in living cells and its significance.
UNIT II
Structure and function of tRNA, rRNA, mRNA; Pre mRNA splicing, tRNA processing, modification and transport.

UNIT III
Structure and function of amino acyl tRNA synthetases; tRNA identity; recognition and charging; proof reading mechanisms.

UNIT IV
Protein synthesis: structure and function of ribosomes; Genetic code: Elucidation, nature and properties; Initiation, elongation and termination cycles in prokaryotes and eukaryotes, Protein synthesis inhibitors and regulation.

UNIT V
Secretion and maturation of polypeptides: Signal sequences and secretion; Spontaneous and Chaperone mediated folding and transport to organelles like chloroplast, mitochondria and nucleus; Post translational modifications and their significance.

Suggested Readings

BI 509/ MBB 602 GENOMICS (3L+0P) III

Objective
To provide insight into the functional aspects of cell function by studying the genome as a whole with special emphasis on structural and functional genomics.

Theory
UNIT I
Structural genomics: Classical ways of genome analysis, large fragment genomic libraries, physical mapping of genomes, genome sequencing, sequence assembly and annotation, comparative genomics.

UNIT II
Functional genomics: DNA chips and their use in transcriptome analysis, Mutants and RNAi in functional genomics, qPCR, SAGE, MPSS.

UNIT III
Application of genomics in crop improvement, protein structure and function, proteins as enzymes, protein purification, 2D, mass spectrometry.
Suggested Readings


BI 510 BIOLOGICAL DATABASES AND DATA ANALYSIS (2L+1P) III

Objective

To know about different biological databases existing in the public domain and perform analysis on the data available in them.

Theory

UNIT I
Nature of biological data; Overview of available Bioinformatics resources on the web; NCBI/EBI/EXPASY etc; Biological Databases: Nucleic acid sequence databases; GenBank/EMBL/DDBJ; Biological Databases: Protein sequence databases; PIR-PSD; SwissProt, UniProtKB; Database search engines: Entrez, SRS.

UNIT II
Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms: Needleman & Wunsch, Smith & waterman; Scoring matrices for Nucleic acids and proteins: MDM, BLOSUM, CSW; Database Similarity Searches: BLAST, FASTA; Multiple sequence alignment: PRAS, CLUSTALW; Biological databases: Genome & genetic disorders;

UNIT III
Genome databases: Human, model organisms, microbes & viral: OMIM; Biological databases: structural databases: PDB, NDB, CCSD; Derived databases: Prosite, BLOCKS, Pfam/Prodom.

Practicals

Nucleic acid sequence databases, Protein sequence databases, Database search engines, Database Similarity Searches, Multiple sequence alignment, Genome databases, Structural databases, Derived databases

Suggested Readings


BI 511 RNA/PROTEIN STRUCTURE PREDICTION AND MOLECULAR MODELING

(1L+2P) III

**Objective**

To get insight into various techniques and tools available for protein structure prediction, visualization and validation.

**Theory**

UNIT I
Structural data, databases and structure analysis: Exploring the Database searches on PDB and CSD, WHATIF Molecular visualization tools; Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins and DNA using molecular visualization softwares such as RasMol, Cn3D, SPDBV, Chime, Mol4D etc.

UNIT II
Structure prediction tools and homology modeling: Prediction of secondary structures of proteins using different methods with analysis and interpretation of the results; Comparison of the performance of the different methods for various classes of proteins. (Fasman method, Garnier Osguthorpe Robson (GOR), Neural Network based; methods); NLP approach for secondary structure prediction of RNA; Introduction to mfold and Vienna packages; Prediction of tertiary structures of proteins using Homology Modeling approach: SWISSMODEL, SWISS-PDB Viewer; Prediction of tertiary structures of proteins different methods for fold recognition along with analysis and interpretation of results (Threading techniques; Homology Modeling and abinitio methods).

UNIT III
Molecular dynamics simulation and docking: Basic principles of theoretical modeling, Empirical force fields for biomolecular simulations, Energy minimization, Molecular dynamics, Monte Carlo simulation Peptide building (PYMOL / DStools).

**Practicals**

Structural data, databases and structure analysis, Molecular visualization tools, Structure prediction tools and homology modeling, Molecular dynamics simulation and docking

**Suggested Readings**


Objective

To aim at exposing the students to advanced statistical and computational techniques related to bioinformatics. The course would prepare the students in understanding bioinformatics principles and their applications.

Theory

UNIT I
Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods. EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, ClustalW and others. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.

UNIT II

UNIT III
Markov chains (MC with no absorbing states; Higher order Markov dependence; patterns in sequences; Markov chain Monte Carlo – Hastings-Metropolis algorithm, Simulated Annealing, MC with absorbing States), Bayesian techniques and use of Gibbs Sampling, Advanced topics in design and Analysis of DNA microarray experiments.

UNIT IV
Computationally intensive methods (Classical estimation methods, Bootstrap estimation and Confidence Intervals, Hypothesis testing, Multiple Hypothesis testing), Evolutionary models (Models of Nucleotide substitution), Phylogenetic tree estimation (Distances: Tree reconstruction – Ultrametric and Neighbor-Joining cases, Surrogate distances, Tree reconstruction, Parsimony and Maximum Likelihood, Modeling, Estimation and Hypothesis Testing), Neural Networks (Universal Approximation Properties, Priors and Likelihoods, Learning Algorithms – Back propagation, Sequence encoding and output interpretation, Prediction of Protein Secondary Structure, Prediction of Signal Peptides and their cleavage sites, Application for DNA and RNA Nucleotide Sequences), Analysis of SNPs and Haplotypes.

Practical

Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods, Statistical methods to discover common motifs in biosequences, Multiple alignment and database search using motif models, ClustalW, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models, Computational analysis of protein sequence, Expression profiling by microarray/gene chip, proteomics, Modelling and prediction of structure of proteins, Bayesian techniques and use of Gibbs Sampling, Analysis of DNA microarray experiments, Analysis of one DNA sequence, Analysis of multiple DNA or protein sequences, Computationally intensive methods, Multiple Hypothesis testing, Phylogenetic tree estimation, Analysis of SNPs and Haplotypes.
Suggested Readings

Retrieved from “http://wiki.bioinformatics.org/Likelihood%2C_Bayesian_and_MCMC_Methods_in_Genetics_%28Sorensen%29”

Retrieved from “http://wiki.bioinformatics.org/Computational_Biology_%28Wunschiers%29”


BI 523 ADVANCED TECHNIQUES FOR SEQUENCE AND STRUCTURE ANALYSIS (1L+2P) I

Objective

To teach various approaches meant for sequence alignment and docking simulation in proteomics.

Theory

UNIT I
Advanced Techniques for Sequence Analysis: Sequence Profiles: Derivation, Databases, Application, Gapped BLAST, PSI-BLAST, PHI-BLAST;

UNIT II
UNIT III
Molecular Dynamics Simulations & Monte Carlo Methods: Electrostatics of biomolecules, Simulations of Bio-macromolecular Structures in Water & membrane, Free energy perturbation method; Simulated Annealing: Multiple Sequence Alignments, Simulations of Bio-macromolecular Structures; Designing of molecules like drug, inhibitors using: Structure based and ligand based docking methods, Different Scoring schemes.

Practicals
Advanced Techniques for Sequence Analysis, Molecular replacement method, Methods for Comparison of 3D structures, Optimization techniques: Sequence Alignments, Prediction of Protein Structure, Docking Simulations; Advance techniques in Prediction of 3D Structure.

Suggested Readings

BI 524  TOOLS AND TECHNIQUES FOR BIOLOGICAL DATA MINING  (2L+1P) I

Objective
To understand various algorithms of machine learning approaches.

Theory
UNIT I
Quality of Biological Data & Data Accuracy; General issues regarding Biological Databases: Representation of errors due to (machines, 3D structural and sequence data of proteins and nucleic acid, Proteomics and Micro array data).

UNIT II
Optimization Techniques: Steepest Descent, Conjugate Gradient, Newton-Raphson, Simulated annealing in Biomolecular Structure Optimization; Genetic Algorithms: *Ab initio* methods for structure prediction; Lattice, SOM, etc., Information theory, entropy and relative entropy, Stochastic Grammars & natural languages processing techniques.

UNIT III
Clustering and Classification Algorithms: Hierarchical and non-hierarchical Clustering, K-Means clustering, Grid based clustering, Analysis of MD trajectories, Protein Array data Analysis.

UNIT IV
Dynamic Programming and application in bioinformatics: Sequence Alignments, Structure Alignments; Foundations for Machine learning Techniques: Hidden Markov Model, Neural
Network, Bayesian modeling, The Cox-Jaynes Axiomes; Support Vector machine & Ant colony optimization: Multiple Sequence Alignments, Biomolecular Structure Prediction; Fuzzy logic system & application in bioinformatics; Introduction to WEKA package; Clustering and classifications, Protein Array data Analysis.

Suggested Readings


Gupta, G. K. 2006. *Introduction to Data Mining with Case Studies*. Prentice Hall of India, New Delhi.


BI 525 ADVANCED PROGRAMMING IN BIOINFORMATICS (2L+1P) I

Objective

To learn programming skills for parsing biological data, database connectivity and web-interface.

Theory

UNIT I

UNIT II
CGI Programming: The CGI Module, Your CGI Program in Context, Simplest CGI Program, Passing Parameters via CGI, Perl and the Web, Object oriented perl: Introduction to modules, Creating Objects; Bioperl: Introduction, Installation procedures, Architecture, Uses of bioperl; introduction to Python/ CORBA.

Suggested Readings


BI 526 COMPARATIVE GENOMICS  
(1L+1P) II

Objective
To understand comparative genomics analysis among various species and their role in nucleotide variations.

Theory
UNIT I
Objective and Overview of Genome Comparisons; Genome Alignments: BLAST2, MUMmer, PipMaker, VISTA, Gene Order; Comparative Genomics: Synteny among Prokaryotes and Eukaryotes.

UNIT II
Comparative Genomics Databases: COG, VirGen, CORG, HOBACGEN, Homophila, XREFdb, Gramene; Single Nucleotide Polymorphisms: dbSNP and other SNP-related databases.

Suggested Readings

BI 527 PHYLOGENETIC ANALYSIS  
(1L+1P) II

Objective
To find out the evolutionary relationship among various species by using different phylogenetic algorithms.

Theory
UNIT I
Phylogenetic trees and their comparison: Definition and description, various types of trees; Consensus (strict, semi-strict, Adams, majority rule, Nelson); Data partitioning and combination. Tree to tree distances, similarity; Phylogenetic analysis algorithms: Maximum Parsimony, Distance-based: UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining.

UNIT II

357
**Suggested Readings**


**BI 528 CHEMOINFORMATICS AND IPR ISSUES (1L+1P) II**

**Objective**

To get insight into chemoinformatics and its role in drug discovery.

**Theory**

UNIT I

Chemoinformatics: History, Current activities and Challenges in the Chemoinformatics, Chemical information and sources, Major chemical databases and information retrieval, Chemical Structure drawing tools.

UNIT II


UNIT III

IPR issues: Definitions, Production of plant varieties and farmer’s rights authority and registry. Registration of plant varieties and essentially derived varieties. Duration and effect of registration of benefit sharing. Surrender and revocation of certificate and recertification and correction of register, farmer’s rights, Compulsory license, Plant varieties protection appellate tribunal, Finance, accounts and audit, Infringement, offences, penalties and procedure.

**Suggested Readings**


Johann Gasteiger. *Handbook of Chemoinformatics. From Data to Knowledge*. 
## Computer Application

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 502</td>
<td>INTRODUCTION TO COMPUTER APPLICATION</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CA 551</td>
<td>MATHEMATICAL FOUNDATIONS IN COMPUTER APPLICATION</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CA 552</td>
<td>COMPUTER ORIENTED NUMERICAL METHODS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 560</td>
<td>COMPUTER ORGANIZATION AND ARCHITECTURE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CA 561</td>
<td>PRINCIPLES OF COMPUTER PROGRAMMING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 565</td>
<td>COMPILER CONSTRUCTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 569</td>
<td>WEB TECHNOLOGIES AND APPLICATIONS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 570</td>
<td>COMPUTER GRAPHICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 575</td>
<td>ARTIFICIAL INTELLIGENCE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 611*</td>
<td>DESIGN AND ANALYSIS OF ALGORITHMS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 621*</td>
<td>ADVANCES IN DATA MINING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 501</td>
<td>COMPUTER FUNDAMENTALS AND PROGRAMMING</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>CA 562</td>
<td>OBJECT ORIENTED ANALYSIS AND DESIGN</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 564</td>
<td>DATA STRUCTURES AND ALGORITHMS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 566</td>
<td>DATA BASE MANAGEMENT SYSTEM</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CA 568</td>
<td>SOFTWARE ENGINEERING</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>CA 572</td>
<td>GIS AND REMOTE SENSING TECHNIQUES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 573</td>
<td>DATA WAREHOUSING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 574</td>
<td>MULTIMEDIA AND APPLICATIONS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CA 577</td>
<td>DATA MINING AND SOFT COMPUTING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 578</td>
<td>INFORMATION SECURITY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 612*</td>
<td>FUZZY SETS AND ROUGH SETS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CA 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 503</td>
<td>STATISTICAL COMPUTING IN AGRICULTURE</td>
<td>1 2</td>
</tr>
<tr>
<td>CA 563</td>
<td>OPERATING SYSTEM</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 567</td>
<td>COMPUTER NETWORKS</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 571</td>
<td>MODELING AND SIMULATION</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 613*</td>
<td>ARTIFICIAL NEURAL NETWORKS</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 614*</td>
<td>KNOWLEDGE BASE SYSTEM FOR SEMANTIC WEB</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 622*</td>
<td>ADVANCES IN DATA WAREHOUSING</td>
<td>2 1</td>
</tr>
<tr>
<td>CA 691</td>
<td>SEMINAR</td>
<td>1 0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** CA 552, CA 560, CA 561, CA 562, CA 563, CA 564, CA 565, CA 566, CA 567 and CA 568

*Advance courses will be offered only after the introduction of Ph.D. in the discipline*
COMPUTER APPLICATION

Major Field : Computer Application

Minor Fields : M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own major field.

The total minimum credit requirements of course work for M.Sc. in Computer Application is 55 including Minor field(s).

DESCRIPTION OF COURSES

CA 501 COMPUTER FUNDAMENTALS AND PROGRAMMING (3L+1P) II

Objective

This course builds an understanding of the structure of computers and how they execute programs, data representation and computer arithmetic. The course is also aimed to develop problem-solving strategies, techniques and skills to help students develop the logic, ability to solve the problems efficiently using C programming.

Theory

UNIT I
Computer Fundamentals - Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, character representation: ASCII, EBCDIC. Functional units of computer, I/O devices, primary and secondary memories.

UNIT II
Programming Fundamentals - Algorithm development, techniques of problem solving, flowcharting, stepwise refinement; Representation of integer, character, real, data types; constants and variables; Arithmetic expressions.

UNIT III
Assignment statement, logical expression; Sequencing, alteration and iteration; Arrays, string processing.

UNIT IV
Sub-programs, recursion, files and pointers.

UNIT V
Structured programming concepts; Top down design, development of efficient programs; Program correctness; Debugging and testing of programs.

Practicals

Conversion of different number types; Creation of flow chart, conversion of algorithm/flowchart to program; Mathematical operators, operator precedence; Sequence, control and iteration; Arrays and string processing; Pointers and File processing.

Suggested Readings


Objective

The course is aimed to provide fundamentals of networking and application protocols with emphasis on developing web based applications.

Theory

UNIT I
Computer organization; Software - System software and Application software.

UNIT II
Networking fundamentals, types of networking, network topology; File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP).

UNIT III
Internet basics; Hyper Text Markup Language (HTML).

UNIT IV
Web designing; Web servers.

Practicals

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

Suggested Readings


UNIT II
Fitting and testing the goodness of fit of probability distributions; Testing of hypothesis; t-test, Chi-square test and F-test.

UNIT III
Concept of analysis of variance and covariance of data for one-way and multi-classified experiments.

UNIT IV
Analyzing crossed and nested classified designs; Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts.

UNIT V
Correlation and regression including multiple regression.

UNIT VI
Multivariate Analysis Techniques: Principal component analysis, Factor analysis, Canonical Correlation Analysis, Cluster Analysis, Discriminant function; Analysis of time series data etc.

Practicals
Use of SPSS, SAS and other statistical packages, Exploratory data analysis, Box-Cox plots; Fitting of distributions, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Analysis of variance; Correlation and regression analysis, Multivariate Analysis Techniques: Principal component analysis, Factor analysis, Canonical Correlation Analysis, Cluster Analysis, Discriminant function; Analysis of time series data.

Suggested Readings

CA 551 MATHMATICAL FOUNDATIONS IN COMPUTER APPLICATION (4L+0P) I

Objective
This course is designed to give basic foundations in mathematics that are needed to complement and improve the understanding of courses based on algorithm and problem solving.

Theory
UNIT I
Matrix algebra: Basic operations on matrices, Rank and inverse of matrices.
UNIT II
System of linear equations, Characteristic roots and equations, Eigen values and eigen vectors; Basic Differentiation, Integration and Differential Equations; Vector algebra: Double and Triple Product of vectors.

UNIT III
Coordinate geometry: circles and conic sections; Three dimensional geometry: point, straight line, plane and sphere.

UNIT IV
Sets: Set theory, subsets, operations on sets, set cardinality and counting; Functions: Bijective functions, pigeon-hole principle, Boolean functions, permutation functions, Boolean algebra, recursion relations.

UNIT V
Number Theory: Binary arithmetic, exponentiation, induction, sequences, Fibonacci sequence, big-oh notation, GCD, Euclidean algorithm, partially ordered sets, congruence and equivalence relation, encryption scheme, linear homogenous recurrence relations with constant coefficients.

UNIT VI
Graph Theory: Graphs, trees, LAN, Eulerian cycles, Hamiltonian cycles, graph coloring, graph algorithms; Mathematical Logic: Propositional calculus, proposition, logic connectives and compound statements, conjunction, disjunction, truth tables, duality, tautologies and fallacies; Turing Machine: DFA, NFA.

Suggested Readings

CA 552 COMPUTER ORIENTED NUMERICAL METHODS (2L+1P) I

Objective
The primary objective of the course is to develop the basic understanding of the construction of numerical algorithms, and perhaps more importantly, the applicability and limits of their appropriate use.

Theory
UNIT I
Introduction to complex variables; Basic concepts: Floating point number system, Implication of finite precision, Rounding off errors.

UNIT II
UNIT III
Linear system of equations: Gaussian’s elimination, Operation counts, Implementation including pivoting and scaling, Direct factorization methods, Iterative techniques and their analysis.

UNIT IV
Linear Difference equations; Non-linear equations: Bisection, Newton Raphson, false positions, Secant methods, Iterative methods.

UNIT V
Inverse of Matrices; Computation of eigen values and eigen vectors: Error estimates, the power methods – Jacobi and Householder Method.

UNIT VI
Exposure to mathematical software packages.

Practicals
Interpolation formula, Numerical integration, Runge-Kutta methods, Gaussian elimination, Non-linear equations, Inverse of Matrices, Computation of eigen values and eigen vectors.

Suggested Readings

**CA 560 COMPUTER ORGANIZATION AND ARCHITECTURE**  
(3L+0P) I

Objective
This course builds an understanding of the structure of computers and how they execute programs. The course introduces data representation, computer arithmetic, and machine instruction set design. It then introduces the common physical components of a computer, their interconnections, and the processes underlying program execution.

Theory

UNIT I
Number systems; Boolean algebra - minimization of Boolean function using Karnaugh Map.

UNIT II

UNIT III
Organization of CPU, Control Unit- Instruction and Execution cycle in CPU, Register Organization, The Instruction Cycle, Instruction Pipelining.
UNIT IV
Memory organisation - Internal memory: Semiconductor Main Memory (RAM, ROM, EPROM), Cache Memory, Advanced DRAM Organization; External Memory - Magnetic Disks, RAID, Optical Memory, Magnetic Tape.

UNIT V
Basic structure of computer hardware and system software - Addressing methods and machine programme sequencing; Input-output organisations - accessing I/O devices - direct memory access (DMA) interrupts.

UNIT VI
Introduction to microprocessors – CISC and RISC Architecture, Study of functional units of microprocessors.

Suggested Readings

CA 561 PRINCIPLES OF COMPUTER PROGRAMMING (2L+1P) I

Objective
The course is aimed to develop problem-solving strategies, techniques and skills, to help students develop the logic, ability to solve the problems efficiently using object oriented programming.

Theory
UNIT I
Techniques of problem solving, Algorithm development, Flowcharting, Stepwise refinement.

UNIT II
Structured programming; Object oriented programming, classes, objects, Abstract data types, Data types, Operators (Arithmetic, Logical and Comparison) and expressions.

UNIT III
Branching and iteration, Arrays, Object/Message paradigm.

UNIT IV
Data encapsulation- modules and interfaces; Polymorphism - Static and dynamic binding, Inheritance: class and object inheritance.

UNIT V
Object oriented software design; Generic and reusable classes, Debugging and testing of programs.
Practicals

Programming constructs, control statements: branching and looping, file operations, Creation of classes with features - overloading, inheritance, data abstraction, polymorphism and a case study using and Object oriented language.

Suggested Readings


CA 562 OBJECT ORIENTED ANALYSIS AND DESIGN (2L+ 1P) II

*(Pre-requisite: CA-561)*

Objective

Object oriented analysis and design has emerged as a new paradigm of analysis and design of the systems. This course is designed to give exposure to basic concepts of object-oriented technology so as to program using object-oriented paradigm.

Theory

UNIT I

UNIT II
Describe Use-Case Modelling, Use-case and Use-case relationships, Object Diagrams and Composite Structure Diagrams, Relationships between classes.

UNIT III
Concepts of Association and Aggregation, Reflexive and Package relationships and application of generalization and specialization principles, Design Relationships, Attribute and Method Visibility.

UNIT IV
Refining the Use Case Model, Modelling Class Interactions, Behaviours, Updating the Object Model to Reflect the Implementation Environment.

UNIT V
Object Reusability and Design Patterns, State diagrams, State transition diagrams, Discovering Object Interactions.

UNIT VI
Working with Activity Diagrams, Component and Deployment Diagrams, Case Studies.
Practicals
Case studies and scenarios describing Use-Case Modelling, Use-case and Use-case relationships, Object Diagrams and Composite Structure Diagrams, Relationships between classes, State diagrams, State transition diagrams, Discovering Object Interactions, Activity Diagrams, Component and Deployment Diagrams.

Suggested Readings

CA 563 OPERATING SYSTEM (2L+ 1P) III
(Pre-requisite: CA-560, CA-561)

Objective
The main objective of this course is to provide core knowledge of Operating Systems features, functions and techniques.

Theory
UNIT I
Operating system overview: operating system as an extended machine and resource manager; Operating system classifications; Operating system modes and system calls.

UNIT II
Operating system architecture; Process model, Process synchronization, Concurrent processes, Process scheduling criterion and algorithms.

UNIT III
Problem of mutual exclusion; Deadlock and prevention; Race conditions; Semaphores; Monitors; Process allocation.

UNIT IV
Memory management; Multi-programming with fixed and variable number of tasks; Continuous allocation; Paging, Demand paging, Page fault; Virtual memory; Fragmentation; Segmented memory management, Shared segments; Segmented and demand paged management, Overlays and swapping, Thrashing.
UNIT V
Multi processor system, Master slave scheduling; Homogeneous scheduling; Device management system; Dedicated share and virtual devices.

UNIT VI
File Management System- Input-Output file protection; Remote Procedure Call; Distributed operating system (Course to be taught in accordance to the Unix Operating System).

Practicals
Problems using system calls for process management, signalling, file management, directory management, protection; Critical section problem; Solution to mutual exclusion by Peterson method; Producer consumer problem with fatal race conditions; Comparison of various CPU scheduling algorithms and Paging, segmentation and demand paging.

Suggested Readings

CA 564 DATA STRUCTURES AND ALGORITHMS (2L+ 1P) II
(Pre-requisite: CA-561)

Objective
The learner should be well versed with the various data structures, fundamentals of algorithms, different sorting and searching techniques so as to use them appropriately as per need during development of programs.

Theory
UNIT I
Representation of character, string and their manipulation.

UNIT II
Linear list structure; Stacks; Queues; Heaps.

UNIT III
Sorting algorithms; Searching algorithms.

UNIT IV
Representation and processing of linear linked lists; Multiple linked structures; Sparse arrays.
UNIT V
Tree Structures: Representation of tree structures and different tree traversal algorithms.

UNIT VI
Graph and geometric algorithms.

Practicals
Implementation of various types of structures - linked lists, doubly linked lists, circular linked lists, queue, dequeue, stack and tree; String processing; Searching and sorting techniques; Graph and geometric algorithms and Case studies.

Suggested Readings

CA 565 COMPILER CONSTRUCTION (2L+1P) I

(Pre-requisite: CA-561)

Objective
The purpose of the course is to acquaint various phases of compiler writing which will help an application/system programmer working on other projects besides compilers.

Theory
UNIT I
Introduction to Compiler, Compilation Process, Compiler Structure.

UNIT II
UNIT III
Introduction to Finite Automata, Deterministic Finite Automata.

UNIT IV
Non-deterministic Finite Automata; Scanning & Parsing Techniques – The Scanner, Regular Grammar and FSA, Top Down Parsing, Parsing Algorithm, Top Down Parsing Without Backtracking, Predictive Parsers, Bottom Up Parsing, Parsing, LR Parsers, Shift Reduce Parsing; Symbol Table.

UNIT V
Organization, Memory Allocation – Static & Dynamic Memory Allocation, Compilation Control Transfer, Procedure Calls, Conditional Execution, Iteration Control Construct; Lexical Syntax Errors, Semantic, Major Issues In Optimization, Optimizing.

UNIT VI
Transformations, Local Optimization, Program Flow Analysis, Global Optimization.

Practicals
Design of a lexical analyser for regular expression; Design of a finite state machine;
Program for - magic squares, context free grammar, shift reduce parsing, operator precedence parsing, recursive decent parsing, predictive parser, simple LR parser and Postfix form for intermediate code.

Suggested Readings

CA 566 DATA BASE MANAGEMENT SYSTEM (2L+ 2P) II
(Pre-requisite: CA-561)

Objective
Database systems are backbone of any information system, enterprise resource planning, research activities and other activity that require permanence of data storage. This course provides the basic introduction to database system technologies; design, concurrency, security and backup/recovery issues of database management systems. The major focus in this course is the Relational database model.

Theory
UNIT I
Database system - Operational Data, Characteristics of database approach, architecture.
UNIT II
Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification.
UNIT III
Entity Relationship model; Relational Data Structure- Relations, Domains and Attributes, Relational Algebra and Operations, Retrieval Operations.

UNIT IV
Relational Database Design - Anomalies in a Database, Normalization Theory and Normal forms; Query processing and optimization; Security, backup and recovery.

UNIT V
Distributed Databases- concepts, architecture, design; Object Oriented databases; Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML), Query by example.

UNIT VI
PL/SQL - Stored procedure, Database triggers; Relational Data Base Management Package.

Practicals
E-R diagram construction; SQL - Command Syntax, Data types, DDL Statements, DML Statements, integrity constraints; Triggers, creating stored procedures/ functions; Normalization of database and case study on a database design and implementation.

Suggested Readings
Date, C.J. 2000. Introduction to Database System. Addison Wesley.

CA 567 COMPUTER NETWORKS (2L+1P) III
(Pre-requisite: CA-560, CA-561)

Objective
This course addresses the principles, architectures and protocols that have gone into the development of the Internet and modern networked applications. The course examines network design principles, underlying protocols, technologies and architectures such as naming, data transport, routing and algorithms for networked applications including messaging, encryption and authentication.

Theory
UNIT I
The importance of Networking, Types of Networking, Network Topology, Transmission Media, Data communication: Concepts of data, signal, channel, bandwidth, bit-rate and baud-rate; Maximum data-rate of channel; Analog and digital communications, asynchronous and synchronous transmission.
UNIT II
Network adapters card, Multiplexer (FDM, TDM, STD), Hub, Repeater. Network References Models: Layered architecture, protocol hierarchies, interface and services.

UNIT III
ISO-OSI references model, TCP/IP reference model; Datalink layer function and protocols: Framing, error-control, flow control; sliding window protocol; HDLC, SLIP and PPP protocol.

UNIT IV
Network layer - routing algorithms, congestion control algorithms; Internetworking: bridges and gateway; Transport layer - connection management, addressing; Flow control and buffering, multiplexing.

UNIT V
Session layer – RPC; Presentation layer - abstract syntax notation.

UNIT VI
Application layer - File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol(SMTP); World Wide Web(WWW) - Wide Area Indexed Servers (WAIS), WAP; Network Security; Data compression and cryptography.

Suggested Readings

CA 568 SOFTWARE ENGINEERING (2L+0P) II

Objective
The objective of the course is to acquaint the students with all the phases of Software Development Life Cycle so that they work efficiently as a software engineer.

Theory
UNIT I
Software engineering definition; Software Development: Phases, Process models, Project structure, Project team structure, Role of metrics, Measurement, Software quality factors.

UNIT II
Planning and Software Project: Requirement analysis, Cost estimation, Project Scheduling, Quality Assurance Plan, and Project Monitoring Plans, Gantt charts, PERT and CPM.

UNIT III

UNIT IV
Structured Programming Coding: Programming practices, Verification, Monitoring and Control.
UNIT V

UNIT VI

Suggested Readings

CA 569 WEB TECHNOLOGIES AND APPLICATIONS (2L+1P) I
(Pre-requisite: CA 562 and CA 566)

Objective
The main objective of the course is to introduce the whole range of web technologies. Through the various examples, the course will describe how to design a specific page, dynamic web pages, forms and frames and interaction with a database.

Theory
UNIT I
Web designing – Hyper Text Markup Language, Cascading Style Sheets.
UNIT II
Scripting languages - JavaScript, VBScript.
UNIT III
Web servers and its administration– IIS, Apache, Tomcat; Web designing tools- MS FrontPage/ Dreamweaver, Visual Studio/Java IDE; Web application development using ASP.NET/ JSP/ PHP.
UNIT IV
Database connectivity through ADO.NET/ JDBC; Report Generation.
UNIT V
Extensible Markup Language, XML Stlyesheet Language (XSL), XML Stlyesheet Language Transformation (XSLT).
UNIT VI
Advanced JavaScript – AJAX; Web Services.
Practicals

Designing static website with features like tables, hyperlink among pages, pictures, frames and layers; Client side scripting for user interface validation; development of business logic for server side processing and database integration, Designing of an information system.

Suggested Readings


Ellis, M.D. 2007. ASP.NET AJAX Programming Tricks. Magma Interactive, LLC.


CA 570 COMPUTER GRAPHICS (2L+1P) I

(Pre-requisite: CA 561)

Objective

This course examines the principles of computer graphics, with a focus on the mathematics and theory behind 2D and 3D graphics rendering.

Theory

UNIT I

UNIT II
Raster scan and random scan graphics; Continual refresh and storages displays; Display processors and character generators; Colour display techniques.

UNIT III
Frame buffer and bit operations, Concepts in raster graphics; Points, Lines and Curves; Scan conversion; Line-drawing algorithms; Circle and ellipse generation; Polygon filling; Conic-section generation.

UNIT IV
Anti-aliasing; Two-dimensional viewing: Basic transformations; Co-ordinate systems; Windowing and clipping; Segments; Interactive picture-construction techniques; Interactive input/output devices.
UNIT V
Three-dimensional concepts: 3-D representations and transformations; 3-D viewing; Algorithm for 3-D volumes, Spline curves and surfaces.

UNIT VI
Fractals; Quadtree and Octree data structures; Hidden line and surface rendering and animation

Practicals
Implementation of algorithms for drawing geometrical figures, rotation, charts; Pixel handling on screen; Clipping – Line clipping – Polygon Clipping, Windowing; Use of primitive transformations and/or their combinations; Implementation of 3D Object Representation and Fractal programming and animation.

Suggested Readings

CA 571 MODELING AND SIMULATION (2L+ 1P) III
*(Pre-requisite: CA 501 or CA 561)*

Objective
The courses aims at teaching simulation and modeling technique for conducting experiments on models that describe the behaviour, uncertainty and structure of real world systems. This course will help in simulation of agricultural research problems and systems.

Theory
UNIT I
Uses and purposes of simulation; Classification of models.
UNIT II
Generation and testing of random numbers.
UNIT III
Simulation of stochastic events and processes, Discrete event simulation.
UNIT IV
Design of simulation experiments, Analysis of data generated by simulation experiments, Verification and validation of simulation models.
UNIT V
Simulation languages.
UNIT VI
Simulation of agricultural problems and systems.
Practicals

Generation of random numbers; Testing randomness of generated random numbers; Generation of random variates following Normal, Beta, Gamma, Exponential, Chi-square, Student’s-t, F, Weibull, Binomial, Poisson distributions with the given parameters; Discrete event simulation and Simulation from specific models applicable in agriculture.

Suggested Readings


CA 572 GIS AND REMOTE SENSING TECHNIQUES

(2L + 1P) II

(Pre-requisite: CA-566)

Objective

The basic objective of this course is to teach concepts of GIS and remote sensing with specific applications in agriculture related statistics.

Theory

UNIT I
Introduction to Geographical Information System; Components of a GIS; Data Models in GIS-Raster and Vector.

UNIT II
Spatial Data Analysis- Raster and Vector. Data input, verification, storage and output.

UNIT III
Introduction- maps and spatial information; manual and automatic digitizing process; Spatial and non-spatial data linking; preparation of thematic maps. Data errors in GIS; Spatial modeling; Spatial interpolation; Current and potential uses of GIS in agricultural planning; GIS in India.
UNIT IV
Physics of remote sensing, Satellites and their characteristics; Satellite Remote Sensing and Sensors; Spectral signatures of earth surface features, spectral characteristics of vegetation, soil and water.

UNIT V
Data acquisition Data Reception, Transmission, Processing and data storage; Visual and digital image interpretation; Digital image processing. Applications of Remote Sensing in Agriculture.

UNIT VI
Basics of GPS; Observables and Biases; Errors and Limitations; Type and applications of GPS.

Practicals
Digitization of a map with the help of a digitizer; Map editing; Geo-referencing and map projections; Creation of attribute database and linking with spatial data; General analysis of the data with the help software; Applications of digital elevation models using GIS; Spatial interpolations using GIS; Visual interpretations of remote sensing data; Geometric corrections of remote sensing digital data; Methods for improving quality of digital data and Techniques of image classifications.

Suggested Readings

CA 573 DATA WAREHOUSING
(2L + 1P) II

(Pre-requisite: CA-566)

Objective
The basic objective of this course is to familiarize students about this state of art of setting data warehouse for business intelligence in relation to agricultural research, development and planning.

Theory
UNIT I
Concepts and principles of data warehousing; Project management and requirements.
UNIT II
Dimensional modelling; Data warehousing architecture; System process and process architecture.
UNIT III
Data warehousing design; Database schema; Data staging.
UNIT IV
Partitioning strategy; Aggregations; Data marts; Meta data management; OLAP Modelling, Query management.

UNIT V
Data warehouse security; Backup and recovery; Building end-user Applications; Capacity planning; Testing the warehouse.

UNIT VI
Implementation and maintenance of data warehouse; Case study.

Practicals
Data warehouse design, selection of schema; Normalization and renormalization; Query plan strategy; Performance tuning, backup and recovery of data warehouse; Dynamic reports and OLAP Reports.

Suggested Readings
Gupta, G.K. 2006. *Introduction to Data Mining with Case Studies*. Prentice Hall of India, New Delhi.

CA 574 MULTIMEDIA AND APPLICATIONS

(1L + 1P) II

(Pre-requisite: CA 560)

Objective
This course introduces students to current practices, technologies, methodologies, and authoring systems in the design and implementation of systems that incorporate text, audio, images, animation and full-motion video.

Theory
UNIT I
Introduction to Multimedia Technology - Computers, communications and entertainment; Framework for multimedia systems.
UNIT II
M/M devices, presentation devices and the user interface, M/M presentation and authoring.

UNIT III
Digital representation of sound and transmission; Brief survey of speech recognition and generation; Digital video and image compression; JPEG image compression standard; MPEG motion video compression.

UNIT IV
DVD technology, Time based media representation and delivery; M/M software environment; Limitation of workstation operating systems.

UNIT V
M/M systems services; OS support for continuous media applications; Media stream protocol; M/M file system and information representation.

UNIT VI
Data models for M/M and Hypermedia information.

Practical
Script Writing and Story Boards; Hot Spots and Buttons, Layouts and designing of visuals, Basics of colors; Working with text, presentations, charts and putting animations; Creating interactive presentations; Adobe Photoshop – Introduction, Working with images, Image editing and cleaning; Macromedia Flash - Introduction, Creating shapes, Inserting text, Concepts of colors, layers, frames and timelines; Creating Animation - Creating scenes, creating movie, testing and playing movie; Adobe Acrobat –Overview, Creating Adobe PDF e-Books; Macro Media Director Basics.

Suggested Readings

CA 575 ARTIFICIAL INTELLIGENCE

(Pre-requisite: CA 564)

Objective
The primary objective of this course is to provide an introduction to the basic principles and applications of Artificial Intelligence that includes problem solving, knowledge representation, reasoning, decision making, planning, perception & action, and learning.

Theory
UNIT I
Introduction to Artificial Intelligence (AI); Scope of AI: Games, theorem proving, natural language processing, robotics, expert system.
UNIT II
Knowledge: General concept of knowledge, Knowledge based system, Representation of knowledge, Knowledge organization and manipulation, Acquisition of knowledge.

UNIT III
Symbolic approach: Syntax and Semantics for Prepositional Logic (PL) and First order predicates logic (FOPL), Properties of well formed formulas (wffs), Conversion to clausal form, Inference rules, Resolution principle, Non deductive inference methods.

UNIT IV
Search and Control strategies: Blind search, Breadth-first search, Depth – First search, Hill climbing method, Best – First search, Branch and Bound search.

UNIT V
Learning: Concept of learning, learning automation, genetic algorithms, learning by induction.

UNIT VI
Expert System: Introduction to expert system, Characteristics features of expert system, Applications, Importance of Expert system, Rule based system architecture; Software Agents.

Practicals
Search and Control strategies: Blind search, Breadth-first search, Depth – First search, Hill climbing method, Best – First search, Branch and Bound search; Learning by induction; Genetic algorithms; Case study of a rule based expert system and Construction of Decision tree.

Suggested Readings

CA 577 DATA MINING AND SOFT COMPUTING  
(Pre-requisite: CA 564)  
(2L + 1P) II

Objective
Data Mining and Soft Computing is oriented towards pattern discovery from large datasets. Size of the agricultural data is increasing at exponential rate. Therefore there is a need to supplement traditional data analytical techniques with new innovative techniques. The present course aims to cover data mining and soft computing techniques which can be used for analysis of large datasets.
Theory

Data Mining

UNIT I
Introduction to Data Mining and its Tasks, Data Pre-processing, Data Discretization.

UNIT II
Classification and Prediction, Decision Tree, Naive Bayes' Classifier.

UNIT III
Output and Knowledge Representation, Evaluation and Credibility, Association Rule Mining.

UNIT IV
Clustering: Similarity measures, Hierarchical Clustering, k-Means Clustering.

Soft Computing

UNIT V
Introduction to Soft Computing, Fuzzy sets, Rough sets.

UNIT VI
Neural Network, Support Vector Machines, Genetic Algorithm.

Practicals

Introduction to Data Mining software, Data Pre-processing, Discretization, Decision Tree: D3, Naive Bayes’ Classifier, Association Rule Mining: Apriori Algorithm, Clustering: Hierarchical Clustering, K-Means; Fuzzy set, Rough set, ANN, SVM, Genetic Algorithm.

Suggested Readings


Gupta, G.K. 2006. Introduction to Data Mining with Case Studies. Prentice Hall of India, New Delhi.


Objective

The field of information security has grown and evolved significantly in recent years. Issues like globalization and free trade have made the matter of information security more sensible. In addition to the legislation with respect to information security, pressure coming from industrial piracy, liability, public image and advancement of technology have put a lot of pressure on business to address the information as an asset to be protected. Students are required to understand the principles and techniques of information security to build secure systems.

Theory

UNIT I
Basic concepts of information security; Program security: malware, types of attacks, intrusion detection and prevention.

UNIT II
Cryptographic techniques: conventional cryptography, public-key cryptography, and digital signatures, steganography.

UNIT III
Security services: message integrity, confidentiality and authentication, certification and key management.

UNIT IV
Access control in computer networks: authentication protocols and services (Kerberos).

UNIT V
Firewalls and Virtual Private Networks (VPNs).

UNIT VI
Network security applications: IP security (IPsec), Web security (SSL, TLS, SET), Electronic mail security (PGP, S/MIME), and SNMP security.

Practicals
Malware and their removal, Types of attacks and their detection, Cryptography algorithms, Web security, E-mail security, Firewall, Port blocking, VPN.

Suggested Readings
Objective

This course provides a theoretical foundation in designing algorithms. The focus is on the advanced analysis of algorithms and on how the selections of different data structures affect the performance of algorithms.

Theory

UNIT I

UNIT II

UNIT III
Dynamic Programming: General Method – Multistage Graphs – All-Pair shortest paths – Optimal binary search trees – 0/1 Knapsack – Travelling salesperson problem.

UNIT IV

UNIT V
Graph Traversals – Connected Components – Spanning Trees – Biconnected components – Branch and Bound: General Methods (FIFO & LC) – 0/1 Knapsack problem – Introduction to NP-Hard and NP-Completeness.

Practicals


Suggested Readings


Objective

Fuzzy sets and Rough sets are used to represent vagueness in everyday life. These theories provide an approximate and yet effective means for describing the characteristics of a complex system. In this course, focus is on the advanced methods for handling uncertainty using rough sets and fuzzy sets. The techniques are useful for hybridization of data mining algorithms, feature selection and rule generation, dependencies and other applications.

Theory

Unit I
Introduction to Fuzzy Sets, Basic Notions, Concepts of Fuzzy Sets.

Unit II

Unit III
Introduction to Rough Set Theory, Knowledge representation, Information systems.

Unit IV
Exact Sets, Rough sets, approximations, Logical aspects of rough sets & dependencies, Decision System.

Unit V
Knowledge reduction, Reduct via boolean reasoning, discernibility approach, reduct in decision system, rough membership functions, Generalized and approximate reduct: Frequency based reduct, Local reduct, Dynamic reduct, generalized dynamic reduct, Genetic and hybrid algorithms in reduct computation.

Practicals

Fuzzy system software overview, Applications of Fuzzy Theory, Rough set software overview, Algorithms for reduct computations, Reduct Computation methods, Rule Formulation, Applications of Rough set theory.

Suggested Readings


CA 613* ARTIFICIAL NEURAL NETWORKS  

(Pre-requisite: CA 611)

Objective

This course presents an overview of the theory and applications of artificial neural network to various applications with emphasis on data mining and knowledgebase systems. The objective of this course is on the understanding of various neural networks. The students will be encouraged to use existing software having ANN capabilities as well as to program basic ANN algorithms.

Theory

Unit I

Unit II
Learning Algorithms: Supervised, Reinforcement, Unsupervised, Competitive, Self Organizing Feature Maps, Bayesian, Temporal, Spatiotemporal

Unit III
Associative Networks: Feed-forward and Recurrent networks, Linear Associator, Hopfield, Bidirectional Associative Memory

Unit IV
Neural network architectures: Multilayer networks, Kohonen networks, Counter propagation Networks, GMDH (Group Method of Data Handling), Hamming Networks, Radial Basis Function networks

Unit V
Frontiers of Neurocomputing: Hybridization of neural networks with other soft computing techniques, Neurocomputing Applications,

Practicals

ANN Software, Perceptron, Linear Separable Function, Multilayer Perceptron, Radial Basis Function, Self Organizing Map Networks, Counter propagation Networks, GMDH (Group Method of Data Handling), Hamming Network, Neurocomputing Applications.
Suggested Readings


CA 614* KNOWLEDGEBASE SYSTEMS FOR SEMANTIC WEB (2L + 1P) III

(Pre-requisite: CA 575)

Objective

This course is an introduction to knowledge representation for Semantic Web, ontology, semantic web and knowledgebase systems for Semantic Web. This course aims to provide basic understanding of technologies supporting e-governance. It examines Ontologies and the Semantic Web in the context of developing ontology based systems. It also presents a case study of ontology based system.

Theory

UNIT I

UNIT II
Ontology building methodologies. Ontology Editors, Querying RDF/OWL through SPARQL.

UNIT III
Introduction to Description Logics, Knowledge representation in Description Logics, Description Logic Reasoning, Reasoning with OWL.
UNIT IV
API for building and querying Ontologies, Ontology based systems.

Practicals
Resource Description Framework (RDF)/RDF Schema, Ontology web Language (OWL), Ontology Editors, Querying RDF/OWL through SPARQL, API for building and querying Ontologies, Reasoning with OWL, Ontology based systems.

Suggested Readings

CA 621* ADVANCES IN DATA MINING (2L +1P) I
(Pre-requisite: CA 577)

Objective
Size of the agricultural data is increasing at exponential rate. Therefore there is a need to supplement traditional data analytical techniques with new innovative techniques. Data Mining is oriented towards pattern discovery from large datasets. The present course aims to cover data mining techniques in length. Focus of the course will be on application of data mining techniques on agricultural datasets.

Theory
UNIT I
Review of data mining techniques and challenges, Classification: Decision Tree Classifiers, Bayesian Classifiers, Instance-Based Learners, Support Vector Machines.

UNIT II
Clustering: Distance measures and Symbolic Objects, Scalable Clustering Algorithms, Clustering with Categorical Attributes, Conceptual Clustering, Cluster Validity Indices.

UNIT III
Rule based mining, Candidate Generation and Test Methods, Interesting Rules, Multilevel Rules, Other Variants.

UNIT IV

UNIT V
Web Mining: Concept of web mining, search engines, approaches for web mining; Text Mining: Keyword-based search and mining, Text analysis and retrieval, Similarity-based matching for documents and queries, Latent semantic analysis; Applications in Bioinformatics, Applications in Agriculture.
Practicals
Decision Tree Classifiers, Bayesian Classifiers, Instance-Based Learners, Support Vector Machines, Clustering Algorithms, Rule based mining, Hybridization techniques in data mining, Applications with case studies in agriculture.

Suggested Readings
Gupta, G.K. 2006. Introduction to Data Mining with Case Studies. Prentice Hall of India, New Delhi.


CA 622* ADVANCES IN DATA WAREHOUSING (2L + 1P) III

(Pre-requisite: CA 573)

Objective
The course provides a theoretical foundation in designing an efficient data warehousing solution with efficient query processing including indexing, data compressions and data management. The course will also provide the students to think in the direction of taking research studies in the data warehousing schema design and development, query management techniques, partitioning techniques etc.

Theory
UNIT I
Introduction to Data Warehousing: Heterogeneous information; The integration problem; The Warehouse Architecture; Data Warehousing; Handling of large datasets; Real time data warehousing; Spatial Data warehousing.
UNIT II
Modules of ERP System: HRD, Personnel Management, Training and Development, Skill
Inventory, Material Planning and Control, Inventory, Forecasting, Manufacturing, Production
Planning, Scheduling and Control, Sales and Distribution, Finance, Resource Management in
global scenario.

Unit III
Data Warehouse Models and OLAP Operations: Data Marts; The Multi-Dimensional data model;
Dimensional Modelling; Criterion for OLAPs; Star, snowflake and any other schemas; Roll-up,
Slicing, and Pivoting.

Unit IV
Issues in Data Warehouse Design: Monitoring; Wrappers; Integration; Data Cleaning; Data
Loading; Materialized Views; SQL and Aggregations; Aggregation functions; Grouping; Warehouse
Maintenance; OLAP Servers; Metadata.

Unit V
Data Compression, Query Processing and Partitioning of Database/Table: Data compression and
various techniques of Data compression, Partitioning techniques, Indexing and advanced query
processing and optimization.

Practicals
Case Study: Design and Development a prototype model of the data warehouse with the
implementation and query strategies.

Suggested Readings
Prentice and Hall, New Delhi.
Course Technology.
Publisher: lulu.com
Mark Humphries, Michael W. Hawkins, Michelle C. Dy. 1999. Data warehousing: architecture and
implementation Harris Kern's Enterprise computing institute Solutions for IT Professionals. Prentice Hall.
Data Management Systems Series IT Pro collection. Morgan Kaufmann.
Modelling. Wiley.
Tom Hammergren. 1996. Data warehousing: building the corporate knowledge base ITCP Computer Science
## 11 Entomology

### Trimester Wise Distribution of Courses

#### I Trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 005</td>
<td>Major Pests of Crops and Their Management</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>ENT 500</td>
<td>Insect Biodiversity</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 501</td>
<td>Insect Morphology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 502</td>
<td>Pest Management in Field Crops</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 503</td>
<td>Insect Pest Management</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ENT 505</td>
<td>Principles of Biological Control</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 507</td>
<td>Principles of Insect Physiology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 509</td>
<td>History of Entomology</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>ENT 606</td>
<td>Insect Biochemistry</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II Trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENT 506</td>
<td>Principles of Insect Ecology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 508</td>
<td>Principles of Insect Toxicology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 512/ NANO</td>
<td>Nanotechnology in Crop Protection</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 512/ PL. PATH 521/ NEMA 513/ MB 512</td>
<td>Insect Biosystematics</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 600</td>
<td>Advances in Biological Control</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 603</td>
<td>Pests of Horticultural and Plantation Crops</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 608</td>
<td>Advances in Insect Physiology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 610</td>
<td>Insect Genetics and Molecular Biology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ENT 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

391
### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENT 504</td>
<td>POST HARVEST ENTOMOLOGY</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 601</td>
<td>INSECT PATHOLOGY</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 604</td>
<td>INSECT NUTRITION AND HOST PLANT RESISTANCE</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 605</td>
<td>ADVANCES IN INSECT TOXICOLOGY</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 607</td>
<td>BIOCHEMISTRY OF INSECTICIDE ACTION</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 609</td>
<td>RECENT TRENDS IN ENTOMOLOGY</td>
<td>2 1</td>
</tr>
<tr>
<td>ENT 611/PL</td>
<td>PLANT HEALTH DIAGNOSTICS &amp; MANAGEMENT</td>
<td>2 2</td>
</tr>
<tr>
<td>PATH 607</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENT 691</td>
<td>SEMINAR</td>
<td>1 0</td>
</tr>
</tbody>
</table>

**Core Courses:**

*For M.Sc.: With in the discipline: ENT 500, ENT 501, ENT 505, ENT 506, ENT 507, ENT 508*

*Outside the discipline: PGS 504*
ENTOMOLOGY

**Major Fields**: Insect Biosystematics
Insect Pest Management (Ecology and Biological Control)
Insect Toxicology
Insect Physiology

**Minor Fields**: Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

**DESCRIPTION OF COURSES**

**AGR 005 MAJOR PESTS OF CROPS AND THEIR MANAGEMENT** (1L+2P) I

**Objective**
To impart basic knowledge of insect pest and related problems to the non-agricultural graduates so that they can understand the whole gamete of agriculture for effective research programmes.

**Theory**

UNIT I
Introduction to Entomology: Position of insects in animal kingdom and brief history of Entomology in India; non-insect pests and pollinators.

UNIT II
Insect Pests of important crops and their management:
- Cereals: Paddy, barley, wheat, sorghum, and maize.
- Pulses: Pigeon pea, chickpea, mung bean, cowpea, and lentil.
- Oil seeds: Mustard, groundnut, castor, and jatropha.
- Vegetables: Cole crops, okra, cucurbits, potato, garden peas, and spinach.
- Fruits: Mango, guava, banana, citrus, ber, and aonla.
- Cotton.
- Sugarcane.

UNIT III
Pests of storage and their management: Beetle insects, moth insects, mites, fungi, birds, and rodents.

UNIT IV
Pesticide application appliances and their safe handling: Sprayers, dusters and miscellaneous equipments.
Practicals


Suggested Readings


ENT 500 INSECT BIODIVERSITY (2L+IP) I

Objective

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families in insects.

Theory

UNIT I
Introduction to class Insecta and its position in phylum Arthropoda; history of insect classification; phylogeny, evolution and nomenclature; diversity of insect and mite fauna in various ecosystem; importance of biodiversity in relation to agriculture and environment.

UNIT II
Classification of insects up to orders and identification of agriculturally important families in major insect orders of agricultural importance.

UNIT III
Methods of collecting, preserving and studying insects and their immature stages. Visits to ZSI, NBAII, BNHS etc.

Practicals


Suggested Readings

ENT 501 INSECT MORPHOLOGY (2L+1P) I

Objective
To acquaint the students with external morphology of the insect’s body, i.e., head, thorax and abdomen, their appendages and functions.

Theory
UNIT I
Insect dominance, structural perfections and developmental characteristics; embryology and post embryonic development.

UNIT II
Integument, its structure, functions; head, its origin, segmentation, sclerites, sutures; types of antennae; mouth parts and their modifications; sensilla on various appendages; tentorium, neck and its sclerites.

UNIT III
Thorax, its sclerites and modifications; wing venation, articulation and wing coupling; legs and their modifications.

UNIT IV
Abdomen, its sclerites, appendages, glands on the body surface and external genitalia.

Practicals
Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia; sense organs.

Suggested Readings
ENT 502 PEST MANAGEMENT IN FIELD CROPS

Objective
To familiarize the students about nature of damage and seasonal incidence of insect pests that causes loss to major field crops and their effective management by different methods.

Theory
Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests, and vectors.

UNIT I
Insect pests of cereals and millets, and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, etc.)

UNIT II
Insect pests of pulses, tobacco, oilseeds and their management.

UNIT III
Insect pests of fibre crops, forages, sugarcane and their management.

Practicals
Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

Suggested Readings

---

ENT 503 INSECT PEST MANAGEMENT

Objective
To familiarize the students with principles of insect pest management, including concept and philosophy of integrated pest management (IPM). Train students in computation of ETL, implementing IPM programmes.

Theory
UNIT I
History and concepts; ecological and sociological aspects; determination of single- and multi-pest economic injury level, and natural enemy- based economic levels.
UNIT II
Dimensions of insect plant interactions and advances in varietal resistance including transgenics to crop pests; biological, chemical, legal, cultural, genetic, behavioural and other management tactics and development of PM modules; impact assessment.

UNIT III
Analysis of spatial distribution, sampling, measuring economic levels of damage and modeling; biotype development and importance of biosystematics in pest diagnostics; bio-intensive IPM; bio-pesticides and toxicology in pest management, sanitary and phytosanitary measures; effect of radiations on insects, sterile male techniques.

UNIT IV
Wide area management of epidemics of crop pests; case studies on pests of national importance and their management.

Suggested Readings

ENT 504 POST HARVEST ENTOMOLOGY (2L+IP) III

Objective
To familiarize students with different pests associated with stored commodities and bulk storage, storage structures and safe use of fumigant. Besides, exposure to handle the agri-horticultural produce for contamination free trading, treatment protocols, and other sanitary and phytosanitary regulations.

Theory
UNIT I
Bionomics and biology of pests of stored products including fungi, mites, rodents, and other non-insect pests.

UNIT II
Principles and methods of safe storage, detection methods, seed disinfection, and estimation of losses caused by the pests. Improved storage structures, warehouses, grain storage facilities and their management, insect trapping devices used in storage, and use of plastics in storage.
UNIT III
Systems approach for quarantine security, fumigation with conventional and inert gases including modified atmosphere, vacuum fumigation, vapour heat treatment, hot water treatment, pesticidal dip, gamma irradiation, and microwave heat treatment.

UNIT IV
Sanitary and phytosanitary considerations as well as Montreal Protocol.

Practicals
Demonstration of losses in storage by insects, identification of storage insects (Adult and immature stages), moisture maintenance, storage material damaged by insects, storage structures, and fumigation.

Suggested Readings

ENT 505 PRINCIPLES OF BIOLOGICAL CONTROL (2L+1P) I

Objective
To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory
UNIT I
History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control-importation, augmentation and conservation.

UNIT II
Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc. Biological control of weeds using insects.

UNIT III
Mass production techniques of quality bio-control agents and economics.

UNIT IV
Methods of natural enemy colonization, recovery, evaluation and conservation. Pest-natural enemy ratios; biological control of important crop pests and weeds.

UNIT V
Establishment of biocontrol laboratories and related infrastructure.
UNIT VI
Successful biological control projects, analysis, trends and future possibilities of biological control; importation of natural enemies-quarantine regulations; biotechnology in biological control; and semiochemicals in biological control.

Practicals
Identification of common natural enemies of crop pests (parasitoids, predators, and microbes), and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids; common predators; microbes and their laboratory hosts; and phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, and identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Readings

ENT 506 PRINCIPLES OF INSECT ECOLOGY (2L+1P) II

Objective
To teach the students the concepts of ecology, basic principles of distribution and abundance of organisms and their cause. Study life tables, organization of communities, and diversity indices. Train students in sampling methodology, calculation of diversity indices, constructing life tables, and relating insect population fluctuations to biotic and/or abiotic factors.

Theory
UNIT I
History of ecology and its basic concepts; habitat and niche, food chain; ecological succession; population theories, Hopkin's bioclimatic law, phase and biotic theory.

UNIT II
Ecological and biological indicators; natural balance; biotic potential and environmental resistance; competition; factors affecting insect distribution in time and space; biotic and climatic control; diapause and quiescence, migration and dispersal; tropism and kinases.
UNIT III
Spatial distribution; sampling; social life and thermoregulation; diversity; global climate change.

UNIT IV
Modeling population dynamics; life table and key factor analysis; determination of thermal constant and threshold of development, population-weather models, forecasting concept, agro-ecological zoning, and remote sensing.

Practicals
Types of distributions of organism. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters-measures of central tendencies, Poisson distribution, negative binomial distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling’s Disc equation assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagramatic representation of niches of organisms. Calculation of some diversity indices-Shannon's and Avalanche. Index and understanding their associations, and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Readings

ENT 507 PRINCIPLES OF INSECT PHYSIOLOGY (2L+1P) I

Objective
To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology and adaptation of different system of insects according to habits and habitats of the insects.
Theory

UNIT I
Scope and importance of insect anatomy and physiology.

UNIT II
Structure, modification and physiology of different systems-digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive musculature, and endocrine and exocrine glands.

UNIT III
Thermodynamics, physiology of integument, moulting; growth, metamorphosis and diapause.

Practicals
Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient, preparation and evaluation of various diets, and consumption, utilization and digestion of natural and artificial diets.

Suggested Readings

ENT 508 PRINCIPLES OF INSECT TOXICOLOGY (2L+IP) II

Objective
To acquaint students with basic concepts of toxicology, types of insecticides and their formulations, plant protection appliances and bioassay techniques.

Theory
UNIT I
Measurement of potency and susceptibility; factors affecting toxicity of insecticides; bio-efficacy; chemical, biological and physical properties of conventional insecticides.
UNIT II
Laboratory evaluation of insecticides; bioassay techniques and their importance.

UNIT III
Formulations types, uses, advances and their importance; insect growth regulators and chitin inhibitors.

UNIT IV
Plant protection appliances; safe storage and handling of pesticides; symptoms of insecticide poisoning and their antidotes; restricting/phasing out of harmful insecticides. Insecticides Act; BIS standards.

Practicals
To prepare pesticide formulations; measurement of potency and susceptibility; laboratory evaluation of insecticides; plant protection appliances; safe storage and handling of pesticides; symptoms of insecticide poisoning and their antidotes.

Suggested Readings

ENT 509 HISTORY OF ENTOMOLOGY (1L+0P) I

Objective
To acquaint students with history, pioneer entomologists, and development of entomological science.

Theory

UNIT I
Evolution of Insects; earliest records of insect, fossils; genesis of Entomology as a hobby and science–global and national efforts.

UNIT II
Entomology in the colonial era; Genesis of Agricultural Entomology & Forest Entomology; contributions of H.M. Leforoy, T. B. Fletcher, H. S. Pruthi, Tashkeer Ahmed, Lionel de Nicevelle, T. V. R. Iyer, E. S. Narainan, S. Pradhan, N. C. Pant and K.N. Mehrotra and many others.

UNIT III
World leaders in entomological research & teaching and their contributions: International level institutes in Entomology like Commonwealth Institute of Entomology, CAB International, British Museum of Natural History, Natural Resources Institute, I.I.I.P.E.; Entomological Societies: USA, Briton, Australia, Canada, India & China; and about leading Journal and Text books in Entomology.

Suggested Readings
ENT 512 NANOTECHNOLOGY IN CROP PROTECTION (2 L + 1P) II
(Multi-disciplinary: Agric. Chemicals, Plant Pathology, Nematology, Microbiology)

Objective
To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology

Theory
UNIT I

UNIT II
Effect of bioactive nano-materials on insect pests and beneficial insects. (2 Lectures, Entomology)

UNIT III
Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi, bacteria and viruses with special reference to copper, sulfur etc. Interaction of bioactive nano-materials on plant pathogens including fungi, bacteria, virus etc (3 lectures, Plant Pathology).

UNIT IV
Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano-chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus. Identification and quantification of biotoxins effective in nano-doses. (3 lectures, Nematology).

UNIT V
Microbes: Microbes of agricultural importance. Life cycle: genesis, growth, reproduction, identification and quantification. Nanotechnological application in microbiology (3 lectures, Microbiology)

UNIT VI

Practicals
Identification, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests.

Suggested Reading
ENT 600 INSECT BIOSYSTEMATICS

Objective
To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

Theory
UNIT I
Principles and application of zoological nomenclature; paleontology and phylogeny, species concept and speciation; taxonomic publications.
UNIT II
Identification keys, description of new taxa; taxonomic characters, numerical taxonomy; cladistics and phenetics.
UNIT III
Molecular systematic; current trends in insect classification.
UNIT IV
Taxonomic collections and curation; institutions of importance in biosystematics; status of biosystematics in India.

Practicals
Measurement of insects and their parts; Drawing of insects and their parts- preparation of illustrations; Microphotography of insects; Image analysis; Application of ICZN; Preparation and use of diagnostic keys; Morphometrics of insects-statistical procedures; Numerical taxonomy; Taxonomic publications-preparation of publications.

Suggested Readings

ENT 601 INSECT PATHOLOGY

Objective
To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence, provide hands-on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

Theory
UNIT I
History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma, and nematodes.
UNIT II
Epizootiology, symptomatology and etiology of diseases caused by the above, and the factors controlling these. Defense mechanisms in insects against pathogens.

UNIT II
Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens (Safety and registration of microbial pesticides).

UNIT IV
Mammalian toxicity and safety of insect pathogens. Safe use of insect pathogens in integrated management of insect pests.

UNIT V
Biopesticides formulations, commercial production and economics.

Practicals
Laboratory practice, introduction to the microscope, aseptic techniques, preparation of microbiological media, Culturing and isolation techniques of insect pathogens, smear preparation, Bacteria, gram’s staining, spore staining, Spore counting. Isolation of Bacteria from soil/diseased larvae, isolation of genomic DNA from Bt isolates, PCR analysis of Cry Genes of Bacillus thuringiensis isolates, resolving PCR product on agarose gel electrophoresis, enumeration of NPV using a standard haemocytometer, production of nuclear polyhedrosis, extraction of POBs of NPV, bioassay with NPV, bioassay with Bt, isolation of Fungus from diseased insect, preparation of media for mass culture of fungi.

Suggested Readings

ENT 602 ADVANCES IN BIOLOGICAL CONTROL (2L+1P) II

Objective
To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.
Theory

UNIT I
Scopes of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents vis-a-vis target pest populations.

UNIT II
Mass culturing techniques, immature stages of parasitic and predatory insects, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

UNIT III
National and international guidelines on natural enemy introduction; success stories of classical biological control, scope of fortuitous biological control due to liberalization in global trade in agriculture; international standards for testing side effects of pesticides on natural enemies; quality control parameters of parasitoid and predators, status of commercialization and field use of parasitoid and predators of important insect pests of crops, and beneficial insects and weeds.

UNIT IV
Colonization, techniques of release of natural enemies; recovery evaluation, conservation and augmentation of natural enemies; survivorship analysis and ecological manipulations; large-scale production of biocontrol agents, bankable project preparation.

UNIT V
Scope of genetically engineered microbes and parasitoids in biological control, and genetics of ideal traits in biocontrol agents for introgression and for progeny selections breeding techniques of biocontrol agents.

Practicals
Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests, project document preparation for establishing a viable mass production unit/insectary.

Suggested Readings
ENT 603 PESTS OF HORTICULTURAL AND PLANTATION CROPS  

**Objective**

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, and their integrated management.

**Theory**

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage, and management of insect pests of various crops.

**UNIT I**
Fruit Crops - Mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, ber, fig, citrus, aonla, pineapple, apple, peach and other temperate fruits.

**UNIT II**
Vegetable crops - Tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables, etc.

**UNIT III**
Plantation crops - Coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.

**UNIT IV**
Spices and Condiments - pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetle vine, etc.

**UNIT V**
Ornamental, medicinal and aromatic plants and their pests in polyhouses/protected cultivation.

**Practicals**

Collection and identification of important pests and their natural enemies on different crops, study of life history of important insect pests and non-insect pests.

**Suggested Readings**


ENT 604 INSECT NUTRITION AND HOST PLANT RESISTANCE  

**Objective**

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management. nutritional physiology and their application in entomology.
Theory

UNIT I
History and importance of resistance, principles, classification, components, types and mechanisms of resistance.

UNIT II
Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

UNIT III
Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance; induced and acquired resistance.

UNIT IV
Factors affecting plant resistance including biotypes and measures to combat them.

UNIT V
Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer; successful examples of resistant crop varieties in India and world. Role of biotechnology in plant resistance to insects.

UNIT VI
Insect nutrition - role of vitamins, proteins amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular micro-organisms and their role in physiology, artificial diets.

Practicals

Screening techniques for measuring resistance, measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

Suggested Readings


ENT 605 ADVANCES IN INSECT TOXICOLOGY (2L+1P) III

Objective

To acquaint students with advances in toxicology, insecticide resistance and pesticide residues.
Theory
UNIT I
Pesticides industry in India-commercial aspects; effect of insecticides on insects at population level.
UNIT II
Insecticide resistance; detection, monitoring and management; synergism, antagonism and potentiation; ecotoxicology and biomagnification.
UNIT III
Botanical insecticides, synthetic pyrethroids, neonicotinoids, ecdysone, agonist, avermectins and novel group of insecticides.
UNIT IV
Pesticide residues in commodities and their decontamination; Codex Alimentarius” considerations.

Practicals
Determination of pesticide residues and decontamination; monitoring and detection of insecticide resistance; synergists; joint toxicity; analysis of biomagnification; and study of antifeedant activity of plant products.

Suggested Readings

ENT 606 INSECT BIOCHEMISTRY (2L+1P) III

Objective
To acquaint students with metabolic specializations in insects in relation to carbohydrates, lipids, amino acids and protein; biosynthesis and mode of action of insect juvenile hormones and ecdysones.

Theory
UNIT I
Metabolic specializations in insects in relation to carbohydrates, lipids, amino acids and proteins; role of trehalose and glycogen in energy production.
UNIT II
Insect lipids and their metabolism during flight, diapause and reproduction; biochemistry of tyrosine, tryptophan and proline metabolism in insects.
UNIT III
Biosynthesis, mode of action and metabolism of insect juvenile hormones and ecdysones; pheromone biosynthesis and regulation of release; insect neuropeptides and special emphasis on PTTH, adipokinetic hormone, proctolin and bursicon; insect specific proteins.

Practicals
Estimation of carbohydrates, lipids, amino acids and protein, JH, ecdysone etc. in insect haemolymph. To study pheromone biosynthesis and regulation of neuropeptides, adipokinetic hormone, proctolin and bursicon.
Suggested Readings


**ENT 607 BIOCHEMISTRY OF INSECTICIDE ACTION**  
(2L+1P) III

**Objective**

To impart knowledge to students on biochemical and biophysical targets in the nervous system of insects and non-target organisms; structure-activity relationships and mode of action of insecticides; and basic aspects of insecticide metabolizing enzymes.

**Theory**

**UNIT I**
Biochemical and biophysical targets in the nervous system of insects and non-target organisms; molecular targets in the neuroendocrine, integument, gut and respiratory systems.

**UNIT II**
Structure-activity relationships and mode of action of insecticides at the molecular level especially of carbamates, organo phosphates, nicotinoids, pyrethroids and recently introduced compounds.

**UNIT III**
Basic aspects of insecticide metabolizing enzymes, metabolism of insecticides in insects and non-target organisms; molecular basis of insecticide selectivity.

**Practicals**

To study molecular targets in the neuroendocrine, integument, gut and respiratory systems; mode of action of insecticides at the molecular level; and metabolism of insecticides in insects and non-target organisms.

**Suggested Readings**


**ENT 608 ADVANCES IN INSECT PHYSIOLOGY**  
(2L+1P) II

**Objective**

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones and mechanism of polymorphism, diapause, migration, etc.

**Theory**

**UNIT I**
Ultra structure, physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, and types of sclerotization.
UNIT II
Digestive enzymes, digestive physiology in phytophagous insects, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development, physiology of excretion and osmoregulation, water conservation mechanisms. Evolution of digestive system with food habits and insect habitats.

UNIT III
Detailed physiology of nervous system ultra structure of nerve and glial cell. Advances in physiology of neuro-endocrine system. Adaptation of insects to various ecosystem transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV
Endocrine system and insect hormones, physiology of insect growth and development—metamorphosis, polyphenism and diapause. Energetics of muscle contractions. Hormonal control of flight and migration.

Practicals
To estimate chitin in insect cuticle; study digestive enzymes in phytophagous, mycetomes; to understand physiology of nervous system, endocrine system, defence mechanisms, diapause, polyphenism, frequency of wing beat, abrasion of wax layer of cuticle, food utilization indices, feeding stimulants, dissection of insect brain and associated structures, study of neurosecretory cells, response of heart beat towards test solutions, etc.

Suggested Readings

ENT 609 RECENT TRENDS IN ENTOMOLOGY (3L+0P) III

Objective
To impart knowledge to students on recent developments in entomological research, extension and education.

Theory
UNIT I
Current topics in biosystematics, molecular and numerical approaches; DNA barcodes and biological names register; insect biodiversity and prospects for genetic transformation.
UNIT II
Chemical Ecology of agriculturally important insect pests; tri-trophic interactions; recombinant insect viruses in insect control; insect behavioural and morphological defenses against parasitoids; perception of sound and light by insect and their applications.

UNIT III
Ecological side effects of biological control. Bt crystal proteins and their mode of action; Cry genes in developing insect resistant transgenic crops.

UNIT IV
Advances in insecticide evaluation; ion channels as targets for insecticides cholinergic, octopamine and GABA receptors.

UNIT V
Recent advances in reproductive biology and endocrinology of insects. Reproductive parasitism and role of Wolbachia; transgenic insects; insect tissue culture; recent developments in sterile insect release programmes; insect gut protease and amylase inhibitors and lectins-their role in transgenic technology.

UNIT VI
Computer aided decision making and modeling; system approach in agro-ecosystem; remote sensing.

UNIT VII
Quarantine entomology; forensic entomology; urban entomology. International Standards for Phyto-sanitary Measures (ISPM's).

Suggested Readings

ENT 610 INSECT GENETICS AND MOLECULAR BIOLOGY

**(2L+1P) II**

*(Inter disciplinary: Entomology with Genetics/ molecular biology)*

**Objective**

To impart knowledge to students on genetics, cytogenetics and molecular basis of insect behaviour.

**Theory**

UNIT I
Scope and importance of insect & molecular biology; Relevance to crop pest management.
UNIT II
Diversity of genetic systems in insects. Sex chromosome in Lepidoptera, Diptera, Coleoptera, Hemiptera and Hymenoptera. Genetic variations in populations; formation of biotype and sibling species; statistical techniques to study genetic variations in populations; parthenogenesis in insects, role of microorganisms such as Wolbachia.

UNIT III

UNIT IV
Insect transgenesis; risk assessment of genetically modified organisms, molecular biology of insect viruses (NPV, GV), genetic modifications in insect viruses for field efficacy; and advances in molecular biology of Bacillus thuringiensis.

Practicals
Study of insect polymorphism and other traits using facilities like PCR, Gel electrophorosis, genetic analysis related to insect resistance, development of insect population for genetic variability, bioassays for event selection in insect population, study of chromosomes in insects and crossing methods and study of symbionts like Wolbachia in natural enemies.

Selected Readings

ENT 611 PLANT HEALTH DIAGNOSTICS & MANAGEMENT (2L+2P) III
(Multidisciplinary course in collaboration with Plant Pathology and Nematology)

Objective
To familiarize the students with different abnormalities caused by insects, pathogens, nematodes, weeds and imbalance use of plant nutrients. Also, develop the confidence in them to handle plant protection problems faced by the farmers/growers.

Theory
UNIT I
Introduction to the plant health clinic: concept, importance, infrastructure, etc. Identification of important beneficial insects (parasitoids, predators, pollinators and others of economic importance). Principles of pest management.

UNIT II
Injury caused by different type of insects to the plants by feeding, oviposition, sheltering or any other means.

UNIT III
Screening of damaged material for establishing the identity of casual agent viz., insect, microbe, nematode, mites, rodents, vertebrates, competitive plant as well as nutritional or any other physiological disorders.
UNIT IV
Important plant parasitic nematodes and their symptoms produced on major field, fruit, ornamental and plantation crops.

UNIT V
Damage caused by important nematodes causing root knot, ear-cockle and other diseases in different crops and their management.

UNIT VI
Molecular approaches for viral, bacterial and fungal diseases with regards to diagnostics and management.

UNIT VII
Symptoms of diseases caused by imbalances in plant nutrients.

UNIT VIII
Identification of problematic weeds and their management.

Practicals

Suggested Readings
Nair, MRGK.1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.
## Environmental Sciences

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 500</td>
<td>INTRODUCTION TO ENVIRONMENTAL SCIENCES</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 501</td>
<td>ANALYSIS OF AGROECOSYSTEMS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 502/ WST 502</td>
<td>ENVIRONMENTAL POLLUTION</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 506</td>
<td>INSTRUMENTAL METHODS OF ENVIRONMENTAL ANALYSIS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 510/AE 510</td>
<td>SOIL AND WATER CONSERVATION ENGINEERING</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 601</td>
<td>BIODIVERSITY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ES 612</td>
<td>CROP GEOGRAPHY AND ECOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 503/ PP 503</td>
<td>GLOBAL CLIMATE CHANGE AND AGRICULTURE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 505/ MB 505</td>
<td>MICROBIAL ECOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>ES 602</td>
<td>ENVIRONMENTAL IMPACT ASSESSMENT</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 603</td>
<td>WASTE MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 604/ SSAC 604</td>
<td>SOIL ORGANIC MATTER</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 605</td>
<td>AGROFORESTRY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ES 606/ SSAC 606</td>
<td>SOIL AND WATER POLLUTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 607</td>
<td>ADVANCED ENVIRONMENTAL MONITORING TECHNIQUES</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ES 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 504</td>
<td>ENVIRONMENTAL CHEMISTRY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ES 507</td>
<td>ENVIRONMENTAL MICROBIOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 508</td>
<td>PERSISTENT ORGANIC POLLUTANTS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Hours</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>ES 509</td>
<td>BIOFUEL AND ENVIRONMENTAL PROTECTION</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ES 608/ AE 608</td>
<td>RENEWABLE ENERGY CONVERSION SYSTEM</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 609</td>
<td>SIMULATION OF ECOLOGICAL PROCESSES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 610</td>
<td>AIR POLLUTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ES 611</td>
<td>INTRODUCTION TO ENVIRONMENT LAW AND POLICY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ES 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** ES 500, ES 502, ES 504  
**Ph.D.:** ES 607, ES 611, ES 612
ENVIRONMENTAL SCIENCES

Major Field : Environmental Sciences

Minor Fields: Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

ES 500 INTRODUCTION TO ENVIRONMENTAL SCIENCES (3L+0P) I

Objective
To give an overview to the students on the importance of environment in agriculture

Theory
UNIT I
Definitions and concepts in environmental sciences; ecology, ecosystem and environments; components of environment and their interactions

UNIT II
Structure and functions of ecosystems; biotic and abiotic interactions; energy flow and nutrient cycling in different eco-systems- trophic levels, food chain and food webs, primary and secondary productivity; biological building blocks; ecosystems of the world and biogeographic regions; agroclimatic regions; biodiversity – their genesis, utilization, erosion and conservation.

UNIT III
Climate change and climate variability and their impact on agriculture; crop modelling; soil-plant atmospheric interactions; soil and cropping patterns of India; emerging diseases and pests of crops; sustainable agriculture; greenhouse effect; global warming; GHGs emission and mitigation strategies to reduce their emission.

UNIT IV
Environmental pollution- soil, water and air, and their source and sink; impact assessment of environmental pollution on agriculture; evaluation of agroecosystem services; agricultural and non-agricultural wastes and their management

UNIT V
Environmental issues; acts and legislation; generation of biofuels from agriculture resources; water conservation strategies to improve agricultural productivity

Suggested Readings
Air pollution Control (I-III) by Werner Strans
Concept of Ecology by E.D. Karmandy,
Ecology by E.P.Odum; Oxford and IBM Publishing Co.
ES 501 ANALYSIS OF AGROECOSYSTEM (3L+0P) I

Objective
To disseminate the knowledge about the concepts related to agro-ecosystems and their role in agriculture.

Theory
UNIT I
Agro-ecosystems; ecological and social attributes; interactions among chemical, physical, biological and socio-economic components of agro-ecosystems
UNIT II
Trophic systems in agriculture; nutrients cycling, carrying capacity, community concepts, competition, biodiversity and complexity
UNIT III
Characteristics, structure and functions of agro-environmental resources (soil, water, climatic factors, living organisms, farm chemicals, rural infrastructure); energy movements; interactions between biotic and abiotic components; properties of various agro-ecosystems; biogeochemical cycles
UNIT IV
Integrated management of agro-ecosystems and their adaptation strategies for sustainable production; sustainable agriculture and its significance; agro-ecological analysis of various agro-ecosystems - productivity, stability, profitability, autonomy and sustainability aspects
UNIT V
Impact assessment of environmental changes on agro-ecosystems; options for sustainable development; ecological assessment of traditional and modern agriculture

Suggested Readings
Ecology by E.P.Odum; Oxford and IBM Publishing Co.
Environmental and Plant Ecology By J.REtherington. Jhon Wiley & Sons
The analysis of Indian agro-ecosystem by Mitchell. R
Objective

To provide the related information on the Environmental Pollutants and their impacts on agriculture and environments

Theory

UNIT I
Introduction to environmental pollution; water borne diseases and their control; biological and chemical indicators of environmental pollution

UNIT II
Sources and types of water pollution; heavy metals in surface and sub-surface waters; pesticide residues in surface and sub-surface waters; phosphates in surface and sub surface waters; uptake of pollutants by plants; radio-active wastes and their safe disposal; sampling and analysis techniques; aquatic plants and their role in pollution control-phytoremediation

UNIT III
Particulate and heavy metal pollution of air; atmospheric pollution from fossil fuels used in vehicles and industry; biofuels for air pollution control; ozone layer and its importance; mechanism of ozone layer depletion and diffusion of CFCs; renewable sources of energy

UNIT IV
Sources and sinks of SOx & NOx in atmosphere; sources and sinks of CO and CO₂ in atmosphere; sources and sinks of CH₄ and nitrous oxide in atmosphere

UNIT V
Solid wastes (crop residues, sludges, food processing industries wastes) and their disposal; sources & nature of soil pollution and their harmful effects; soil and groundwater pollution by nitrates, fluorides and heavy metals

UNIT VI
Anthropogenic influences on terrestrial and aquatic environments and their coping strategies for greater environmental sustainability

UNIT VII
Environmental impact assessment and industrial effluent treatment and their disposal; pollution control in agro-based industries by agri-cycling of their effluent; environmental standards; laws for control of water and air pollution

Suggested Readings

Air pollution Control (I-III) by Werner Strans
Analysis of Air pollutants by Peter O. Warmer
Chemistry in waste reuse by W.J.Cooper
Dictionary of the Environment, Hutchinson Pocket Book Series
Elements in the Environmental Series (Cu, Zn, Od, Hg, Pb) by J.O. Nariagu
Environmental and Pollution Science by Ian L.Pepper. Charles P.
Environmental pollution and control by P.A.Vesilind
ES 506 INSTRUMENTAL METHODS OF ENVIRONMENTAL ANALYSIS (2L+1P) I

Objective
To impart theoretical and practical knowledge about instrumental techniques used in environmental analysis.

Theory
UNIT I
Basic principles of instrumental analysis, principles of electrometric equipments- EC meter, pH meter, ion meter and polarography
UNIT II
Spectroscopic techniques used in environmental analysis- UV, visible, flame -emission, absorption, Infra red, inductively coupled plasma and mass spectrometry
UNIT III
Chromatographic techniques in environmental analysis – column, thin layer, gas, high pressure, ion chromatography and electrophoresis
UNIT IV
Advanced molecular techniques – Biolog, polymerase chain reaction (PCR)
UNIT V
Other techniques of environmental analysis- Kjeltech, particular sampler, infra red gas analyser, BOD and COD kits, fermentation technique – fermentor; Free air carbon dioxide enrichment (FACE) and open top chamber (OTC) techniques

Practicals
Determination of pH and EC, Determination of metals and ion using polarographic analyzer; Heavy metal analysis using AAS; Analysis of group I and II metals using flame photometer; Chromatographic analysis; Microbial activity measurement – Biolog and PCR; Determination of N using Kjeltec; Particulate sampling and analysis; Free air carbon dioxide enrichment studies

Suggested Readings
Environmental instrumentation and analysis handbook by Randy D. Down, Jay H. Lehr
Instrumental Methods Of Analysis, by Willard and Merrit
Methods for Environmental Trace analysis by John R. Dean
Principles of Instrumental Analysis by Douglas A.

ES 510/AE 510 SOIL AND WATER CONSERVATION ENGINEERING (3L+0P) I

Objective
To acquaint and equip with the process of soil and water conservation design of erosion control structures.
Theory

UNIT I
Concepts of soil and water conservation; relevance of soil and water conservation in agriculture; productivity loss due to soil erosion; moisture stress and moisture excess.

UNIT II
Types of soil erosion; mechanics of water erosion of soil; effect of land preparation and cultivation practices on soil erosion; theories of sediment yield and sediment transport; bed load movement; measurement of sediment yield and sediment transport; effective life of dams and water detention structures; effect of soil erosion on the life of multi-purpose river valley projects; soil erosion loss and fertility; erosion in water conveyance systems;

UNIT III
design of channel for erosion control; maximum permissible velocity; hill soil erosion; land slides; mechanics of wind erosion; types of wind erosion and soil movement; wind erosion control measures.

UNIT IV
Analysis of hydrologic data including rainfall, evapotranspiration; watershed characteristics; overland flow; methods of estimation of runoff; peak rate and time distribution of hydrograph; synthetic hydrograph; infiltration process;

UNIT V
Hydrologic evaluation of land treatment; flood routing. Erosion control; design of soil conservation structures; farm ponds and temporary storage reservoirs, drop structures; chute spill ways; temporary storage reservoirs; small earth dams;

UNIT VI
Afforestation and associated agronomic practices; the role of river valley projects; soil conservation department, CADA etc. in undertaking soil and water conservation work.

Suggested Readings


ES 601 BIODIVERSITY (2L+0P) I

Objective
To impart knowledge and awareness about the evolution mechanism, strength, status, environmental significance, utilization and conservation of biological diversity

Theory
UNIT I
Biodiversity- an overview; level and scale of biodiversity – genetic, species and ecosystem diversity, alpha, beta and gamma diversity; origin of life, organic evolution; genesis of biodiversity; biodiversity changes in space and time; speciation and isolation mechanism.
UNIT II
Biogeography- horizontal and vertical distribution of plants, monophylatic and polyphylatic origin of plant species, global and national phytogeographical regions, botanical provinces, dispersal and migration of plants; major centres of origin and domestication of crop plants; exploration and collection of genetic resources; introduction, characterization and utilization of crop genetic resources; status and strength of floristic diversity; hot spots of biodiversity.

UNIT III
Plant nomenclature and classification; major and minor unit of plant classification; binomial and trinomial theory of plant classification; taxonomy of monocotyledons and dicotyledons.

UNIT IV
Genetic erosion and loss of biodiversity – causes and criteria of genetic erosion, levels of genetic erosion; global climate change and loss of biodiversity; biodiversity, bio-productivity and sustainability; biodiversity and life security - food, health, environment and job security

UNIT V
Microbial diversity; species, genetic and molecular diversity indices; diversity and stability of microbial communities; animal diversity; biodiversity and biotechnology; use of microbial biodiversity in environmental pollution control – bioremediation

UNIT VI
Biodiversity conservation- in-situ and ex-situ conservation; biodiversity convention and its law and policy; international Inst.and Agencies working on CBD; cultural, religious, social and environmental aspects of biodiversity.

Suggested Readings
Biodiversity Implication for Global Food Security. eds. by M.S. Swaminathan and S. Jana, Mac Millan India Limited
Cytology, Genetics and Evolution by P.K. Gupta, Rastoki Publishers, Meerut
Diversity- Special volume for south east asia . vol. 12(3), 1996.
Plant Breeding by B.D.Singh, Kalyani Publishers, New Delhi

ES 612 CROP GEOGRAPHY AND ECOLOGY (3L+0P) II

Objective
To impart knowledge about the geographical distribution of crops, their interactions with physical and biological environments and adaptation to diverse agro-climatic conditions

Theory
UNIT I
General principles and scope of crop geography; physical, biological and social factors determining crop distribution; classification and characteristics of edaphic, climatic and biotic environments; agro-climatic and agro-ecological zones; bioclimatic parameters.
UNIT II
Crop domestication and their centers of origin; geographic distribution of crops; agro-ecosystem classification and its structure and function; crop response to diverse environmental stresses e.g. temperature, light, excess and deficit water; properties of agro-ecosystem, their efficiency and interaction between biotic and abiotic components; food chain and food webs; trophic levels and energy flow in various agro-ecosystems.

UNIT III
Thermal and photo-thermal units; relationship and manipulation of developmental physiology of crops; ecological implication of different photosynthetic systems of crop plants; physiological limits of crop yield; net primary productivity; ecological approaches to world food Problems; ecological optimum and efficiency of different crops; resource utilization efficiency of different crops under diverse environments.

UNIT IV
Crop adaptation to diverse environments through natural selection and biological modification; natural biological and anthropogenic adaptation of crops to various abiotic stresses; ecotype concept of crop adaptation and distribution; agricultural region-concept and technique; water, carbon, mineral nutrient and energy dynamics in ecosystems and crop communities.

UNIT V
Ecological analysis of traditional and modern agriculture on the basis of productivity, stability, diversity and sustainability; Agricultural systems of the world and India; surveys and models in crop geography; land use pattern and land use change; ecological/sustainable agricultural production systems.

Suggested Readings
Adaptation of Food Crops to temperature and water stress. Proceeding of an international symposium. Edited by C. George Kue, AVRDC, council of Agriculture, ROC, Taiwan
Ecological implications of dividing plants into groups with distinct photosynthetic production capacities by C.C. Black, Advances in Ecological Research, Academic Press

ES 503/ PP 503 GLOBAL CLIMTE CHANGE AND AGRICULTURE (2L+1P) II

Objective
To impart theoretical and practical knowledge about the evidence, causes and impact of climate change and its adaptation and mitigation options

Theory
UNIT I
Definition and concept of climate change and variability; global warming and dimming; science and politics of climate change and international conventions; evidence, scenario and causes of climate change
UNIT II
Greenhouse gases and mechanism of their production and emission from various agro-ecosystems, source and sinks of GHG; warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases
UNIT III
Impact assessment of rise in atmospheric temperature and CO$_2$ on growth, physiological processes, productivity and quality of different crops, soil health, water availability, insect pest dynamics, crop-weed competition, milk and inland and marine fish production; climate change and loss of biodiversity; spatial and temporal changes in agricultural production in context of climate change.

UNIT IV
Evidence and causes of global dimming; causes of global dimming; impact assessment of global dimming on crop productivity, quality and crop-pest interaction.

UNIT V
Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on crops; International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints and govt. strategies and policies on climate change management.

Practicals
Measurement of CO$_2$ from crop fields, Measurement of CH$_4$ from crop fields, Measurement of N$_2$O from crop fields, Measurement of O$_3$ from crop fields, Recent techniques for assessing the impact of high temperature on crops, Recent techniques for assessing the impact of CO$_2$ fertilization on crops, Recent techniques for assessing the impact of elevated O$_3$ on crops, Modelling impact of high temperature and CO$_2$ on crop yield, Modelling impact of high temperature on soil and water, Modelling impact of high CO$_2$ on soil and water

Suggested Reading
Climate change and global crop productivity ed. by K.R. Reddy and H.F. Hodges, CABI Publishing
Climate change Journal
Greenhouse gas emission from agricultural system, Published by IPCC-USEPA
IPCC Assessment Report 2007

ES 505/MB 505 MICROBIAL ECOLOGY (3L+ IP) II

Objective
To provide the modern concepts of microbial ecology of soil and aquatic environments, microbial interactions and biogeochemical cycling

Theory
UNIT I

UNIT II
Dispersal, Colonization, Succession and the climax, Interspecific competition, Commensalism, Homeostasis, Parasitism, Predation, Proto-cooperation, Symbiosis, Ammensalism.
UNIT III
Microbiology of water bodies, Effect of micro-organisms on animals and plants, Environmental influences on microorganisms, Effect of temperature, aeration, moisture, osmotic pressure, pH, Energy cycle.

UNIT IV
Transformation of phosphorus, sulphur, iron, manganese, magnesium, copper, mercury and arsenic, Mycorrhizal links with plants and their functioning.

UNIT V
Ecology of microbial corrosion, Microbial plasticity, Relevance to microbial ecology, Modeling, Microbial contribution to climatic change, Molecular approaches for measuring the microbial diversity.

Practicals
Sampling and enumeration techniques for micro-organisms, Effect of environmental variables on nitrification, ammonification and microbial growth, Effect of temperature on bacterial interactions, Isolation of nucleic acids from environmental samples, Nitrogen transformations, Microbial corrosion and detection of microbial activities, Symbioses amongst micro-organisms, Synergism and antagonism amongst micro-organisms, Estimation of iron oxidizing and reducing bacteria from soil samples, Isolation of thermophilic, mesophilic and psychrophilic microorganisms from soil samples, Isolation of antibiotic synthesizing microorganisms, Enumeration of sulphur oxidizing and reducing bacteria from soil, Enrichment and isolation of phosphate solubilizing microorganisms from phosphorus deficient and ‘P’ sufficient soils, Mineralization of phytins by bacteria and fungi, Estimation of phosphorus solubilizing activity of a bacterium and a fungus using different inert phosphorus sources.

Suggested Readings

ES 602 ENVIRONMENTAL IMPACT ASSESSMENT (3L+0P) II

Objective
To impart theoretical knowledge about Environment Impact assessment, Life cycle assessment of agriculture related products and processes, Environmental audit and defining the standards for environmental quality assessment and monitoring.
Theory

UNIT I
EIA- purpose and aims; key elements of the EIA process and methodologies

UNIT II
Monitoring tools for EIA; EIA administration and practice

UNIT III
Cost and benefits of evaluation of EIA; understanding strengths and limitation of EIA

UNIT IV
EIA standards; risk assessment; potential impact to water and air pollution

UNIT V
Integrated impact assessment; policy; legislative implications; current status of EIA legislation in developing countries

UNIT VI
Undertaking an EIA: case studies for agro-industries

Suggested Readings

Anjanayulu, Y. 2002. *EIA Methodologies*. BSP BS publication
Environmental impact assessment Review Journal, 2000-2005
Lawrence, Dravid P. 2003. *EIA Practical Solutions to Recurrent problems*

ES 603 WASTE MANAGEMENT (2L+1P) II

Objective
To develop the awareness about the various types of wastes, their disposal and management

Theory

UNIT I
Waste generation; types - collection and factors affecting rate of waste generation; sources of wastes and their classification; landfills and waste dumpsites; solid wastes - domestic, municipal and hazardous; collection and disposal methods; waste management problems- recovery vs disposal

UNIT II
Physical, chemical and biological properties of wastes; hospital and radioactive wastes and their management; incineration and pyrolysis; chemical and biological treatments of wastes

UNIT III
General overview of industrial wastes; impact of wastes on environment - air, water and soil; wastewater collection; sewage and sludge treatment processes and other technologies

UNIT IV
Theory of anaerobic of digestion of organic wastes for fuel and manure; composting and vermi composting techniques; solid and liquid waste utilization in agriculture; application of wastes in
arable lands and their value added products with reference to N,P, K, organic C and other micronutrients and heavy metals; compost application in agriculture

UNIT V
Legislation and regulatory requirements- Case studies in India and Abroad

Practicals
Determination of total solids, volatile solids and ash content; Determination of total microbial count; Determination of coliform count for pathogenic bacteria; Determination of total bacteria leachable and adsorbed on soil samples of the waste dumping site; Determination of particle size and bulk density of the waste sample; Determination of biofuel potential of waste sample; Determination of calorific value of the waste sample; Analysis of methane and carbon dioxide in a gaseous sample; Demonstration of experiment on composting and vermi composting; Visit to a waste management system in Delhi

Suggested Readings

ES 604/SSAC604 SOIL ORGANIC MATTER  (3L+0P) II

Objective
To teach basic biochemistry of soil organic matter, its composition, fractionation and reactions in soil and its significance in sustenance of soil fertility and environmental quality

Theory
UNIT I
Carbon cycle in nature; carbon stocks of the world and Indian soils; pools, composition, and distribution of organic matter in soil
UNIT II
Biochemistry of the humus formation - theories and pathways for humus synthesis in soil; biochemistry of transformation of N, P and S; organo-metallic interactions and role of chelation in bioavailability of nutrients and pollutant elements
UNIT III
Characterization of humic substances: Extraction, fractionation and purification; elemental analysis, reactive functional groups of humic substances, ion exchange properties, other colloidal properties;
adsorption of organic compounds by clays and role of organic substances in pedogenesis and soil aggregation

UNIT IV
Soil organic matter (SOM) management in tropics; role of crop residues, tillage, land use and crops and cropping systems in SOM management; carbon sequestration - concept, practices and potential of the world and Indian crop lands; soil carbon stocks – issues and priorities for mitigation and sequestration of organic and inorganic carbon in soils,

UNIT V
Environmental issues related to SOM - Green house effect and global warming related to emissions of CO₂, CH₄ and N₂O; organic matter turnover and stabilization in soil - concepts and implications for soil fertility, environmental loads and climate change; soil organic matter dynamics in relation to soil biodiversity in terms of both flora and fauna; carbon transfer model; clean development mechanism -- carbon trading; changes in organic carbon turnover in soils - simulation models - Rothamsted Carbon, Century Carbon, Infocrop and DNDC models.

Suggested Readings


Pierzinsky, 2002.


ES 605 AGROFORESTRY  (2L+0P) II

Objectives

To give an overview to the students on the importance of agroforestry in agriculture and environment

Theory

UNIT I
Agroforestry- its definition, concept, scope and advantage; classification of agroforestry; selection of plant species; plant species interaction; growth & production of tree plant; agroforestry & resource utilization

UNIT II
Agroforestry models for various land use systems; agrisilviculture system, silviagrivulture system, silvipasture system, agrisilvipasture system, regeneration of tree crops
UNIT III
Agroforestry options for sustainable land use; relationships between agro forestry, farm forestry and social forestry; agroforestry research in agricultural research system; environmental education as a tool for sustainable agroforestry

UNIT IV
Agroforestry, biodiversity and sustainability; carbon sequestration through agroforestry; techniques to improve biomass production and climate change mitigation; biofuel production; agroforestry and sustainability

UNIT V
Natural resources and environment management through ecosystem approach; biotic and abiotic components of ecosystem and their linkages; economics of agroforestry system

Suggested Readings
A Text book of Agroforestry by B.S.Chandawat and S.K.Gautam
Agroforestry: Principles and Practices by A.P. Dwivedi
Advances in Agrforestry by L.K. Jha
Agroforestry for Sustainable Land Use by P.Singh, P.S.Pathak and M.M. Roy
Environmental Services of Agroforestry Systems by Florencia Montagnini
Handbook on Agroforestry: Management Practices and Environmental Impact by Lawrence R. Kellimore (Editor)
Potential Application of Agroforestry System from Indian Subcontinent to the Analogous Ecozones of Africa by G.B. Singh (ICAR).

ES 606/SSAC 606 SOIL AND WATER POLLUTION (2L+1P) II

Objective
To teach the students on extent, causes and mitigation of soil and water pollution on global scale and in India

Theory
UNIT I
Soil and water resources of India; Introduction to soil and water pollution; major soil and water problems; status of pollution in India

UNIT II
Sources and cause of soil pollution; types of soil pollution; major soil problems-erosion, salinity, sodicity, pesticide and heavy metal pollution

UNIT III
Physical, chemical and biological characteristics of water; sources and cause of water pollution; point source and non point source pollution; types of pollution in subsurface and surface water; land fill sites and ground water pollution; nitrate, arsenic and fluoride pollution and their control measures.

UNIT IV
Microbial pollution in water, their sources and common water born diseases; Transmission and control of water borne diseases
UNIT V
Impact of modern trends of agriculture on pollution; effect of soil and water pollution on agriculture and soil health; characteristics of domestic, municipal and industrial effluents; merits and demerits of their utilization in agriculture

UNIT VI
Physical, chemical and biological remediation of soil and water pollution; wastewater treatment; integrated nutrient management;

UNIT VII
Laws and legislation for soil and water pollution, permissible limits of pollutants in soil and water

Practicals
Introduction to limnological studies, Determination of nitrate and phosphate in soil and waters; Determination of EC, pH , alkalinity, free CO₂; Estimation of residual chlorine in water, fluoride in water; Determination of calcium, magnesium and hardness of water, dissolved oxygen in water; Determination of minor metallic elements in soil and water; Measurement of Coliform, MPN, B.O.D./COD in natural and waste waters

Suggested Readings
Standard Methods of Water and Wastewater Analysis, APHA, WPCF, N.Y.2003
Water Resources of India by K.L. Rao

ES 607 ADVANCED ENVIRONMENTAL MONITORING TECHNIQUES (2L+2P) II

Objective
To impart the theoretical and practical knowledge of advanced environmental monitoring techniques

Theory
UNIT I
Design of environment quality monitoring programs; monitoring methods, their strength and weakness.

UNIT II
In-situ / Ex-situ monitoring techniques for physical (sediment yield, runoff) and chemical (chemical erosion, salinization/sodification, heavy metal contamination), degradation of soil / water resources at field / catchment scales
UNIT III
Application of spectro-photometric / chromatographic / microscopic and molecular techniques for monitoring inorganic and organic pollutants, pesticide residues, green house gases, microbial biomass / diversity / community structure and phylogeny

UNIT IV
Spatio-temporal environmental resource / degradation mapping with remote sensing tools / techniques; use of GIS, GPS & DSS systems; integration of multi-source and multi scale data

UNIT V
Computer intelligent processing technologies for analyzing environmental data

Practicals
Design of small scale environmental quality monitoring programs; Design of large scale environmental quality monitoring programs; In-situ erosion and run-off measuring techniques for catchments; Demonstration of an automated weather data acquisition system; Sample preparation for elemental analysis by AAS; Sample preparation for elemental analysis by spectrophotometer; Analysis of metals by AAS, Analysis of green house gases by GC; Techniques of estimating TOC in biodegradable wastes; Microscopic techniques for analysis of environmental samples; Microbial community structure analysis using chromatography; Molecular analysis of microbes by PCR; Molecular analysis of microbes by gel documentation techniques, Soil use mapping with remote sensing; Land use mapping with remote sensing,; Environmental monitoring with GIS systems; Environmental monitoring with GPS systems; Application of spatial decision support systems for monitoring large scale productivity declines; Application of decision support systems for sustainable development; Computer intelligent processing technologies analyzing environmental data.

Suggested Books for Study
Fundamentals of Remote Sensing, George Joseph D
Instrumental methods of analysis, Willard, Merritt, Dean and Settle; CBS publishers and distributors.
Instrumental methods of Chemical analysis, Chatwal and Anand; Himalaya Publishing House, Bombay.
Modern methods of Chemical analysis, Pooksook and Willium
Remote Sensing and Image Interpretation, Thomas M. Lillesand, , Ralph W. Kiefer, Jonathan W. Chipman

ES 504 ENVIRONMENTAL CHEMISTRY (2L+2P) III

Objective
To provide the theoretical and practical knowledge about the Environmental Chemistry and related atmospheric phenomenon

Theory
UNIT I
Introduction, concept and scope of Environmental Chemistry; chemistry of solutions and principles of thermodynamic processes
UNIT II
Basic photochemistry, atmospheric radiation chemistry, photo and radiolytic scavengers and their transformation and nuclear transformation

UNIT III
Acid – Base theory, PAN and atmosphere, classification and nature of environmental pollutants; mechanism of organic reactions and isomerism

UNIT IV
Hydrological cycle in the environment; Oxygen cycle in the environment, Phosphate, Sulphur and Nitrogen cycles in the environment

UNIT V
Chemistry of fossil fuels, chemistry of CFC and Ozone depleting substances and hydrosols

UNIT VI
Chemistry of metals & non-metals with reference to agriculture; chemical toxicology with reference to metals and non-metals

UNIT VII
Analytical techniques and methodology for detecting major pollutants; chemistry of agro-based industrial wastes

Practicals
Qualitative organic analysis and detection of functional groups (Alcoholic, Phenolic, Carboxylic acid, Aldehyde and Ketones etc.); Detection of N, P, K, S and Halogens in water and soil samples; Estimation of solution by volumetric & gravimetric analysis; Qualitative and quantitative polyvalent metal analysis; Detection of heavy metals in soil, water and air; Separation of organic components by chromatography; Analytical techniques for environmental pollutant; Analysis of pollutant with GLC & spectrophotometer

Suggested Readings
Chemistry of Atmosphere by P.S.Sindhu
Environmental Chemistry by A.K. De
Environmental Chemistry by J.W.Moore
The Chemistry of our Environment by R.I.A.Horne
Inorganic Chemistry by Cotton & Wilkinson
Inorganic Chemistry P.L.Soni
Organic Chemistry by I.L.Finar vol. 1 and 2
Organic Chemistry by Morrison Boyd
Physical Chemistry by Atkin
Physical Chemistry by S.Gladstone

ES 507 ENVIRONMENTAL MICROBIOLOGY (2L+1P) III

Objective
To impart theoretical and practical knowledge about defining the important microbes involved in environmental microbiology, methodologies used to monitor the microbes and their activities and the effects of these microbes in environmental microbiology
Theory

UNIT I
Environmental microbiology at the end of second millennium; environmental microbiology; International dimension
UNIT II
Environmental determinants governing the existence of microbes in the terrestrial; aquatic and extreme environments
UNIT III
Bioindicators – their relevance and utility in assessing/monitoring the degree/status of environmental degradation
UNIT IV
Microbial transport and bioaugmentation; biodegradation and bioremediation; biocorrosion and biofouling; microorganisms and metal pollutants
UNIT V
Microbial risk assessment of water and food; monitoring and molecular methods in Environmental Microbiology
UNIT VI
Emerging technologies in environmental microbiology and its application; bioreporters, biosensors, and microprobes; microbial fuel cell
UNIT VII
Intellectual property rights.

Practicals
Isolation and characterization of micro-organisms from environmental samples; Evaluation of environmental parameters that influences the microbial growth; Measurement of microbial activity in environmental samples; Substrate utilization patterns in environmental isolates; Measurement of biodegradation capacity of microorganisms; Soil enzyme assays; Extraction of quorum sensing molecules from plant pathogens; Detection of quorum sensing molecules in Plant microbe interaction; Biofuel production from different substrates; Impact of radiation on soil biodiversity.

Suggested Readings
Environmental Microbiology by R.M.Maier
Environmental Microbiology By. R. M. Maier
Laboratory Manual in general Microbiology by H. J. Benson
Laboratory Manual in general Microbiology by H.J.Benson
Manual of environmental Microbiology by Hurst et al.
Microelectrodes: their use in microbial ecology. Advances in Microbial

ES 508 PERSISTENT ORGANIC POLLUTANTS (2L+0P) III

Objective
To understand the nature, properties and environmental implications of persistent organic pollutants
Theory

UNIT I
Definitions, origin, properties and classification of persistent organic pollutants

UNIT II
Dynamics and interaction of poly nuclear aromatic hydrocarbons (PAH) in the environment

UNIT III
Dynamics and interaction of poly chlorobiphenyls, furans and dioxins in the environment; dynamics and interaction of persistent pesticides in the environment

UNIT V
Bioremediation of persistent organic pollutants; disposal and decontamination of persistent organic pollutants

UNIT VI
Monitoring of persistent organic pollutants; legislation and treaties to control persistent organic pollutants in the environment

Suggested Readings

Persistent organic pollutants by Claes Beraes, Alnqvist and Wiksell
Persistent Organic Pollutants in Asia, Volume 7: Sources, Distributions, Transport and Fate An Li (Editor), Shinsuke Tanabe (Editor), Guibin Jiang (Editor), John P. Giesy (Editor), Paul S.K. Lam (Editor)
Persistent Organic Pollutants, by Harrad and Stuart

ES 509 BIOFUEL AND ENVIRONMENTAL PROTECTION (2L+0P) III

Objective

To impart theoretical and practical knowledge about bio-fuels and their potential role for providing environmental protection and energy security

Theory

UNIT I
Overview of world fossil fuels production, demand, supply and environmental consequences; Introduction to biofuels and its environmental benefits; production scenario and policy in India and other countries

UNIT II
Resources for biofuel production including energy crop, biomass waste, agri-residues and algae

UNIT III
Phyto-chemistry of various biofuel crops; processes of bio diesel, ethanol, hydrogen and biogas production
UNIT IV
Biodiesel production potential of crops and trees, their management and cost-benefit assessment; Ethanol and hydrogen production potential; limitations and advantages from different feedstocks and cost-benefit analysis.

UNIT V
Biogas production technology from farm domestic, municipal and industrial waste and its environmental benefits

UNIT VI
Biophysical technologies for energy production from biomass; Carbon sequestration and pollution abatement potential of biofuels

Suggested Readings
Biofuels: production, application and development, Edited by Alan Scragg, CABI, Cambridge University press 2009
Bicatalysts and Bioenergy Edited by Ching T.Hou and Jei-Fu Shaw, Willey, Ajohn Willey and Sons, INC Publication 2008
Biofuels, Implications for the feed industry, Edited by Jannes Doppenberg and Piet van der aar Wageningen Academic Publishers 2007
Success and Visions for Bioenergy: Thermal processing of biomass for bioenergy, biofuels and bioproducts, Edited by A.V.Bridgwater CPL Press, September, 2007

ES 608/AE 608 RENEWABLE ENERGY CONVERSION SYSTEMS (2L+1P) III

Objective
Engineering concepts on renewable energy conversions and uses.

Theory
UNIT I
Energy cycle of the earth, Energy flow and storage, Renewable energy sources,

UNIT II
Thermodynamics of energy conversion, Conversion systems of solar energy, wind energy, biomass energy, hydraulic energy etc.

UNIT III
Concepts of hybrid and integrated energy conversion systems,

UNIT IV
Applications and economics of different renewable energy systems in agriculture.

Practicals
Experiments on concepts and processes mentioned in theory.
ES 609 SIMULATION OF ECOLOGICAL PROCESSES (2L+ 1P) III

Objective

To impart the theoretical and practical knowledge of using simulation models on crop-environment interactions.

Theory

Unit I
Fundamentals of dynamic simulation, systems, models and simulation.

UNIT II
Descriptive and explanatory models, modelling techniques steps, states, rates and driving variables, feedbacks and relational diagrams.

UNIT III
Numerical integration, introduction to FST language.

UNIT IV
Modeling crop env. & crop pest interactions, soil water, nitrogen and balance, introduction to a simple crop ecological model, applications of simulation modelling in environmental impact assessment & green house gas emission.

UNIT V
Data requirements & limitations of modeling; modeling crop-environment and pest interaction, soil, water, nitrogen and C balance; assessing crop growth, scheduling and management practices and water use planning through simulation tools.

Practicals

Scheduling planting and harvesting of crops; Drawing relational diagrams; Applying numerical integration techniques; Fitting probability distribution functions; Hands on model validation through statistical indices; FST programming language; Hands on to InfoCrop model; Assessing crop growth through InfoCrop model; Hands on to USAR model, Crop rotation & water use planning through USAR model.

Suggested Readings

Objective
To impart theoretical and practical knowledge about the air pollution and pollutants, their sources and formation in the air, effects on crop plants and control measures,

Theory
UNIT I
An overview of air pollution course; air quality, contamination, pollution, and source of various air pollutants; physical and chemical properties of air pollutants

UNIT II
Classification of air pollutants (primary/secondary /photochemical air pollutants); Physical monitoring of gaseous pollutants and SPM; chemical synthesis of photochemical smog; dispersion and transport of air pollutants

UNIT III
An introduction to air pollution biology; mode of entrance of pollutants into plans; effect of air pollution on vegetation and animal; factors affecting plant response to air pollutants; mode and mechanism of plant-pollutants interaction; defense mechanism against gaseous pollutants in plants; toxicity/injury/symptoms of air pollutants on plants

UNIT IV
Biological (physiological, biochemical and structural) effects of air pollutants (SO₂, HF, PAN & O₃) and on vegetation; effect of different air pollutants on crop growth and yield; mode of air pollutants interaction and their individual and combined effects on vegetation; tolerant and susceptible plant species; Heavy metal pollution, their source and sinks, movements, uptake and biological effects on crops; heavy metal tolerance in plants, adaptation of plant species to heavy metals; phytoremediation of heavy metals.

UNIT V
Volatile organic compounds as an air pollutants; acid rain and its effects on vegetation; vegetation as a biological indicator for air pollution; physical, biological and legal control of air pollution and air pollution law; land use planning for polluted areas.

Practicals
Sampling of gaseous pollutants from atmosphere; Measurement of mass concentration of SPM in the air; Measurement of SO₂, NOx and O₃ concentration in ambient air; Measuring techniques crop response to gaseous air pollutants; Measurement of chlorophyll and carotenoids in plants; Measurement of protein and carbohydrate in plants; Diagnosis of air pollutants effects on vegetation.

Suggested Readings
Air Pollution by A.C. Stern, Academic Press
Analysis of Air Pollution by O. Warner, John Wiley & Sons
Atmospheric Motion and Air Pollution by R.A. Dobbins, John Wiley & Sons
Effect of Air Pollution on Plants Edited by T.A. Mansfield, Cambridge University Press, London
Environmental Pollution and Control by P.A. Vesilind and J.J. Pierce, Am. Arbor Society
Plant Stress from Air Pollution by M. Threshow and F.K. Anderson, John Weiley & Sons

ES 611 INTRODUCTION TO ENVIRONMENTAL LAW AND POLICY (2L+0P) III

Objective
To disseminate the knowledge of law and policy for environmental protection

Theory
UNIT I
Environmental law and the Indian constitution; the Environment Protection Act 1986 and Draft National Environmental Policy 2006

UNIT II
Laws for resource utilization; pollution control act (air, water, noise); waste management; forest conservation act and Wildlife Protection Act; wildlife trade and trafficking; policy dialogues for protection of different species

UNIT III
Right to environment as human right; fundamental principles governing international environmental law; environmental security, rights and duties under international environmental law; International conventions and negotiations

UNIT IV
International and national organizations and environmental institutions for the protection of environment

UNIT V
Nature and origin of negotiations; MEAs (Multiateral Environmental Agreements) and dispute settlement mechanism; Cartegena protocol and transboundry movement of GMOs/LMOs; biosecurity and biosafety issues

Suggested Readings
Leelakrishnan, P. Environmental Law in India, LexisNexis Butterworths Wadhwa Nagpur.
## 13 Genetics

### TRIMESTERWISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP 500</td>
<td>ELEMENTS OF GENETICS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GP 510</td>
<td>PRINCIPLES OF CYTOGENETICS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GP 521</td>
<td>BREEDING FIELD CROPS-I</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 530</td>
<td>QUANTITATIVE GENETICS</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GP 540</td>
<td>INTRODUCTION TO BIOINFORMATICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GP 550</td>
<td>FUNDAMENTAL CONCEPTS OF PLANT BREEDING</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GP 607/</td>
<td>REGULATORY MECHANISMS AND INTELLECTUAL PROPERTY RIGHTS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PGR 607</td>
<td>SEMINAR</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 010</td>
<td>ELEMENTS OF GENETICS AND PLANT BREEDING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 520</td>
<td>ELEMENTS OF PLANT BREEDING</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GP 522</td>
<td>BREEDING FIELD CROPS-II</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 600</td>
<td>DEVELOPMENT OF GENE CONCEPT</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>GP 610</td>
<td>CROP CYTOGENETICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 612</td>
<td>DIVERSITY ANALYSIS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 643</td>
<td>CONCEPTS IN HETEROSIS BREEDING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGS 506</td>
<td>HISTORY OF AGRICULTURE</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>GP 602</td>
<td>MUTAGENESIS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>GP 603</td>
<td>TOPICS IN POPULATION GENETICS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 604</td>
<td>INNOVATIVE APPROACHES IN PLANT BREEDING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GP 605</td>
<td>BREEDING FOR STRESS RESISTANCE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>GP 606</td>
<td>PLANT GENE EXPRESSION AND REGULATION</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>MSc</td>
<td>PhD</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>GP 620</td>
<td>APPLIED CYTOGENETICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GP 621</td>
<td>BREEDING FOR CROP QUALITY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>GP 640</td>
<td>ADVANCES IN PLANT BREEDING</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>GP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Core Courses

**M.Sc.:** GP500, GP510, GP520, GP530

**Ph.D.:** GP550, GP600, GP 604
GENETICS

Major Fields : Genetics
Plant Breeding

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

PGS 506 HISTORY OF AGRICULTURE (1L+0P) III

Objective
To learn about the evolution and achievements of agricultural science in India, lessons learnt and vision for future

UNIT I
Agriculture in ancient India: archaeological findings and literature.

UNIT II
Ancient literature on: farm implements, forecast of weather and rains, types of lands, manure, irrigation, seed and sowing, pests and their management, horticulture and arboriculture, cattle management etc.

UNIT III
Agricultural research, education and extension in pre-and post-independent India. Green revolution, success, associated problems, lessons learnt.

UNIT IV
Challenges to Indian agriculture: future needs and capabilities, environmental problems, international agriculture and partnership. Emerging scenario and expectations.

Suggested Readings

AGR 010 ELEMENTS OF GENETICS AND PLANT BREEDING (2L+1P) II

Objective
To provide a basic introduction to Genetics and Plant Breeding to students from a non agriculture background.
Theory

UNIT I
History of Genetics and Plant Breeding. Cell and cell division.

UNIT II

UNIT III
Role of genetics in crop improvement. Polyploidy and mutation.

UNIT IV

UNIT V
Breeding for biotic and abiotic stresses. Variety development and seed production.

UNIT VI
Agricultural Biotechnology, Molecular Biology in Crop improvement

Practicals

Parts of Microscope, Basics of mitotic and meiotic slide preparations, Stages of Mitosis, Meiosis, field visit and study of floral biology, crossing techniques, variability and breeding methods in different crops - Wheat, Chick pea and Brassica.

Suggested Reading


GP 500 PRINCIPLES OF GENETICS (3L+2P) I

Objective

The aim of this course is to understand basic concepts of genetics and to develop analytical, quantitative and problem-solving skills in classical and molecular genetics.

Theory

UNIT I
History of Genetics; Mitosis & Meiosis, Pre-Mendelian concepts of inheritance, Mendel’s laws; Discussion of Mendel's paper; Probability, Chromosomal theory of inheritance. Multiple alleles, Sex-linkage, Linkage Detection, Linkage estimation by various methods in test crosses, intercroses; recombination and genetic mapping in eukaryotes -classical to modern, Somatic cell genetics.

UNIT II
Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Epigenetics.
Genetic code; Protein biosynthesis,Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Gene families and clusters.
UNIT III
Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Gene expression & regulation in eukaryotes.

UNIT IV
DNA sequencing Gene cloning, genomic and cDNA libraries, PCR-based cloning, Nucleic acid hybridization and immuno-chemical detection; DNA restriction and modification, Anti-sense RNA, Gene silencing and ribozymes; Micro-RNAs (miRNAs).
Genomics: Functional, structural & comparative, proteomics, metagenomics

UNIT V
Methods of studying polymorphism; Transgenic bacteria and bioethics; genetics of mitochondria and chloroplasts, Extra chromosomal inheritance. Eugenics, Genetic Disorders and Behavioural Genetics

UNIT VI

Practicals
Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Gene mapping using three point test cross; Tetrad analysis; Induction and detection of mutations, complementation. Study of chromosome aberrations, (deletions, inversion, translocations ); DNA extraction and PCR amplification - Electrophoresis – basic principles separation of DNA; Visit to transgenic glasshouse.

Suggested Readings

GP 510 PRINCIPLES OF CYTOGENETICS (3L+2P) I

Objective
The aim is to provide insight into chromosomes structure and function, mapping, variations in chromosomal ploidy and structure; its role in crop evolution.

Theory
UNIT I
Chromosome architecture in prokaryotes and eukaryotes; Eukaryotic chromosome structure & organisation Artificial chromosomes- BACS, YACs, construction and its uses; Special types of chromosomes.
UNIT II
Chromosomal theory of inheritance, Cell Cycle and cell division, mitosis and meiosis, Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure: evolutionary significance – karyotyping techniques; Chromosome banding and painting - in situ hybridization and its applications,

UNIT III
Structural and Numerical variations of chromosomes and their implications - Symbols and terminologies for chromosome numbers - euploidy - haploids, diploids and polyploids; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes

UNIT IV
Inter-varietal chromosome substitutions, Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids — Role of aneuploids in basic and applied aspects of crop breeding; their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization; Apomixis: Evolutionary and genetic disadvantage.

UNIT V
Reversion of autopolyploids to diploids; genome mapping in polyploids - Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids - Bridge species

UNIT VI
Fertilization barriers in crop plants at pre-and postfertilization levels- In vitro techniques to overcome the fertilization barriers in crops, Chromosome manipulations in wide hybridization; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding;

Practicals
Preparation of tissues for cytogenetical analyses (Fixatives, fixation, dehydration, embedding, staining, cleaning etc.) - Microscopy: various types of microscopes, Mitosis in wheat, pearl millet, onion, Aloe vera, oilseeds, forage crops and pulses, Measuring pollen grain size in various crops with micrometer, Methods of preparing permanent slides, Pollen germination in vivo and in vitro, Identification of polyploids in different crops, Morphological observations on autopolyploids and allopolyploids - Morphological observations on aneuploids, Cytogenetic analysis of interspecific and intergeneric crosses, Maintenance of Cytogenetic stocks and their importance in crop breeding; Fluorescent in situ hybridization (FISH), Genome in situ hybridization GISH.

Suggested Readings

**GP 520 ELEMENTS OF PLANT BREEDING (3L+2P) II**

**Objectives**

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

**Theory**

UNIT I
History of Plant Breeding (Pre and post Mendelian era), Objectives of plant breeding, Characteristics improved by plant breeding. - Centres of Origin-biodiversity and its significance

UNIT II
Genetic basis of breeding self- and cross - pollinated crops, nature of variability, components of variation, heritability and genetic advance, genotype-environment interaction, general and specific combining ability, types of gene actions and implications in plant breeding; plant introduction and role of plant genetic resources in plant breeding. Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III
Breeding self pollinated crops, Pure line theory; pure line selection and mass selection methods, line breeding, pedigree, bulk, backcross, single seed descent and multiline method.

UNIT IV
Breeding methods in cross pollinated crops, population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites.

UNIT V
Breeding methods in asexually/clonally propagated crops, clonal selection.
Self-incompatibility and male sterility in crop plants and their commercial exploitation; concept of plant ideotype and its role in crop improvement. Special breeding techniques- Mutation breeding,polyploids.

Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT VI
Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights,DUS

Molecular breeding-molecular markers (isozymes, RFLP, RAPD AFLP), mapping populations (RILs, NILs, DH, Backcross), their merits and demerits, markers assisted selection

Practicals

Suggested Readings

GP 521 BREEDING FIELD CROPS-I (2L+1P) I

Objectives
To provide insight into recent advances in improvement of cereals, pulses, oilseeds and fiber crop grown during Kharif Season using conventional and modern biotechnological approaches

Theory
UNIT I CEREALS
Rice: evolution and distribution of species and forms - wild relatives and germplasm – cytogenetics and genome relationship - breeding objectives: yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis and hybrid development: Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level, Maintenance breeding, coordinated system of testing.
Maize: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - breeding objectives: yield, quality characters, biotic and abiotic stress resistance/tolerance - Heterosis breeding, Breeding approaches –conventional and non conventional including MAS, Emerging challenges at national and international level.
Pearl millet: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship: breeding objectives: yield, quality characters, biotic and abiotic stress resistance/tolerance, exploitation of heterosis and hybrid development; Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.
Sorghum: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship: breeding objectives: yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis and hybrid development; Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.

UNIT II PULSES
Pigeonpea: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc. Protein quality improvement – conventional and modern plant breeding approaches conventional and non conventional including MAS, progress made - Breeding for anti nutritional factors; Progress in hybrid development, emerging challenges at national and international level.

Urd bean: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them – emerging challenges at national and international level.

Moong bean: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them – emerging challenges at national and international level.

UNIT III OILSEEDS
Soybean: evolution and distribution of species and forms wild relatives and germplasm - genetics - cytogenetics and genome relationship; breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress, Breeding approaches conventional and non conventional including MAS - Oil quality – characteristics in different oils emerging challenges at national and international level.

UNIT IV: FIBRE CROP
Cotton: evolution, breeding objectives: yield, quality characters, biotic and abiotic stress etc, Breeding, development and maintenance of male sterile lines, Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

UNIT V
Distinguishing features of popular released varieties in – Rice, maize, pearl millet, sorghum, pigeonpea, urd bean, moong bean, cotton and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production. Maintenance Breeding and All India Coordinated System of testing and release of crop varieties and hybrids.

Practicals
Floral biology – emasculation - pollination techniques; Study of variation for yield and yield components - Trait based screening for stress resistance in important crops– Use of descriptors for cataloguing Germplasm maintenance; Using Standard Evaluation System (SES) and descriptors, Field and lab visit of the concerned crops

Suggested Readings


GP 522 BREEDING FIELD CROPS-II (2L+1P) II

Objectives

To provide insight into recent advances in improvement of cereals, Pulses, Oilseeds and forage crops grown during Rabi Season using conventional and modern biotechnological approaches

Theory

UNIT I CEREALS
Wheat: evolution and distribution of species and forms - wild relatives and germplasm – cytogenetics and genome relationship - breeding objectives: yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc Breeding approaches-conventional and non conventional including MAS, emerging challenges at national and international level.
Barley: evolution and distribution of species and forms - wild relatives and germplasm – cytogenetics breeding objectives: yield, quality characters, biotic and abiotic stress resistance, Breeding approach –conventional and non conventional including MAS, Breeding for malt barley; emerging challenges at national and international level.

UNIT II PULSES
Chickpea: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc. Protein quality improvement – conventional and modern plant breeding approaches conventional and non conventional including MAS, progress made - Breeding for anti nutritional factors; emerging challenges at national and international level.
Lentil: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress etc, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses -problems, prospects and implications, emerging challenges at national and international level.

Fieldpea evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses problems, prospects and implications, emerging challenges at national and international level.

Rajmash: evolution, cytogenetics and genome relationship, - breeding objectives: yield, quality characters, biotic and abiotic stress etc, Breeding approaches-conventional and non conventional including MAS, - interspecific crosses problems, prospects and implications, emerging challenges at national and international level.

UNIT III OILSEEDS
Rapeseed and Mustard: evolution and distribution of species and forms wild relatives and germplasm - genetics - cytogenetics and genome relationship; breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. Breeding approaches conventional and non conventional including MAS, emerging challenges at national and international level. Utilisation of wild relatives for yield and quality improvement.

UNIT VI
Distinguishing features of popular released varieties in - Wheat, barley, lentil, chickpea, fieldpea, rajmash, mustard and toria and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production; Maintenance Breeding and All India Co-ordinated system of testing and release of crop varieties and hybrids.

Practicals
Floral biology – emasculation and pollination techniques; Study of range of variation for yield and yield components - Trait based screening for stress resistance in crops of importance – Use of descriptors for cataloguing Germplasm maintenance Using Standard Evaluation System (SES) and descriptors, Field and lab visit of the concerned crops

GP 530 QUANTITATIVE GENETICS (4L+1P)

Objective
To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory
UNIT I
Probability and its application in genetic analyses; Random variables and Probability distributions.
UNIT II
Genotypic and Phenotypic variation. Genetic component analyses; Partitioning of main effects and variances – ANOVA-MANOVA.
UNIT III
General concepts of gene action – single and multigene models – genetical parameters and their estimations.
Heritability & components of gene action. Linkage & Linkage Disequilibrium. Inbreeding and covariance between relatives.

UNIT IV
Mating systems and designs; Combining ability – effects and variance; Genetic divergence. Heterosis; Populations- concepts and their improvement approaches.

Practicals

Suggested Readings


GP 540 INTRODUCTION TO BIOINFORMATICS     (3L+1P) I

Objective
To introduce basic concepts of bioinformatics

Theory
UNIT I
History and development of concept of bioinformatics; overview of protein and DNA sequences; sequences databases, retrieval and analysis; methods of sequence alignment - local, global pair wise and multiple alignment; Collection and storage of sequences in the laboratory: DNA sequencing; genomic sequencing; cDNA libraries and sequencing cDNA; processing and
submission of sequences; computer storage; sequence formats- Gen Bank, EMBL, NCBI, Stanford University, etc.

UNIT II
Introduction to database management and DBMS. Introduction to Perl and Bioperl.

UNIT III
Phylogenetic prediction: Phylogeny and sequence variations; concept of evolutionary trees; methods in phylogeny-maximum parsimony, distance methods, maximum likelihood, reliability of prediction.

UNIT IV
Gene prediction: Gene structure and characteristics; ORF; methods for microbial and Eukaryotic gene predictions. Internet Resources.

UNIT V
Genome analysis: Genome structure and organization-Prokaryotes and Eukaryotes; sequence assembly and gene identification; methods - comparative genomics, proteomics; synteny, functional genomics.

Practicals
Sequence searching and alignment, writing programs in Perl for bioinformatics applications, Phylogenetic prediction, gene prediction

Suggested Readings
Web based Public databases and softwares

GP 550 FUNDAMENTAL CONCEPTS OF PLANT BREEDING (3L+2P) I

Objectives
To learn principles of Mendelian and quantitative genetics and it’s applications in practical plant breeding.

Theory
UNIT I
Variability -phenotypic, genetic and environmental and their role in breeding, adaptation and evolution.

UNIT II
Concepts of quantitative traits and Mendalian genetics and their molecular basis; Nature of quantitative traits and their inheritance - Multiple factor hypothesis - analysis of continuous variation - Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Resemblance between relatives; Heritability; Estimation of variance components-additive and dominance variances, combining ability-GCA, SCA effects.
UNIT III
Mating designs, examples from crops to illustrate inferences drawn for plant breeding decisions. Generation mean analysis, mating designs- Diallel, Partial Diallel, Line x tester analysis, NCDs and TTC,

UNIT IV
Genetic diversity analysis; phenotypic and genotypic correlations, Path analysis; Heterosis-relationship between Heterosis and genetic diversity. Concepts of combining ability and gene action— Inbreeding and cross breeding; changes of mean and variance and applications.

UNIT V
Simple concepts of selection, selection - heritability and genetic advance; various selection methods through specific examples from various crops. Response to selection, the speed of advance under selection, correlated response under selection, Selection for multiple characters, Tandem selection, Selection index. Basic concepts of Marker assisted selection.

UNIT VI
G x E interactions- principle and interpretation -various methods of their estimation with illustrative examples from crop plants. Analysis of genotype x environment interaction - adaptability and stability,

Practicals
Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance Cluster analysis; Correlation and Path analysis - Diallel analysis: Griffin's method II & HAYMAN’s graphical approach; NCD and Line x tester analysis; Generation mean analysis; Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions. Practical on G x E interaction.

Suggested Readings

GP 600 DEVELOPMENT OF GENE CONCEPT

Objectives
To give insight in to the dynamic concept of gene, its structure, function and regulation of expression in prokaryotes and eukaryotes
Theory

UNIT I
Pre-Mendelian concepts of gene: physical basis of heredity; Gene concept in classical genetics: Mendelian concepts of inheritance, gene interactions, recombination and linkage in lower and higher organisms, crisscross inheritance, gene mapping; Intra- and inter-genic complementation: complementation as test of allelism, complex loci, pseudoalleles.

UNIT II

UNIT III
Chemical nature of gene: structure and properties of DNA and RNA; DNA, RNA and Prion as genetic material; Replication of genetic material in prokaryotes and eukaryotes; Transfer of genetic information: Central dogma of molecular biology, transcription and translation in prokaryotes and eukaryotes; reverse transcription, multiple factor hypothesis and quantitative traits, genetic code: deciphering and analysis of genetic code, nature and properties of genetic code, one code-two amino acids; Mutation: nature and molecular mechanism of mutation, intra- and inter-genic mutation suppression.

UNIT IV
Regulation of gene expression in prokaryotes: inducible and repressible system, operon concept, attenuation, feedback inhibition; Regulation of gene expression in eukaryotes: level of gene regulation, gene activation through promoter-binding and enhancer-binding protein interaction, transcription regulation, post-transcriptional modifications including RNA processing, RNA editing, post-translational modifications; ncRNA, miRNA, siRNA, significance and ncRNA mediated regulation of gene expression, gene silencing, riboswitches.

UNIT V
Nuclear architecture and gene expression: nuclear compartments, chromatin domains, non-random nuclear architecture; Genetic basis of antibody diversity; alternate splicing; split gene: properties and evolution, Extra-chromosomal genes; Mobile genetic elements; Genetic regulation of virus, viroids, virusoids and prions; Genome complexity: C-value paradox, gene cluster, gene families.

UNIT VI
Genes in population: Hardy- Weinberg law, molecular evolution, linkage disequilibrium.

Suggested Readings

GP 602 MUTAGENESIS (3L+2P) III

Objectives
To provide insight into mutations, mutagens & their mode of action, effects, screening and their utility and application in crop improvement.
Theory

UNIT I
History of mutation and experimental mutagenesis- nature and classification of mutations: spontaneous mutations and induced mutations, micro and macro mutations, forward and reverse mutations, role of mutation in evolution, multi gene families.

UNIT II
Mutagens: Physical mutagens: properties and effect of ionizing radiations, RBE and LET, direct and indirect effects; Chemical mutagens- nature of action, classification, comparative evaluation of physical and chemical mutagens; Transposons as mutagens.

UNIT III
Application methodology of mutagens and modification of their action in cell; Mutation repair; Mutagenic effectiveness and efficiency: Estimation and implications in mutation breeding, biological and environmental parameters influencing mutagenic efficiency. Genetic sieves in mutation induction. Screening techniques and selection procedures of induced mutations; test systems in M1 and subsequent generations.

UNIT IV
Crop improvement through induced mutagenesis; targeted gene replacement; gene silencing. Somaclonal variations. In vitro mutagenesis. Mutation in the organellar genome.

UNIT V
Use of mutagens in genomics, TILLING and Eco TILLING: Use of specific chemical mutagens in creating lesions associated with physical changes in the nucleotide sequence of DNA and analysis of polymorphism for detection of SNPs, functional alleles etc.

UNIT VI
Mutation breeding in animals and microorganisms- scope and achievements. Mutational reconstruction of crop ideotype. Mutagens as carcinostatic agents. Environmental mutagenesis- bacteria, mammalian cell cultures, Drosophila; transgenics as environmental mutagen monitors. Comparative assessment of various types of mutations.

Practicals

Precautions of handling mutagens; Dosimetry - Studies of mutagenic agents: Radiation hazards- safety regulations and safe transportation, use and disposal of radioisotopes, gamma chamber, treating seeds with gamma rays, Chemical mutagens- learning hazards due to chemical mutagens - Treating plant propagules with physical and chemical mutagens - combined mutagenic treatments in M1 and subsequent generations in different crops – cereal, pulses, oilseeds, vegetatively propagated crops.

Suggested Readings


Objective
To study the genetic properties of populations and the effect of various evolutionary forces on population genetic parameters.

UNIT I
Introduction to population genetics; Review of math and probability theory; Measures of genetic variation and genetic distance

UNIT II
Genetic constitution of a population – frequencies of genes and genotypes, Hardy-Weinberg Equilibrium, two alleles, multiple alleles, linkage and sex linked inheritance, HWE testing

UNIT III
Changes of gene frequency under selection, mutation and migration: basic selection model, gametic selection, selection against recessives, dominants and heterozygotes; Allele frequency change caused by mutation, forward and backward mutation, fate of a single mutation, mutation-selection balance; Gene flow and population structure, Continent-Island and general model, Wahlund's principle, F coefficients.

UNIT IV
Genes in small populations: Genetic drift, inbreeding and effective population size, Founder Effect and Bottlenecks

UNIT V
Linkage Disequilibrium and Association Genetics, Nested Association Mapping (NAM)

Practicals
Exercises on probability, calculation of genes and genotypic frequencies, testing of HWE, estimation of allele frequencies under forces of selection, mutation and migration. Inbreeding coefficient and estimation of linkage disequilibrium.

Suggested Readings
Philip W Hedrick. 2005. Genetics of populations. Jones and Bartlett publishers, Inc

GP 604 INNOVATIVE APPROACHES IN PLANT BREEDING (2L+0P) III

Objective
To familiarize students with the latest in plant breeding approaches.

Theory
UNIT I
Introduction, Markers: morphological, isozymes, DNA markers (RFLP, RAPD, AFLP, SSR, SNP). Construction of linkage map; use of mapping populations (F2, RILs, NILs, back cross, doubled haploids)-applications, advantages, constraints.
UNIT II
Applications of molecular markers-fingerprinting, phylogenetic relationships. Tagging agronomically important traits. Assessing heterotic performance; Marker assisted selection (MAS) for oligogenic traits, MAS for QTLs. Gene pyramiding using molecular markers.

UNIT III
Transgenic plants-applications of transgenic technology, molecular farming, antisense RNA technology examples from published literature (crop quality, herbicide resistance, insect resistance, disease resistance, viral resistance)-organelle transformation, stability of transgenes, integration of transgenics in plant breeding.

UNIT IV

UNIT V

UNIT VI
Functional markers, Reverse genetics approaches: Targeting Induced Local Lesions IN Genomes (TILLING), ECOTILLING and its application in crop breeding, Allele mining, Genome assisted breeding, Metabolomics assisted breeding, Overcoming domestication bottlenecks using molecular tools.

Suggested Readings
Jain, C.M. and Brar, D.S. 2010. Molecular Techniques in Crop Improvement 2nd ed. Springer
Yunbi, Xu. 2010. Molecular Plant Breeding. CABI

GP 605 BREEDING FOR STRESS RESISTANCE (3L+0P) III
UNIT I
UNIT II
Host-parasite interaction-variation in pathogen and host, factors affecting host reactions, gene-for-gene concept, implications and significance in plant breeding.

UNIT III

UNIT IV
Marker aided selection. Introgression of genes from the wild relatives of crop plants, pyramiding of resistance genes, elimination of linkage drag. Transgenics in the management of biotic stresses. Use of Bt toxins, rotease inhibitors, electins, chitinases and glucanases for insect pest management.

UNIT V
Importance and crop specificity of stresses due to temperature, drought, salinity, alkalinity, Aluminium toxicity, water logging and excessive rains.

Suggested Readings

GP 606 PLANT GENE EXPRESSION AND REGULATION (3L+0P) III

Objective
To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

Theory
UNIT I
Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

UNIT II
Coordinated genetic regulation-examples- Anthocyanin gene family in maize; Genetic and molecular basis of tissue specificity.
UNIT III
Gene expression-Transposons in plant gene expression, cloning-transposon tagging; Light regulated gene expression-model systems in Arabidopsis and maize; Paramutations and imprinting of genes and genomes.

UNIT IV
Transgene expression and gene silencing mechanisms; Regulatory genes, horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

UNIT V
Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

Suggested Readings

GP 607/ PGR 607 REGULATORY MECHANISMS AND INTELLECTUAL PROPERTY RIGHTS AND INTELLECTUAL PROPERTY RIGHTS (3L+0P) I

Objectives
To educate students about concepts and instruments of intellectual property rights, plant breeders's rights, farmer's rights, access and benefit sharing, international treaties and national legislation related to plant genetic resources.

Theory
UNIT I
Concept of intellectual property, need for IP protection, Dimensions and nature of IPR, conflicting community interest with private right. Forms of IPR, patents, copyright, trademark, design, trade secret/ confidential information, GI registration. Process of obtaining an IPR, World Intellectual Property Organization, patent cooperation treaty (PCI).

UNIT II
Plant breeder's rights, protection of plant varieties, UPOV; registration of plant varieties and essentially derived varieties, during and effect of registration; traditional knowledge systems,
farmer’s rights, fork lore, code of conduct, access and benefit sharing; compulsory license; plant varieties protection appellate tribunal; finance, accounts and audit; infringement, offenses, penalties and procedure.

UNIT III
International instruments concerning agro-biodiversity, Agenda 21, convention on biological diversity (CBD), FAO and global system of PGR, the International Treaty on Plant Genetic Resources for food and agriculture (ITPGR), Global Plan of Action, TRIPS agreement and IPR protection of life forms, geographical appellations.

UNIT IV
Multilateral agreement on trade in goods – relevance to agriculture, agreement on agriculture (AOA); agreement on application of sanitary and phyto-sanitary measures (SPS, international plant protection convention, agreement on technical barriers to trade (TBT), Plant quarantine, bio-safety related issues.

UNIT V
National legislations related to biodiversity conservation and IPR protection

Suggested Readings

Use of Biodiversity: Access to Genetic Resources and Benefit Sharing by Kerry Ten Kate and Sarah A Laird; Earthscan 2002.


GP 610 CROP CYTOGENETICS (2L+1P) II

Objective
To study crop evolution and cytogenetic approaches for crop improvement.

Theory
UNIT I
Origin and evolution of species; Centres of diversity/origin, diffused centres; domestication; Patterns of evolution and domestication-examples and case studies. Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT II
Speciation and domestication – The process of speciation – Reproductive isolation barriers – Genetic differentiation during speciation –Hybridization - speciation and extinction.

UNIT III
Exploitation of natural variation – Early attempts to increase variation –Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques;Validation of transferred genes and their expression; Controlled introgressions.
UNIT IV
Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction – Intergenomic interaction – Genome introgression. Cytogenetic analysis of species relationships and evolution of wheat, rice, maize, sugarcane, Brassica, cotton, jute, tobacco, potato, tomato, pulse crops, forage crops and cucurbits.

UNIT V
Methods to study crop evolution - Contemporary Methods – Cytogenetic analysis – Allozyme variations and crop evolution – DNA markers, genome analysis and comparative genomics.

UNIT VI

Practicals
Patent Information Search; Patent Drafting; Opinion on Patentability; Patent Infringement

Suggested Readings
Hancock, J.F. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed.CABI.

GP 612 DIVERSITY ANALYSIS (2L+1P) II

Objective
To expose students to various aspects of genetic diversity, its measurement, grouping and study of phylogenetic relationship

UNIT I
The meaning of diversity, history, importance and its use in agriculture. Assessment of diversity: Morphological, biochemical and molecular.

UNIT II
Statistical techniques for measuring diversity: Measures of quantitative and qualitative variability, diversity indices; and methods for marker data analysis. Statistical techniques for clustering: Hierarchical and non-hierarchical cluster analysis, algorithms for forming clusters/ dendrograms, data transformation and choice of scales, exposure to various clustering softwares.

UNIT III
Evolution and Diversity: Phylogenetics, concept of evolutionary trees, rooted and unrooted topology, methods for studying phylogeny-maximum, parsimony, distance methods, maximum likelihood, reliability of prediction. Exposure to various softwares (MEGA, Phylip. NTSYS etc.)

UNIT IV
Collection of germplasm diversity, required sample size and introduction to various germplasm sampling models, Spatial tools for studying plant germplasm diversity
Practical

Estimation of diversity, Practical exercises using statistical software for clustering. Developing phylogenetic trees based on various methods, estimating and locating diversity using DIVA GIS, determination of sample size for collecting diversity

Suggested Reading


GP 620 APPLIED CYTOGENETICS (3L+1P) III

Objectives

This course aims to teach advanced techniques in manipulating cytogenetics for genome analysis in crop species.

Theory

UNIT I
Karyotyping – Chromosome banding and chromosome painting Tracking introgressions using FISH, GISH, localization and mapping of genes/genomic segments. – Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT II
Location and mapping of genes on chromosomes by various cytogenetical tools : Deficiency method, Interchanges, all arms marker method, linked marker method, Inversions, Telocentrics. Relative efficiency of different methods

UNIT III
Applications of cytogenetical methods for crop improvement; balanced lethal systems, their maintenance and utility; multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods;

UNIT IV

UNIT V
Trisomics- different types, production, breeding behaviour and location of genes using trisomics. Monosomics -methods of production, intervarietal substitutions, allelic and non-allelic interactions.

UNIT VI
Gene transfer by distant hybridization: scope and limitation, methods to overcome barriers- tissue culture. Allopolyploids-synthesis of new crop species and varieties, Alien chromosome addition and substitutions. Chromosomal control of meiotic pairing and induced transfer of alien genetic variation.
Suggested Readings


GP 621 BREEDING FOR CROP QUALITY TRAITS (2L+2P) III

Objectives

To understand recent advances in improving quality traits in cereals, millets, legumes, oilseeds and forage crops by conventional and modern approaches.

Theory

UNIT I
Nutritional improvement - A human perspective, Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Wheat quality-nutritional, rheological, baking properties and fractional aspects; - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

UNIT II
Breeding for grain quality parameters in rice and its analysis- aroma, amylose, GT, gel consistency, elongation ratio, cooking quality, post harvest manipulation for quality improvement – vitamin A enriched and aromatic rice – breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.

UNIT III
Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize- – concept and breeding strategies –kernel mutants and their uses in breeding for quality; Speciality corns; Breeding for quality improvement in forage crops; Genetic resource management for sustaining nutritive quality in crops

UNIT IV
Breeding for quality in pulses; groundnut, sesame, sunflower and minor oilseeds – Fatty acid metabolism and its manipulation to increase PUFA in oil, Brassica-breeding for low erucic acid and glucosinolates; Soybean- breeding for amelioration of anti nutritional factors; Genetic manipulation for quality improvement in cotton.

UNIT V
Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; classification and importance - Nutritional genomics and Second generation transgenics

Practicals

Grain quality evaluation in rice; correlating ageing and quality improvement in rice - Quality analysis in millets; a comparison - Quality parameters evaluation in wheat; Quality parameters
evaluation in pulses - Quality parameters evaluation in oilseeds - Value addition in crop plants; Post harvest processing of major field crops - Quality improvement in crops through tissue culture techniques - Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

Suggested Readings

Speciality rices of the World – Breeding, production and marketing. 2001. FAO Oxford IBH.

GP 640 ADVANCES IN PLANT BREEDING (3L+0P) III

Objective

To impart knowledge on advancement in plant breeding methodology, approaches and their implications in crop improvement.

Theory

UNIT I
Introduction, course outline, overview & Perspectives; Different approaches to crop breeding including improvement for quality and resistance attributes: concepts and new developments;
Marker assisted selection-Approaches, applications and outcomes, for realizing specific objectives;
Variations at genomic level, analysis and implications- from plant breeding point of view.; Stability-Concept and applications;

UNIT II
Current developments in breeding and improvement of important cereals (wheat, Rice) and oil seed crops (Brassica & Sunflower); pulses.

UNIT III
Crop domestication, adaptation and selection: an update; Classical experiments in crops – long term selection,its consequences and utility; Comparison and contrasts between crop domestication, classical breeding and molecular breeding; Hybrid technology in plant breeding: Concept development, utilization & consequences;

UNIT IV
Associations mapping & in silico mapping: application and implications in plant breedingGene introduction and selection –Natural and induced; utilization in plant breeding; Mutational variation and long term selection response;

UNIT V
Approaches and effectiveness of breeding for drought tolerance, in different crops; Current developments in improvement of pulses; Hybrid technology in Sunflower, brassica.
UNIT VI
Implication of plant variety protection on plant breeding – past experience from other countries;
Implication of PVP&FR on crop improvement efforts in India; gearing up for change and meeting
specific requirements and obligations; EDV vs IDV – Approaches of development and
differentiation; Issues and impact of current & prospective approaches - (i) Participatory plant
breeding (ii) Organic farming (iii) Processing, post harvest requirements & value addition

Selected Readings
Publishing.
Yunbi, Xu. 2010. Molecular Plant Breeding. CABI.

GP 643 CONCEPTS IN HETEROSIS BREEDING

(2L+1P) II

Theory

UNIT I
Heterosis: Introduction, Nomenclature and definitions of heterosis - Heterosis in natural and
bred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and
cross-pollinated and asexually propagated crops crops;

UNIT II
Pre Mendelian and Post Mendelian ideas - Genetic theories of heterosis – Physiological,
Biochemical and molecular factors underlining heterosis; theories and their estimation; -
Evolutionary concepts of heterosis

UNIT III
Prediction of heterosis from various crosses - Inbreeding depression, frequency of inbreeding
and residual heterosis in F2, and segregating populations, importance of inbreeding in exploitation
of heterosis – case studies. - Relationship between genetic distance and expression of heterosis
– case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic
distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks
and inbreds, their improvement for increasing heterosis

UNIT IV
Types of male sterility and use in heterosis breeding, Maintenance, and transfer of different
types of male sterility. Fertility restoration- Genetics, Allelic relationship and breeding of new
restorer lines. Hybrid seed production methods involving 3-lines, 2-lines and 1-line system,
Development of inbreds and parental lines- A, B and R lines Use of self-incompatibility in
development of hybrids

UNIT V
Fixation of heterosis in self, cross and often cross pollinated crops, asexually / clonally propagated
crops, Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI
Molecular basis of heterosis, molecular basis of male sterility and fertility restoration, genetic
basis of inbreeding depression. Heterosis breeding in wheat, rice, cotton, maize, pearl millet,
sorghum and oilseed crops
Practicals

Selection indices and selection differential – calculations and interpretations - Male sterile line characterization in millets; using morphological descriptors; restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton; problems in creation of CGMS system; ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters -Hybrid seed production in field crops – an account on the released hybrids; their potential; problems and ways of overcoming it; hybrid breeding at National and International level; opportunities ahead.

Suggested Readings


# Horticulture

## TRIMESTER-WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 007</td>
<td>PRINCIPLES OF HORTICULTURAL CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>HORT 501</td>
<td>BASIC HORTICULTURE</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>HORT 502</td>
<td>NUTRITIONAL REQUIREMENT OF HORTICULTURAL CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>HORT 601</td>
<td>EXPORT ORIENTED HORTICULTURE</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 601</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSC 501</td>
<td>FRUIT PRODUCTION-I</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FSC 502</td>
<td>FUNDAMENTALS OF FRUIT PRODUCTION</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>FSC 601</td>
<td>PRODUCTION TECHNOLOGY OF PLANTATION CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FSC 602</td>
<td>NATIONAL HORTICULTURAL PROBLEMS AND CURRENT ISSUES IN FRUIT PRODUCTION</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>VSC 501</td>
<td>PRINCIPLES OF VEGETABLE PRODUCTION</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>VSC 502</td>
<td>PRINCIPLES OF VEGETABLE BREEDING</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>VSC 601</td>
<td>HI-TECH VEGETABLE FARMING</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FLA 501</td>
<td>FUNDAMENTALS OF FLORICULTURE</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>FLA 502</td>
<td>LANDSCAPE GARDENING</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>FLA 503</td>
<td>SPECIALTY FLOWERS AND CUT GREENS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>FSC/VSC/</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>FLA 691</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>HORT 611</td>
<td>PROTECTED CULTIVATION OF HORTICULTURAL CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FSC 511</td>
<td>FRUIT PRODUCTION-II</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FSC 512</td>
<td>PLANT PROPAGATION</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>FSC 611</td>
<td>BREEDING OF FRUIT CROPS</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>VSC 511</td>
<td>PRINCIPLES AND TECHNIQUES OF VEGETABLE SEED PRODUCTION</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>SST 511</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSC 512</td>
<td>WINTER VEGETABLES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>VSC 513</td>
<td>PRODUCTION OF UNDERUTILIZED EXOTIC VEGETABLES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VSC 611</td>
<td>BREEDING OF CROSS-POLLINATED VEGETABLE CROPS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>FLA 511</td>
<td>BREEDING OF ORNAMENTAL PLANTS</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
FLA 611 COMMERCIAL FLORICULTURE 3 1
FSC/VSC/ SEMINAR 1 0
FLA 691

III TRIMESTER

HORT 621/ GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS 3 2
PP 621
HORT 622 PLANT TISSUE CULTURE IN THE IMPROVEMENT OF HORTICULTURAL CROPS 2 2
FSC 521 SYSTEMATIC POMOLOGY 3 1
VSC 521 SUMMER VEGETABLES 3 1
VSC 621 BREEDING OF SELF-POLLINATED VEGETABLE CROPS 3 1
VSC 622 BIOTECHNOLOGY FOR VEGETABLE CROPS IMPROVEMENT 3 1
FLA 521/ PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS 2 1
SST 521
FLA 522 INDOOR PLANTS 3 1
FLA 621 ADVANCED BREEDING OF ORNAMENTAL CROPS 3 1
FLA 622/ VALUE ADDITION IN ORNAMENTAL CROPS 1 1
PHT 622
FSC/VSC/SEMINAR 1 0
FLA 691

Core Courses

M.Sc.: HORT 501
FSC 501, FSC 502, FSC 512, HORT 502
VSC 501, VSC 502, VSC 512, VSC 521
FLA 501, FLA 502, FLA 511, FLA 521

Ph.D.: FSC 602, FSC 611, HORT 621
VSC 601, VSC 611, VSC 621, VSC 622
FLA 611, FLA 621, FLA 622, HORT 621

Outside the discipline core courses for students of Horticulture Science
(Fruit Science – FSC, Vegetable Science – VSC and Floriculture and Landscape Architecture – FLA)

1. Courses from Crop Improvement School
   a. Genetics
      I. GP 500: Elements of Genetics (3L+2P),
      II. GP 510: Principles of Cytogenetics (3L+2P)
   b. Postharvest Management
      PHT 503: Laboratory Techniques for Food Crops (2L+2P)
2. Courses from Resource Management School
   a. Agronomy
      I. AG 503: Principles and Practices of Weed Management (3L+1P) and
      II. AG 602: Modern Concepts in Agronomy (3L+1P)
   b. Agricultural Physics
      I. AP 640: Remote Sensing in Agriculture (2L+1P)
      II. AP 541: GIS and GPS- Principles and Application (2L+1P)
3. Courses from Basic Sciences School
   a. Molecular Biology and Biotechnology
      I. MBB 501: Principles of Biotechnology (3L+0P),
      II. MBB 502: Fundamentals of Molecular Biology (3L+0P)
      III. MBB 509: Bioinformatics (2L+1P)
      IV. MBB 601: Molecular Breeding (3L+0P)
   b. Plant Physiology
      I. PP 501: Principles of Plant Physiology-I (4L+1P)
      II. PP 505: Physiology of Growth and Yield (2L+1P)
      III. PP 508: Physiology of Plant Mineral Nutrition (3L+2P)
   c. Biochemistry
      I. BIO 501: Basic Biochemistry (4L+1P)
      II. BIO 502: Nutritional Biochemistry (3L+1P)
      III. BIO 601: Nucleic Acids (2L+1P)
      IV. BIO 503: Plant Biochemistry (3L+1P)
      V. BIO 504: Techniques in Biochemistry (2L+2P)
HORTICULTURE
FRUIT SCIENCE - FSC
VEGETABLE SCIENCE - VSC
FLORICULTURE AND LANDSCAPE ARCHITECTURE - FLA

Name of School : Crop Improvement
Major Fields : Floriculture and Landscape Architecture
               Fruit Science
               Vegetable Science
Minor Fields : Ph.D. student shall have to take two minors (9 credits of course work in each) from any other disciplines outside his/her own discipline.
               M.Sc. student shall have to take one minor (9 credits of course work) from any other disciplines outside his/her own discipline.

DESCRIPTION OF COURSES

GENERAL COURSES ON HORTICULTURE (HORT)

AGR 007 PRINCIPLES OF HORTICULTURAL CROPS (2L+1P) I

Objective
To impart basic knowledge about the principles of production of horticultural crops.

Theory
UNIT I
Layout and establishment of orchards, kitchen and flower gardens; growing plants in pots.
UNIT II
Vegetable growing, climatic, soil and cultural requirements of major horticultural crops, varieties, crop rotation.
UNIT III
Canopy management in fruit crops, manures and fertilizers, irrigation, major pests and diseases, weed control, methods of propagation and seed production, crop maturity and yields in horticultural crops.

Practicals
Classification of vegetables; Healthy nursery raising in vegetables; Layout of a model kitchen garden, fruit orchard and flower garden; Propagation in fruit crops and important flower crops.

Suggested Readings
HORT.501 BASIC HORTICULTURE  

Objective  
To impart basic knowledge about the importance and management of different horticultural crops.

Theory  

UNIT I  
Layout of orchards, their establishment and maintenance; principles of planting, training and pruning; propagation, manure and fertilizer application; irrigation and plant protection measures; Production technology of important fruit crops.

UNIT II  
Nutritive value of fruits and vegetables, causes of spoilage of fruits and vegetables and their control measures; principal methods of preservation; commercial fruit and vegetable products; processing equipment.

UNIT III  
Vegetable cultivation in India, types of vegetable growing; cultural practices for important vegetable crops.

UNIT IV  
Importance, scope and principles of floriculture and landscaping; different styles and designs of garden; their features and maintenance; landscaping of public places including their plan and planting material. Production technology of important flower crops.

Practicals  
Nursery management and polyhouse culture; Visit to vegetable farms and nursery, identification of seasonal vegetables; Enzyme test and dehydration of fruits and vegetables; Estimation of acidity and sugars in fruits and vegetables; Preparation of juice and jam; Preparation of nectar and squashes; Systematic description of fruit crops and their propagation; Layout and planting system of orchards; Fertilizer and water use in orchard; Visit to various gardens and identification of ornamental plants.

Suggested Readings  
HORT 502 NUTRITIONAL REQUIREMENT OF HORTICULTURAL CROPS (3L+1P) I

Objective

To acquaint students about the role of different nutrient elements in plant growth and development, principles and practices of fertilizers and manures application and their management in production of different horticultural crops.

Theory

UNIT I
Essential elements identified as plant nutrients, Factors affecting plant nutrition; nutrient uptake and their removal from soil.

UNIT II
Nutrient requirements of major fruits and vegetables.

UNIT III
Methods and techniques for evaluating the requirement of macro- and micro-elements, role of different macro- and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

UNIT IV
Soil and foliar application of nutrients in major horticultural crops.

UNIT V
Fertigation in horticultural crop, bio-fertilizers and their use in IPNM systems.

Practicals

Visual identification of nutrient deficiency symptoms in vegetable/ annual crops; Identification of organic, inorganic and bio-fertilizers and methods of application; Soil and tissue sample collection, preparation for macro- and micro-nutrient analysis; Analysis of soil physical and chemical properties. Soil pH, EC, Organic carbon determination in soil; ‘P’ analysis using spectrophotometer; ‘N’ analysis using auto analyzer; ‘K’ & ‘Na’ analysis using flame photometer; Ca, Mg, Fe and Zn analysis using Atomic absorption spectrophotometer; Visual identification of nutrient deficiency symptoms in fruit crops; Visual identification of nutrient deficiency symptoms in flowers, vegetable crops; Fertigation in glasshouse and field grown horticultural crops; Preparation of micro-nutrient solutions, their spray and soil applications.
Suggested Readings


HORT 601/ PHT 601 EXPORT ORIENTED HORTICULTURE (3L+1P) I

Objective

To acquaint students with the export oriented requirements of horticultural crops.

Theory

UNIT I
India's position and potentiality in world trade; export promotion zones in India.

UNIT II
Scope, produce specifications, quality and safety standards for export of fruits *viz.*, mango, grape, litchi, pomegranate, walnut, cashewnut *etc.*, vegetables *viz.*, onion, chilli, okra, bitter gourd, gherkin *etc*. flowers *viz.*, rose, carnation, chrysanthemum, gerbera, specialty flowers *etc.*, cut greens and foliage plants.

UNIT III
Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

UNIT IV
Seed and planting material; Hi-tech nurseries, implications of PVP.
Practicals

Export promotion zones for vegetables and export of fresh vegetables and their products; Quality standards of vegetables for export purpose; Practical on quality standards of major flowers for export; Quality standards of planting material and seeds; Hi-tech nursery in floriculture; Quality standards of major fruits for exports; Practical on ISO specifications and HACCP for export of fruits; Sanitary and phytosanitary measures during export of horticultural produce; Post harvest management chain of horticultural produce for exports.

Suggested Readings


HORT 611 PROTECTED CULTIVATION OF HORTICULTURAL CROPS (3L+1P) II

Objective

To impart knowledge on agro-technique and management of different horticultural crops under protected environmental conditions.

Theory

Objectives, importance and scope of protected cultivation of vegetables, fruits and ornamental plants; principles and structures used in protected cultivation including hotbed, cold frame, polyhouse, low tunnel etc.; effect of temperature, light, humidity and CO₂ on growth, flowering and production; hi-tech nursery raising technology of vegetables and flowers and propagation of fruit crops; selection of crops and varieties, production technology and economics of production of high value crops;

UNIT I
Vegetables like tomato, cucumber, capsicum, melons, summer squash.

UNIT II
Ornamental crops like rose, chrysanthemum, carnation, gerbera, lilium, orchids, anthuriums.

UNIT III
Fruit crops like strawberry and raspberry.
UNIT IV
Micro-irrigation, fertigation and soil-less culture; manipulation of conditions for staggering production; problems associated with growing of horticultural crops in greenhouse and their remedies; use of greenhouse for seed production; growth regulators for manipulation of growth and flowering in ornamentals; post-harvest management of greenhouse grown commodities.

Practicals
Layout and installation of different protected structures; Climatic requirements maintenance for protected cultivation of horticultural crops; Hi-tech nursery raising technology for vegetables; Hi-tech nursery raising technology for ornamental crops; Laying of plastic low tunnels for off-season vegetable cultivation; Tissue culture and hi-tech nursery management for fruit crops; Production and management of greenhouse flower crops; Fertigation technology for horticultural crops; Soilless cultivation of horticultural crops; Training, pruning and trellising in greenhouse vegetables; Commercial propagation of orchids and anthurium; Post-harvest management of horticultural produce and on farm value addition.

Suggested Readings
Burt, C., Conoor, K.O. and Rueshr, T. 1998. Fertigation: Published by Irrigation Training and Research Centre, California Polytechnic State University, San Wis O Bispo, CA.9340.

HORT 621/PP 621 GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS
(3L+2P) III

Objective
To teach about the growth and development processes of horticultural crops, knowledge of basic physiological and molecular processes affecting growth, flowering and production of quality produce.
Theory

UNIT I
Defining growth and development; physical and physiological aspects of growth, germination, juvenility; root and leaf differentiation.

UNIT II
Flowering, fruit set and development, fruit maturity and ripening, abscission, senescence of horticultural crops; factors influencing flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism.

UNIT III
Biosynthesis of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassino-steroids, synthetic growth inhibitors, morphactins, methyl jasmonates, salicylic acid, polyamines etc. their mode of action.

UNIT IV
Role of plant growth promoters and inhibitors on physiological processes like seed and bud dormancy, fruit thinning, fruit drop, sex expression/ modification in cucurbits and induction of parthenocarpy; plastochrome.

UNIT V
Water relations, stress physiology in relation to drought, temperature and salts, quality improvement in fruits, vegetables and flowers.

Practicals
Visit to Physiology laboratory; Testing of seed germination and breaking dormancy in seeds; Study on fruit set and fruit growth; Estimation of tissue macro- and micro-nutrients; Estimation of enzymes; Estimation of chlorophyll, carotenoids and other pigments; Bioassay of plant hormones; Use of HPLC and GC for estimation of phyto-hormones; application of GRs in fruit thinning and control of fruit drop; sex expression and induction of parthenocarpy in horticultural crops; use of PGRs in ornamental crops; Light manipulation in protected cultivation.

Suggested Readings
Moore, T.C. 1979. Biochemistry and Physiology of Plant Hormone. Springer-Verlag, New York, USA.
HORT 622 PLANT TISSUE CULTURE IN THE IMPROVEMENT OF HORTICULTURAL CROPS
(2L+1P) III

Objective
To familiarize the students and provide hands-on training on various techniques of plant tissue culture and their applications in improvement of horticultural crops.

Theory
UNIT I
Basic principles of plant tissue-culture; morphogenetic potential of higher plants and regeneration pathways.

UNIT II
Application of plant tissue culture techniques in crop improvement with emphasis on ornamental, fruit and vegetable crops, single cell and suspension culture, in vitro mutagenesis, somaclonal variation, embryo culture and rescue, anther culture and haploid production.

UNIT III
Protoplast isolation, fusion and organogenesis, Agrobacterium-mediated genetic transformation and cryobiology.

UNIT IV
In vitro germplasm conservation, genetic diversity analysis using DNA markers.

Practicals
General acquaintance with a tissue culture laboratory; Methods of aseptic culture and sterilization procedure; Stock solutions and preparation of culture media; In vitro culture establishment and plant regeneration, Embryo culture and embryo rescue; Anther isolation and culture; In vitro mutagenesis using EMS and gamma irradiation; In vitro screening for NaCl tolerance; Agrobacterium-mediated genetic transformation of tobacco; DNA isolation and RAPD analysis of plants; Techniques of low temperature germplasm storage, cryo-preservation and visit to NBPGR cryo-bank.

Suggested Readings

FRUIT SCIENCE (FSC)

FSC 501 FRUIT PRODUCTION-I (3L+1P) I

Objective
To impart basic knowledge about the importance, management and latest production techniques in tropical and sub-tropical fruits grown in India.

Theory
Origin, history, soil, climate, cultivars, propagation, canopy management, nutrition, irrigation scheduling, important pests and diseases, major physiological disorders - causes and remedies, quality improvement practices; maturity indices, harvesting, grading, packaging, storage and ripening techniques concerned with the cultivation of important tropical, sub-tropical and temperate fruits, GAPs and organic fruit production systems.

UNIT I
Mango, banana, papaya, cashews.

UNIT II
Citrus, grape, guava.

UNIT III
Coconut, sapota.

UNIT IV
Apple, pear, peach, plum, cherry.

UNIT V
Almond and walnut.

Practicals
Planning, layout and establishment of fruit orchard; Visit to germplasm block of mango, grape and citrus; Propagation of quality planting material in different fruit crops, technique of budwood certification and nursery management; Management of frost and high temperature in fruit crops; Intercropping and mulching in fruit crops; High density planting in fruit crops; Rejuvenation of senile fruit orchards; Methods of irrigation and fertigation; Pruning and training technique of tree and vine crops; Identification of important fruit varieties/roostocks; Identification of important pests and diseases of fruit crops; National problems of important fruit crops and their management.
Suggested Readings


Childers, N.F. 1999. Modern Fruit Science: Orchard and Small Fruit culture, Freeman, USA.


FSC 502 FUNDAMENTALS OF FRUIT PRODUCTION  (4L+1P) I

Objective

To teach the principles of fruit growing, effects of different factors on production and produce quality, effective management of different resources, and techniques of pre- and post-harvest of different fruits.

Theory

UNIT I
Orchard layout principles, Soil and climatic adaptation of different fruit crops.

UNIT II
Occurrence of frost and protection against frost; winter injury in relation to specific fruits, water requirement of fruit crops, intake and utilization of water; response of fruit plants to varying conditions of soil moisture and humidity and pathological conditions associated with excess and deficiency of moisture.

UNIT III
Soil management practices; manures and manuring; systems of cultivation, intercrops, cover crops and mulching.

UNIT IV
Growth and fruiting habits; principles, severity, methods and season of pruning with special reference to major fruits; training methods.

UNIT V
Unfruitfulness associated with internal and external factors; factors concerned with development of fruit, fruit setting as an orchard problem; alternate or irregular bearing; Fruit thinning and fruit drop.
UNIT-VI
Harvesting; pre-cooling, grading, packing and transport; marketing and local market surveys.

Practicals
Identification of fruit plants; Preparation of herbarium; Layout of orchard and nursery; Layout of irrigation systems, preparation of spray solutions and maintenance of sprayers; Methods of application of fertilizers and manures and calculation of fertilizer doses; Training and pruning systems in fruit crops; Rejuvenation of unproductive trees; Strategies to control sun-scalding and frost; Vegetative propagation of fruit plants.

Suggested Readings
Childers, N.F. 1983. Modern Fruit Science: Orchard and Small Fruit Culture, Freeman, USA.
Jackson, M.L. and Looney, N.E. 1999. Temperate/Subtropical Fruit Production. CABI, UK
Janick, Jules (ed.) Horticultural Reviews, AVI, Publishers, Connetient, USA.

FSC 511 FRUIT PRODUCTION-II (3L+1P) II

Objective
To acquaint the students with the importance and management of tropical, sub-tropical and dryland fruits grown in India.

Theory
Importance and nutritional properties of minor fruit crops, Suitability of crops for arid, saline and alkaline, high moisture regimes, cultivation technologies of some minor and under utilized fruit crops.

UNIT I
Ber, sapota, mangosteen.

UNIT II
Litchi, pomegranate, date, avocado, kokum.

UNIT III
Loquat, fig, phalsa, jackfruit, custard apple.
UNIT IV
Bael, aonla, jamun, carambola.

UNIT V
Pineapple, passion fruit, persimmon, kiwifruit, strawberry, raspberry, etc.

Practicals
Introduction and classification of minor and arid fruit crops; Propagation and nursery management in different fruit crops; Micro-irrigation in fruit crops; Efficient spray technologies for fruit crops; Special problems of fruit production; International market standards of fruit crops; Visit to the commercial orchards and nurseries; Economics of production of few important fruit crops.

Suggested Readings
Janick, Jules (ed.). Horticultural Reviews, AVI Press, USA.

FSC 512 PLANT PROPAGATION (2L+2P) II

Objective
To teach the students the principles and practices of propagation and nursery management of horticultural crops.

Theory

UNIT I
Fundamental principles of plant propagation, Propagation structures like cold frame, hot beds, etc. use of plant regulators in propagation; techniques of propagation and equipment.

UNIT II
Seed dormancy and germination, propagation by different specialized plant parts, cutting, layering and grafting; Propagation of annuals through seeds, plug plants production.

UNIT III
Physiological, anatomical, biochemical and genetical basis of rooting, Stionic influence; incompatibilities; rootstocks for fruit crops.

UNIT IV
Techniques of micropropagation, shoot tip grafting and meristem culture, micro-budding, synthetic seed, commercial methods of propagation in different horticultural crops. Commercial tissue culture laboratories and Nursery sector in the country.
UNIT V
Scion bank and Hi-tech nursery, Nursery and seed Acts, Nursery registration, IPR issues related with vegetatively propagated horticultural crops.

Practicals
Layout of nursery and propagation structures; Ideal nursery soil: Different types of propagation media, soil mix and amendments; Preparation of nursery beds, filling of pots and soil treatments; Use of growth regulators in plant propagation, preparation of solutions and pastes; Scarification and stratification, Seed propagation of perennial and annual horticultural crops; Propagation by specialized stem and roots; Propagation of plants by cuttings; Propagation of plants by air-layering; Propagation in guava by stooling; Practice of propagation by other layering methods; Practice of different methods of budding; Visit of commercial nurseries; Glasshouse and greenhouse establishment and their maintenance; Micropropagation techniques: In vitro propagation grape and citrus; Micro-budding and shoot tip grafting in citrus.

Suggested Readings

FSC 521 SYSTEMATIC POMOLOGY (3L+1P) III

Objective
To familiarize students about the taxonomy, classification, nomenclature and descriptor of different fruit crops.

Theory
UNIT I
History of nomenclature of plants, classification and nomenclature systems.

UNIT II
International Code of Nomenclature for cultivated plants; identification features, plant keys, registration, description and classification of mango, banana, grape, citrus, guava, ber, aonla, papaya, apple, pear, peach, plum, almond, sapota, cashewnut, pomegranate and date palm.
UNIT III
Fruit crop descriptors and nomenclature.

UNIT IV
Molecular techniques in modern systematics.

Practicals
Different nomenclature systems of plants; Floral biology and taxonomic description of (a) mango; (b) citrus; (c) grape; (d) guava; (e) ber, (f) papaya; (g) banana; (h) apple; (i) pear; (j) peach; Visit to field gene-banks of mango, citrus and grape; Pollen collection, viability, and storage; Cryopreservation and tissue culture repository; Herbarium preparation of different fruit crops; Techniques of molecular systematics; visit to NBPGRI.

Suggested Readings

FSC 601 PRODUCTION TECHNOLOGY OF PLANTATION CROPS (3L+1P) I

Objective
To impart basic knowledge on the importance and production techniques in plantation crops grown in India.

Theory
Plantation crops and their role in national economy. Classification and varietal wealth. Climatic and soil requirements. Species, origin and cytogenetics, blossom biology, breeding objectives, approaches for crop improvement. Propagation, planting systems, multi-tier cropping, inter- and cover crops, effect of excess or low rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, training and pruning, crop regulation, special cultural operations, physiological disorders, role of growth regulators, irrigation requirements, weed management, maturity indices, harvesting, processing and value addition. Organic and precision farming, seed gardens.

UNIT I
Cashew and cocoa.
UNIT II
Coconut, arecanut.

UNIT III
Tea, coffee and rubber.

UNIT IV
Oil palm and palmyrah palm.

Practicals
Botanical description of plantation crops and varietal features; Criteria for selection of potential mother trees/palms, selection of planting material in coconut and arecanut, planting systems, pit preparation, manuring and floor management practices; Pruning and training techniques, special operation, use of PGRs, maturity standards and harvest index; Preparation of multi-storied cropping system models, visit to plantations.

Suggested Readings

FSC 602 NATIONAL HORTICULTURAL PROBLEMS AND CURRENT ISSUES IN FRUIT PRODUCTION
(4L+0P) I

Objective
To teach the students about the present situation of the different problems confronting fruit production and strategies to manage them.

483
Theory

UNIT I
National and international scenario in fruit production and trade. Climate change and fruit production. Abiotic and biotic factors influencing production, productivity and fruit quality.

UNIT II
Senile and seedling orchards- Replant problems and top working, in-situ rain water harvesting and enhancing water use efficiency, Nutrient and irrigation scheduling, Fruit crop based cropping systems, pesticidal residues and MRLs issues in fresh produce.

UNIT III
GAPs in fruit production, HiTech banana & citrus production, Quality grape production in subtropical regions, crop regulation in pomegranate and guava, Quality plant material.

UNIT IV
Complex problems confronting fruit cultivation and their management: Alternate bearing in mango & apple, mango malformation, panama wilt of banana, citrus decline, guava wilt, coconut wilt, apple scab, chilling and pollination problems in temperate fruits, frost and virus problems in papaya and bacterial oil spot in pomegranate.

Suggested Readings

FSC 611 BREEDING OF FRUIT CROPS (4L+1P) II

Objective
To educate students about the principles and practices of fruit breeding.

Theory
UNIT I
Importance, problems and prospects in improvement of fruit crops; origin and centres of diversity, Germplasm collection, evaluation and conservation, NAGs of different fruit crops.
UNIT II
Causes of natural genetic variations; breeding systems - incompatibility, apomixis, parthenocarpy, sterility, dichogamy etc., pollinizers.

UNIT III
Methods of crop improvement - Introduction, clonal selection, hybridization, mutation and polyploidy; innovative approaches like embryo rescue, in vitro mutagenesis, protoplast fusion, genetic engineering; production of seedless fruits; early evaluation techniques; Breeding objectives and ideotypes, methods of improvement, inheritance of economic traits, breeding for biotic and abiotic stresses and achievements in important fruit crops like mango, banana, citrus, grape, papaya, apple, peach, pear, almond etc.; breeding of rootstocks.

UNIT IV
Use of DNA marker technology and marker-assisted selection in fruit crop breeding.

UNIT V
Variatel registration and patents, Nomenclature and crop descriptors of important fruit crops, norms for release of fruit varieties.

Practicals
Maintenance of breeding block; Nursery raising of hybrid seeds; Hybrid evaluation techniques and preselection criteria; Methods of germplasm introduction and quarantine; Methods of germplasm conservation and exchange; Varietal registration and use of descriptors; Floral biology and hybridization techniques of: a. Citrus b. Mango c. Grape d. Papaya; Pollen collection, viability and storage; Mutation through irradiation; Use of chemical mutations; Embryo rescue in fruit crops, use of DNAmarkers.

Suggested Readings


Janick, Jules and Moore, J.N. 1996. Advances in Fruit Breeding, AVI Pub., USA.


Moore, J.N. and Janick, Jules. 1996. Methods in Fruit Breeding. Purdue University Press, South Campus Court D., USA


Objective
To impart knowledge on basic requirements for successful cultivation of vegetable crops.

Theory
UNIT I
Importance of vegetables; area and production in India; types of vegetable growing; classification of vegetables.

UNIT II
Soil and climate factors; heat units and chilling requirements; cultural practices; physiological basis of growth, yield and quality as influenced by environment, chemicals and growth regulators.

UNIT III
Principles governing vegetable production under glass and plastic houses; nutrients essential for plant growth; manures, chemical fertilizers and their response; irrigation and water requirements; crop rotation, crop succession, inter- and mixed-cropping; mulching.

UNIT IV
Insect pests, diseases, physiological disorders and their control measures; role of plant growth substances.

UNIT-V
Harvesting, grading, storage and marketing; vegetable seed production and its storage.

UNIT-VI
Organic vegetable cultivation; vegetable cultivation for higher nutrition, value addition and export.

Practicals
Visit to Divisional Research Farm; Nursery bed preparation of vegetable crops; Field visit to research and seed crop fields of okra, cowpea, dolichos, tomato, cluster beans & cucurbit crops; Field visit to UVRD research farm for cultural operations; Visit to Centre for Protected Cultivation and W.T.C. for understanding various methods of irrigation; Visit to experimental plots for identifying insect pests and diseases of vegetables; Identification of various vegetable seeds and seedlings.

Suggested Readings


**VSC 502 PRINCIPLES OF VEGETABLE BREEDING**

---

**Objective**

To teach basic principles and practices of vegetable breeding.

**Theory**

UNIT I

Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding; genetic architecture; techniques of selfing and crossing; breeding systems and methods.

UNIT II

Selection procedures and hybridization, Heterosis breeding – basis, facilitating mechanisms like male sterility, self-incompatibility and sex forms; Biotic stress resistance breeding - diseases, insect pests and nematode; abiotic stress resistance breeding – temperature, moisture and salt; Breeding for WUE and NUE; mutation breeding; polyploidy breeding; quality improvement; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

UNIT III

Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of *In vitro* and molecular techniques in vegetable improvement.

UNIT IV

Issues related to intellectual property rights and protection of plant varieties and farmers rights authority; Registration of plant varieties and EDVs.

**Practicals**

Floral biology and pollination behaviour of different vegetables; Techniques of selfing and crossing of different vegetables, *viz.* okra, cole crops, cucurbits, tomato, brinjal, chilli etc.; Breeding system and handling of filial generations of different vegetables; Exposure to biotechnological lab practices.

**Suggested Readings**

Allard, R.W. 1960. Principle of Plant Breeding, John Willey and Sons, USA.


**VSC 511/SST 511 PRINCIPLES AND TECHNIQUES OF VEGETABLE SEED PRODUCTION (4L+1P) II**

**Objective**
To impart knowledge on principles and methods of quality seed and planting material production in vegetable crops.

**Theory**

UNIT I
Importance and present status of vegetable seed industry; intellectual property rights and their implications; new seed policies; DUS testing principles and procedures; impact of PVP on growth of seed industry.

UNIT II
Genetical and agronomical principles of seed production; categories of seed and their maintenance; seed certification; seed standards; seed act; plant quarantine and quality control.

UNIT III
Seed morphology and development in vegetable seeds; agro-techniques for vegetable seed production; environmental factors related to flowering/bolting in vegetable crops; floral biology; pollination systems and breeding techniques related to vegetable seed production in different crops; isolation distances; roguing; selection procedures and criteria for seed production; hybrid seeds; seed extraction methods; maintenance breeding in vegetable crops.

**Practicals**
Visit to Experimental farms of divisions of vegetable science, seed science & technology and CPCT; Seed production technology of cucurbits, solanaceous vegetables and cole crops in open, under poly-house & low tunnel; Crossing & emasculation and pollination systems in different vegetable crops. Seed production techniques of cauliflower, peas, French bean, winter bean, *Dolichos* bean, okra, onion, brinjal, chilli, capsicum, carrot, turnip, and radish; Floral biology, determining of planting ratios for hybrid seed production and maintenance of varieties and parental lines.

**Suggested Readings**
VSC 512 WINTER VEGETABLES (3L+1P) II

Objective

To impart knowledge on production technology and management of cool season vegetable crops.

Theory

Origin, distribution and botanical relationship; morphology and taxonomy; nutritional and medicinal value; principles in growing of these crops; physiological and environmental factors associated with growth and production; modern concept of nursery; water and weed management; physiological basis of growth; yield and quality as influenced by chemicals and growth regulators; standard varieties and F₁ hybrids, seed production techniques, insect pests, diseases and their control measures; nutrient management; physiological disorders (due to macro- and micro-nutrient deficiencies and environmental factors); pre and post harvest management and value addition.

UNIT I
Potato
UNIT II
Cole crops
UNIT III
Root crops
UNIT IV
Bulb crops
UNIT V
Leafy vegetables, pea, broad bean.

Practicals

Identification of winter vegetables & their Seeds; Nursery management of winter vegetables; Identification of Insect pests, diseases and physiological disorders of winter vegetables; field trials of onion, peas, cole crops and root crops; Cultivation of winter vegetables under different protective structures; Identification and cultivation tips of exotic vegetables; Identification of marketable maturity stages in different winter vegetables and seed production techniques of winter vegetables.

Suggested Readings


Objective
To educate students on production technology of underutilized and exotic vegetable crops.

Theory
Importance and scope of growing under utilized and exotic vegetables; origin, distribution, general morphology, taxonomy, climate and soil requirement, production technology, varieties, seed production and management of insect-pests and diseases in underutilized vegetables, namely

UNIT I
Dolichos bean, asparagus bean, cluster bean.

UNIT II
Round melon, spine gourd, long melon, snap melon.

UNIT III
Amaranthus, chenopod, fenugreek, Solanum torvum, Solanum pimpinellifolium, Husk tomato etc.

UNIT IV
Exotic vegetables, namely, artichoke, asparagus, baby corn, broccoli, Brussels sprout, Chinese cabbage, cherry tomato, celery, endive, leek, lettuce, parsley, parsnip, rhubarb, Swiss chard, gherkin and winter bean.

Practicals
Visit to centre of protected cultivation and UVRD; Different aspects of nursery management and production tips of broccoli, Brussels sprouts, Chinese cabbage; Cultivation practices and tips for seed production and Insect pest and disease management in cherry tomato, gherkin, broccoli, celery, lettuce, parsley, Brussels sprouts, Chinese cabbage, parsnip, winter bean, artichoke, asparagus, leek, endive.

Suggested Readings
Decoteau, D. 2000. Vegetable Crops, Printice Hall, USA.
VSC 601 Hi-TECH VEGETABLE FARMING  

Objective
To keep the students abreast with the latest concepts, developments and trends in hi-tech vegetable farming.

Theory

UNIT I
Modern controlled nursery raising system in vegetable crops; improved hybrid vegetable growing system; safe vegetable growing – IPM, INM.

UNIT II
Precision vegetable cultivation – laser leveling, mechanized direct seed sowing; seedling transplanting, mapping of soils and plant attributes, site specific input application management, weed management, insect pests and disease management, yield mapping.

UNIT III
Efficient water and fertilizer utilization – drip irrigation, sprinklers, low pressure irrigation; management of biotic stress – insect proof net vegetable growing, coloured plastic strip mulching; Good agricultural practices in vegetable crops; organic vegetable cultivation.

UNIT IV
On farm minimal primary processing; packaging; value addition; cool chain transportation and end users marketing system; Remote sensing, GIS and GPS system.

UNIT V
Traceability; Quality and safety standards of vegetables; Hydroponics, aeroponics & grafting in vegetable crops, Quality assessment - electronic sensors; vegetable marketing information system; Industry led vegetable growing - processing, nutraceuticals & food colour extraction.

Practicals
Media preparation, filling of plug-trays, and sowing of seeds in modern controlled nursery; Vegetable grafting, exposure to minimal processing, packaging, remote sensing, GIS and GPS; Visit to vegetable mechanized farms including organic farms and cool chain industry; Determination of chemical residues and nutraceuticals in vegetable produce.

Suggested Readings


Tiwari, G.N. Greenhouse Technology for Controlled Environment.
Objective

To impart knowledge on production technology and management of warm season vegetable crops.

Theory

Origin, distribution and botanical relationship; general morphology and taxonomy; nutritional and medicinal value; standard varieties and F₁ hybrids, their evaluation and characteristics; basic principles of production, effect of environmental factors on the growth and yield; nutrient management; seed production, insect pests and diseases and their control measures; physiological disorders (due to macro and micronutrient deficiencies and environmental factors); modern concept of nursery; water and weed management; physiological basis of growth; yield and quality as influenced by chemicals and growth regulators; pre and post harvest management; value addition of summer vegetables.

UNIT I
Solanaceous vegetables.

UNIT II
Okra, peas, beans.

UNIT III
Cucurbitaceous vegetables.

UNIT IV
Green leafy vegetables.

UNIT V
Tapioca, sweet potato.

Practicals

Identification of summer vegetables and their seeds; nursery management of summer vegetables; identification of insect pests, diseases and physiological disorders of summer vegetables; field trials of cowpea, amaranth, ridgegourd and sponge gourd, cucumber, ashgourd, pumpkin, bottlegourd and bittergourd, brinjal, chilli, tomato, okra, cluster bean and sweet potato; Cultivation of summer vegetables under different protective structures; identification of marketable maturity stages in different summer vegetables; seed production techniques of summer vegetables.
Suggested Readings


VSC 611 BREEDING OF CROSS-POLLINATED VEGETABLE CROPS (3L+1P) II

Objective

To impart knowledge on improvement of cross-pollinated vegetable crops and keep abreast the students with the latest advances.

Theory

Origin; evolution; history; genetic resources; distribution; cytogenetics; genetics of important traits; breeding objectives and improvement of;

UNIT I
Cole crops – Cauliflower, cabbage, broccoli, knol khol etc.

UNIT II
Cucurbitaceous vegetables – Cucumber, melons, gourds, pumpkin, squash etc.

UNIT III
Bulb crops – Onion, garlic, leek, bunching onion etc.; root vegetables – carrot, radish, turnip, beet

UNIT IV
Leaf vegetables - Amaranth, palak, Chenopod etc.; asparagus, sweet corn and baby corn.

Practicals

Breeding technique and procedures for bulb and root crops, leafy vegetables; Breeding technique and procedures for cole crops and cucurbitaceous vegetables; Use of biotechnological tools and cytogenetics in vegetable breeding.

Suggested Readings

VSC 621 BREEDING OF SELF-POLLINATED VEGETABLE CROPS (3L+1P) III

Objective
To impart knowledge on improvement of self-pollinated vegetable crops and the recent advancements.

Theory
Origin; evolution; history; distribution; genetic resources; cytogenetics; genetics of important traits; breeding objectives and improvement of;
UNIT I
Solanaceous vegetable crops - Potato, tomato, brinjal, chilli, sweet pepper.
UNIT II
Leguminous vegetable crops – Garden pea, French bean, cowpea, broad bean, cluster bean, winged bean, lab lab and sword bean.
UNIT III
Okra, lettuce and fenugreek.

Practicals
Breeding techniques and procedures for tomato, capsicum, okra, garden pea; Potato, cowpea, Indian bean, bakla, bean etc.; brinjal, French bean, lettuce, fenugreek etc.; Application of biotechnological tools and cytogenetics in breeding of above vegetables.

Suggested Readings

VSC 622 BIOTECHNOLOGY FOR VEGETABLE CROPS IMPROVEMENT (3L+1P) III

Objective
To educate students on application of basic concepts of biotechnology as a tool for improvement of vegetable crops.

Theory
UNIT I
Role and scope of biotechnology and molecular tools in vegetable breeding; In vitro culture methods, somaclonal variation, transformation, somatic hybridization, phylogenetic relationships; Androgenesis, meristem, ovary and embryo culture; synthetic seeds; haploidization; instant inbred line development.
UNIT II
Introduction to molecular tools, markers – morphological, isozymes, DNA markers (RFLP, AFLP, RAPD, SSR, SNPs, ESTs etc.; construction of linkage maps; development of mapping populations (F₂, RILs, NILs, back crosses, DH) and their uses; application of markers – finger printing; diversity analysis; tagging of important traits, gene pyramiding, hybrid testing, QTL analysis; marker-assisted breeding for biotic & abiotic stresses, nutraceutical bioactive health compounds; and food colour related improvement in vegetable crops.

UNIT III
Bioinformatics – principles and application; molecular breeding advances in important vegetable crops.

UNIT IV
Recombinant DNA technology, methods of transformation; Transgenic development in vegetable crops –insect pest, fungal bacterial and viral diseases resistance; male sterility, parthenogenesis; post harvest management – shelf-life enhancement; Biosafety issues and regulatory procedures of GMOs and intellectual property rights.

Practicals
Demonstration of the procedure for in-vitro culture in few vegetables; Molecular marker analysis including DNA finger printing, diversity analysis and hybridity testing of different vegetable crops; Development of transformation protocol for transgenic.

Suggested Readings

FLORICULTURE AND LANDSCAPE ARCHITECTURE (FLA)

FLA 501 FUNDAMENTALS OF FLORICULTURE  (3L+2P) I

Objective
To teach the principles and practices of cultivating ornamental crops and gardens.

Theory
UNIT I
Importance and scope of floriculture; history and development of gardens; garden styles and designs; features of gardens.
UNIT II
Uses and cultivation of ornamental trees, shrubs, climbers, bulbous plants and flowering annuals; cacti and succulents, ferns, palms and foliage plants; greenhouse plants, their uses, cultivation and maintenance; principles of training, pruning, bending, pinching and disbudding.

UNIT III
Turf culture; factors governing growth and flowering of ornamental plants including exploitation of photo-periodism; Principles of soilless culture and protected cultivation.

UNIT IV
Layout and management of nursery of ornamental plants; propagation methods and structures.

UNIT-V
Fundamental of post harvest technology of important flower crops; factors governing the post harvest life of cut flowers; principles like precooling, pulsing, bud opening, storage; flower senescence; physiological disorders; cutting, grading, packaging and marketing of cut flower crops.

Practicals
Identification of important ornamentals; Layout of nursery; Propagation techniques like cutting, budding, layering, grafting; Exposure to cultural practices like pinching, disbudding in loose flower crops; Training, pruning and bending in roses; Post harvest management of cut flowers and loose flowers.

Suggested Readings

FLA 502 LANDSCAPE GARDENING (3L+2P) I

Objective
To familiarize the students with principles and practices of landscape design and gardening.
Theory

UNIT I
Principles of landscaping and interiorscaping; natural and manmade forms and features; bioaesthetic planning of parks, urban areas, industrial area, golf courses, traffic islands and highways.

UNIT II
Exposure to CAD, developing computer aided designs (CAD); analysis of various types of sites and their landscape treatments; history of gardens in India; types and styles of gardens.

UNIT III
Organization of spaces; visual aspects of plan arrangement namely, view, vista and axis; analysis of problems and application of landscape principles for various types of houses; - landscape principles for educational institutions, religious places, industrial sites, country sides; landscaping of terrace and roof gardens and multistory buildings.

UNIT IV
Landscape principles for farm complexes, embassies, hotels and other buildings, for tourist complexes, picnic spots, camping grounds and archaeological as well as other monuments; landscaping of various categories of roads; master-plans of cities in relation to open spaces, parks and other recreational areas. Eco-tourism, theme parks, xeriscaping and waterscaping.

Practicals
Identification of landscape flowering/foliage plants, shrubs, hedges/edges, climbers/creepers and annuals and perennials: their description; Visit of School of Planning and Architecture; Estimate preparation of Horticulture Development as per DSR; Landscaping of five star hotels: Visit to Delhi Golf Course, Golf Link; Visit to Japanese park for identification and study of landscape features; Layout planning and designing of various types of formal/informal, Japanese gardens, water gardens, roundabout; Layout designing for public parks, hospitals, educational institutions and religious places, Layout designing for Hill gardens.; Propagation and management of landscape planting material. Designing of home garden, rock garden and lily pool garden; Planning and designing for interiorscaping.

Suggested Readings
Bhattacharjee, S.K. 2006. Advances in ornamental horticulture (Vol. 5), Pointer Publisher, Jaipur, India.


**FLA 503 SPECIALTY FLOWERS AND CUT GREENS**

**Objective**

To impart the knowledge on importance and cultivation of specialty cut flower and cut green crops.

**Theory**

UNIT I
Introduction, present status, scope importance and avenues for specialty flowers.

UNIT II
Role in diversification.

UNIT III
Cultivation of specialty like Heliconia, red ginger, Bird of Paradise, Ornamental banana, ornamental curcuma, gingers, wax flower, kangaroo paw limonium, lupins, gypsophila, rice flower, solidago etc.

UNIT IV
Cultivation of cut greens like anthurium, ferns, asparagus, cycas palm, thuja, golden bottle brush, ornamental palms, zanado, dracena, eucalyptus etc.

UNIT-V
Post harvest management, quality standards, packing, packaging and marketing trends of cut flowers and cut greens.

**Practicals**

Identification of specialty cut flowers and cut greens; Media and bed preparation for cultivation; Propagation; Integrated disease and pest management; Post harvest handling of specialty cut flowers and cut greens.

**Suggested Readings**


Objective

To impart comprehensive knowledge about the principles and practices of breeding of ornamental plants.

Theory

UNIT I
Origin, evolution and distribution of ornamentals; genetic resources and conservation of ornamentals; floral and pollen biology, cytology and cyto-genetics of important flower crops; role of introduction and selection in domestication of wild plants.

UNIT II
Breeding systems; methods of breeding suited to seed and vegetatively propagated plants; role of polyploidy and mutations in the evolution of new varieties; role of heterosis and its exploitation.

UNIT III
Production of F₁ hybrids; utilization of male sterility and self incompatibility; breeding for biotic and abiotic stresses; inheritance of quantitative and qualitative traits; variation in flower characters like fragrance, flower forms (doubleness) and colour.

UNIT IV
Genetic improvement; breeding objectives and constraints in crops like roses, chrysanthemum, gladiolus, carnation, orchids, anthurium, tuberose, gerbera, heliconia, aster, crossandra, jasmine, marigold, petunia, antirrhinum, gypsophila, cosmos, pansy, phlox, stocks, zinnia, sweet pea, dahlia, lilies, amaryllis, bougainvillea, hibiscus etc.

Practicals

Floral and pollen biology of important flower crops; Methods of breeding suited to seed propagated plants; Polyploidy and mutations to evolve new varieties; breeding methods for biotic and abiotic stresses; Male sterility and self incompatibility studies in flower crops; Heterosis and its exploitation in flower crops like marigold; Breeding for characters like fragrance, flower forms (doubleness) and colour.

Suggested Readings

Objective

To impart basic knowledge about the importance of planting material and production of seed in important flower crops grown in India.

Theory

UNIT I
Scope and importance of planting material in flower crops;

UNIT II
Global and Indian scenario in planting material and flower seed production. Propagation techniques and nursery management.

UNIT III
Propagation structures, sanitary and phyto-sanitary issues, plug plant production, nursery standards, Hi-tech nurseries, micropropagation of ornamental plants.

UNIT IV
F₁ hybrid seed production advantages, steps involved in hybrid seed production, methods in production of F₁ hybrids in different flowers like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc., pollination behaviour and isolation, pollination management.

UNIT V
Use of incompatibility, use of male sterility, maintenance of variety and seed production in open-pollinated crops.

Practicals

Demonstration of propagation techniques; Nursery management techniques; Plug plant production; Steps involved in hybrid seed production; Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc

Suggested Readings

Theory

UNIT I
Introduction, importance and use of potted plants; environmental factors affecting growth of indoor plants like light, temperature, humidity and air; watering; plant care and maintenance.

UNIT II
Properties of soil in relation to foliage plants; growing media, substrates: potting media; containers, nutrition and fertilization; description of important flowering and foliage indoor plants.

UNIT III
Cacti and succulents; propagation of indoor plants; plug and pot plant production; diseases and insect-pests of indoor plants; growth regulation in indoor plants.

UNIT IV
Interiorscaping-principles and factors; flower arrangement with fresh and dry flowers; special gardens like dish, terrarium, hanging baskets, window boxes, miniature gardens, vertical garden etc.

Practicals
Identification of indoor plants; propagation of indoor plants; growth regulation in indoor plants; Plug and pot plant production; Potting and repotting of plants; Flower arrangement with fresh and dry flowers; special gardens like dish, terrarium, handing baskets, window boxes.

Suggested Readings

FLA 611 COMMERCIAL FLORICULTURE (3L+1P) II

Objective
To impart basic knowledge about the importance and production technology of commercial flower crops grown in India.

Theory
UNIT I
Scope and importance of commercial floriculture in India; production technology including integrated nutrient, water, weed, insect pests and disease management of ornamental plants like rose, marigold, chrysanthemum.
UNIT II
Production technology of orchid, carnation; gerbera, gladiolus, jasmine, dahlia, tuberose, China aster and crossandra under open field conditions for domestic markets; production technology of non traditional flowers; commercial seed production in open field conditions.

UNIT III
Post harvest technology of loose and cut flowers; value addition in flower crops including dry flowers, essential oils, pigments etc. Flower forcing and year round flowering through physiological interventions, chemical regulation and environmental manipulation.

Practicals
Post harvest technology of loose and cut flowers; Dry flower making; Extracting of essential oils, pigments; Flower forcing; year round flowering through physiological interventions, chemical regulation and environmental manipulation.

Suggested Readings

FLA 621 ADVANCED BREEDING OF ORNAMENTAL CROPS (3L+1P) III

Objective
To teach students about the recent research trends in the field of breeding of flower crops with special emphasis on crops grown in India.

Theory
UNIT I
Role of biotechnology in improvement of flower crops; in vitro mutagenesis, embryo culture, somaclonal variation, transformation, somatic hybridization, anther and ovule culture including somatic embryogenesis.

UNIT II
Marker assisted selection; molecular characterization; construction of c-DNA library; breeding for biotic and abiotic stresses using biotechnological means; IPR and DUS testing for floricultural crops.

UNIT III
Biosynthetic pathways of pigment, fragrances and senescence flower form; chemistry and importance of secondary metabolites in rose, jasmine, marigold, tuberose, carnation, orchids, lilium and bougainvillea.
UNIT IV
Biinformatics-principles and applications; advances in important ornamental crops through biotechnology; bio-safety of transgenics.

Practicals

*In vitro* mutagenesis, embryo culture, somaclonal variation and somatic hybridization, anther and ovule culture and somatic embryogenesis; Genetic transformation, marker assisted selection; IPR and DUS testing for floricultural crops; Construction of c-DNA library; Bioinformatics.

Suggested Readings


FLA 622/PHT 622 VALUE ADDITION IN ORNAMENTAL CROPS (1L+1P) III

Objective

To acquaint the student about the scope and ways of value addition in ornamental crops.

Theory

UNIT I
Importance, opportunities and prospects of value addition in floriculture; national and global scenario. production and exports, supply chain management.

UNIT II
Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aromatherapy; pigment and natural dyes extraction technology, sources, uses and trade.

UNIT III
Pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and uses, preparation of products like *gulkand*, rose water, *gulroghan*, *attar*, *pankhuri*.

UNIT IV
Floral craft including bouquets, garlands, flower arrangements *etc.* tinting (artificial colouring) of flower crops; Women empowerment through value added products making.
Practicals

Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils; Pigment and natural dyes extraction technology; pharmaceutical and neutraceutical compounds from flower crops; preparation of products like gulkand, rose water, gulroghan, attar, pankhuri; Petal embedded handmade paper making, floral craft including bouquets, garlands, flower arrangements etc.; tinting (artificial colouring) of flower crops.

Suggested Readings

# Microbiology

## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB 501</td>
<td>MICROBIOLOGY-I</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MB 502</td>
<td>SOIL MICROBIOLOGY-I</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>MB 503</td>
<td>MORPHOLOGY AND ECOLOGY OF PHOTOSYNTHETIC MICRO-ORGANISMS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 504</td>
<td>TECHNIQUES IN MICROBIOLOGY</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MB 608</td>
<td>IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB 505</td>
<td>MICROBIAL ECOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>ES 505</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MB 507</td>
<td>FOOD MICROBIOLOGY</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>MB 512</td>
<td>NANOTECHNOLOGY IN CROP PROTECTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 512</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL. PATH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>521</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENT 512</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEMA 513</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MB 601</td>
<td>PHYSIOLOGY OF ALGAE</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 603</td>
<td>BACTERIAL PHYSIOLOGY-I</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 607</td>
<td>MICROBIAL GENETICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 609</td>
<td>RECENT ADVANCES IN MICROBIAL BIO-TECHNOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB 506</td>
<td>MICROBIOLOGY OF MILK AND WATER</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>MB 508</td>
<td>SOIL MICROBIOLOGY II</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MB 602</td>
<td>INDUSTRIAL MICROBIOLOGY</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Name</td>
<td>M.S.</td>
<td>Ph.D.</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>MB 604</td>
<td>BACTERIAL PHYSIOLOGY- II</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>MB 605</td>
<td>ALGAE IN AGRICULTURE AND INDUSTRY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MB 606</td>
<td>APPLICATIONS OF MICROORGANISMS IN AGRICULTURE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** MB 501, MB 504, MB 606, BIO 501

**Ph.D.:** MB 503, MB 602, MB 607
MICROBIOLOGY

Major Fields:
- Environmental and Evolutionary Microbiology
- Plant Microbe Interactions
- Industrial Microbiology

Minor Field:
- Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
- M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

MB 501 MICROBIOLOGY-I (4L+1P) I

Objective
To teach the basic concepts in development of microbiology science, diversity in structure and functions of microbial cells, classification of archaea, prokaryotes and eukaryotes and economic importance of microorganisms

Theory
UNIT I
Development and scope of microbiological science, Microbial world, History of microbiology and types of micro-organisms, Prokaryotic and eukaryotic cell, Classification and major characteristics of different microbial groups.

UNIT II
Bacterial growth and reproduction, Bacterial communication, Environmental and nutritional requirements for microbial growth, Pure cultures, Control of microorganisms: Principles, methods including radiation, Chemicals, Antibiotics etc.

UNIT III
Morphological characteristics, Internal structures and their functions in bacteria, archaea, algae, cyanophages, viroids, prions, fungi, actinomycetes, mycoplasma, rickettsias, chlamydia, viruses, bacteriophages.

UNIT IV
Economic importance of microbes, Role of microorganisms in environment, soils, mining, food, industry and pharmaceuticals, Recent development on microbial communities and role in nutrient cycling.

Practicals
Methods of isolation, purification and maintenance of microorganisms, Aseptic techniques: Sterilization and autoclaving, Selective and enrichment culturing, Use of antibiotics and chemicals, Morpho- physiological and biochemical characterization of bacteria, Isolation of selected groups of microorganisms such as nitrogen fixers and phosphate solubilizers.
Suggested Readings


MB 502 SOIL MICROBIOLOGY-I

(3L+2P) I

Objective

To teach the basic concepts related to soil environment (microbial cycling of elements, diversity in microbial functions, microbial interactions, plant growth promoting microorganisms: conventional and molecular methods of microbial identification and enumeration-role of microorganisms in productive systems and ecological health)

Theory

UNIT I
Soil microorganisms: Major groups, their diversity, abundance, characteristics.

UNIT II
Direct and indirect methods of studying soil microorganisms and their activities: Dilution plate count method, Burried slide technique, G+C estimate, MPN method, Staining procedures and identification aided by microscopy, Molecular methods of microbial diversity analysis: RISA, TGGE, DGGE, T-RFLP, BIOLOG, FAME analysis.

UNIT III
Carbon cycle, Decomposition of organic matter, Dynamics of micro-organisms during formation of soil organic matter, Humus and fulvic acid, Quantity and distribution of organic matter in soil.

UNIT IV
Biodegradation of starch, Cellulose, Hemicellulose, Pectin and lignin in soil, Nitrogen cycle: Ammonification, Nitrification, Denitrification, Non-symbiotic and symbiotic nitrogen fixation through bacteria and nitrogen assimilation, Soil health, Major microbial indicators and their significance.
Practicals
Quantification of total bacterial, fungal and actinomycetes counts from soils by pour & spread plate method under contrasting agronomic use, Assessment of soil microbial activity by soil respiration, dehydrogenase and FDA- hydrolysis analysis, Evaluation of cellulase activity of soil microflora in soils with and without amendment with crop residues, Evaluation of the amylolytic activity of soil microflora and its comparison with known (standard) microorganisms, Study of the decomposition rate of different agricultural residues in soil by carbon dioxide evolution method, Fractionation of soil organic matter content (Humus), Estimation of ammonia oxidizing bacteria and nitrite oxidizing bacteria from a soil sample using most probable number (MPN) technique, Isolation of free living nitrogen fixing bacteria from a soil sample.

Suggested Readings

MB 503 MORPHOLOGY AND ECOLOGY OF PHOTOSYNTHETIC MICROORGANISMS (3L+1P) I

Objective
To familiarize the students regarding the significance of photosynthetic bacteria, including cyanobacteria, their morphological features and ecology, concepts of photosynthesis-bacterial and algal photosynthesis, extremophiles and their tolerance mechanisms

Theory
UNIT I
Classification and taxonomy of photosynthetic organisms: Microalgae (cyanobacteria, green algae) and bacteria, Major characteristics of different groups, Photosynthetic eubacteria: Introduction, Characteristics of important genera of photosynthetic eubacteria.

UNIT II
Range of thallus organization and reproduction in microalgae with emphasis on blue-green algae (cyanobacteria) and green algae, Cyanobacteria / Cyanophyceae: Taxonomic approaches and evolutionary trends, Detailed account of different sub-groups.

UNIT III
Microalgal habitats: Physical and chemical characteristics, Ecology of aquatic (fresh and marine) photosynthetic microorganisms, Ecology of photosynthetic terrestrial microorganisms, Soil and rice fields, Cyanobacteria in geothermal habitats, Oil pollution and cyanobacteria, Phylogenetic approaches to study cyanobacterial distribution.
UNIT IV
Limnology, Eutrophication, Energy flow and nutrient cycling, Succession in water bodies, Lime stones, Extremophiles, Halotolerance, Osmotolerance in microalgae and photosynthetic bacteria, UV tolerance and adaptation in microalgae and photosynthetic bacteria.

Practicals
Collection of soil and water samples from IARI fields/stagnant cess pools and extreme environments and enrichment set up for isolation of cyanobacteria/photosynthetic bacteria, Winogradsky column set up for isolation of cyanobacteria/photosynthetic bacteria, Isolation, purification, identification and axenisation of isolates from the enrichment cultures, Microscopic and ecological observations on isolates from extreme environments and analyses of their adaptive mechanisms, Study of ecological habitats of algae, Preservation techniques for algae, Microscopic observations of non-heterocystous cyanobacteria and heterocystous cyanobacteria, Measurement of algal productivity from different ecological habitats, Studies on microalgae/cyanobacteria from polluted habitats, Field trip for collection of samples.

Suggested Readings
Objective

To familiarize the students with basic safety rules in the microbiological laboratory and to introduce the concepts involved in different methods and techniques applied in microbiological sciences.

Theory

UNIT I
An introduction to laboratory instruments, Safety rules in laboratory, Handling of different glassware, Handling of autoclave, Hot air oven, BOD incubator, Laminar flow, Colony counter, pH meter, Biological filters, Spectrophotometer, Microscopy: Light, Compound, Darkfield, Phase Contrast, Fluorescent, EM, TEM, SEM.

UNIT II
Culture: Types of culture and culture media, Inoculation techniques, Isolation of pure culture, Proof of purity of cultures, Maintenance and preservation of pure cultures, Culture collection: World scenario and Indian scenario, Techniques for microscopic examination of living microorganisms (Bacteria/Cyanobacteria): Wet mount, Hanging drop technique, Stains and staining techniques, Enumeration of bacteria, Cyanobacteria by plate count, Turbidometric method and MPN method.

UNIT III

UNIT IV
Molecular- biology techniques, Isolation of Genomic DNA and PCR amplification in bacteria and cyanobacteria, RAPD and RFLP, Isolation of plasmids, Protein profiling by SDS-PAGE, Transposon and chemical mutagenesis, Biochemical characterization in cyanobacteria.

Practicals

Introduction to safety measures in laboratory and maintenance of aseptic conditions, Microscopy and instrumentation, Media preparation and sterilization, Isolation and purification techniques, Enumeration and quantification techniques, Staining of micro-organisms: Simple staining, Negative staining, Gram staining, Capsule staining, Spore staining, Motility test, Biochemical characterization of micro-organisms, Identification of unknown bacteria, Carbohydrate fermentation, Triple sugar-iron agar test, IMViC test, Hydrogen sulfide test, Urease test, Litmus milk reaction, Nitrate reduction test, Catalase and Oxidase test, Isolation and purification of cyanobacteria, Identification of cyanobacteria, RAPD analysis in cyanobacteria, Enumeration techniques in cyanobacteria, Estimation of pigments and nitrogen fixation, Antibiotic resistance, Isolation of Genomic DNA and PCR amplification, Restriction digestion of DNA, RFLP analysis, Isolation of plasmids, Protein profiling, Transposon and chemical mutagenesis, Bioinformatic tools.

Suggested Readings

Bergey’s Manual of Systematic Bacteriology: All volumes.

MB 505/ ES 505 MICROBIAL ECOLOGY  (3L+1P) II

Objective
To provide the modern concepts of microbial ecology of soil and aquatic environments, microbial interactions and biogeochemical cycling

Theory
UNIT I
UNIT II
Dispersal, Colonization, Succession and the climax, Interspecific competition, Commensalism, Homeostasis, Parasitism, Predation, Proto-cooperation, Symbiosis, Ammensalism
UNIT III
Microbiology of water bodies, Effect of micro-organisms on animals and plants, Environmental influences on microorganisms, Effect of temperature, aeration, moisture, osmotic pressure, pH, Energy cycle.
UNIT IV
Transformation of phosphorus, sulphur, iron, manganese, magnesium, copper, mercury and arsenic, Mycorrhizal links with plants and their functioning.
UNIT V
Ecology of microbial corrosion, Microbial plasticity, Relevance to microbial ecology, Modeling, Microbial contribution to climatic change, Molecular approaches for measuring the microbial diversity.

Practicals
Sampling and enumeration techniques for micro-organisms, Effect of environmental variables on nitrification, ammonification and microbial growth, Effect of temperature on bacterial interactions, Isolation of nucleic acids from environmental samples, Nitrogen transformations, Microbial corrosion and detection of microbial activities, Symbioses amongst micro-organisms, Synergism and antagonism amongst micro-organisms, Estimation of iron oxidizing and reducing bacteria from soil samples, Isolation of thermophilic, mesophilic and psychrophilic microorganisms from
soil samples, Isolation of antibiotic synthesizing microorganisms, Enumeration of sulphur oxidizing and reducing bacteria from soil, Enrichment and isolation of phosphate solubilizing microorganisms from phosphorus deficient and 'P' sufficient soils, Mineralization of phytins by bacteria and fungi, Estimation of phosphorus solubilizing activity of a bacterium and a fungus using different inert phosphorus sources.

Suggested Readings


MB 506 MICROBIOLOGY OF MILK AND WATER (2L+1P) III

Objective

To familiarize the students with the concepts of microbial quality of milk and water, microbial risk assessment and modern concepts of waste water treatment

Theory

UNIT I

UNIT II
Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne disease.

UNIT III
Sewage treatment, Biological oxygen demand, Effluent management, Sewage systems.

Practicals

Instructions on media preparation, Phosphatase test in pasteurized milk, Methylene blue reduction test in milk, Total microbial count in milk (raw, pasteurized and UHT treated milk) and water, Total microbial count in ice cream and curd, Enumeration of lactobacilli in curd and milk, Detection of E. coli in drinking water by β-galactosidase test, Conventional method for enumeration and detection of E. coli in water from different sources (rain, surface water, underground water, water from well) and from sewage, Microbiological examination of sewage effluents.
Suggested Readings


MB 507 FOOD MICROBIOLOGY (3L+2P) II

Objective

To provide the basic concepts of microbial quality of food, microbial contamination and food-borne diseases

Theory

UNIT I
Food and their composition, Food as substrate for micro-organisms, Important bacteria in food microbiology, Microflora of meat, fish, eggs, fruits, vegetables, juices, flour, canned foods.

UNIT II
Food spoilages, Fermented foods (Sauerkraut, Pickle, Soy Sauce, Tempeh, Miso), Bacterial toxins in food, Food-borne diseases and intoxications, Action of microbes on different components of food, Methods of food preservation.

UNIT III
Microarray in food microbiology, Mycotoxin, Microbiological quality assurance, Specification and standards, Hazard analysis and critical control point (HACCP) concept, Methods for examination of micro-organisms in food.

Practicals

Preparation of various media, Preparation of Sauerkraut from cabbage, Determination of acidity, pH, Sensory evaluation of product, Microscopy of fermented fluid, Isolation and enumeration of lactic acid bacteria from sauerkraut, Isolation and enumeration of acid producers from pickle/sauerkraut, Enumeration of halophiles from pickle, Enumeration of microflora (bacteria, fungi and yeast) in flour of wheat and gram, Detection of coliforms in flour and grain (Presumptive, completed and confirmed test), Enumeration of microflora of bread and pastry, Enumeration of thermophiles, psychrophiles and osmophiles in food sample, Pectinolytic bacteria in fruit sample, Enumeration of lipolytic and proteolytic bacteria in given food sample, Microbial observations of fruit surface flora and spoilage, Enumeration of microflora in juices, Detection of enterotoxigenic Staphylococcus aureus strains in food sample, Microbial examination of egg and canned food.
**Suggested Readings**

Banwart George G. 1989. Basic Food Microbiology AVI.

**MB 508 SOIL MICROBIOLOGY-II**  
(3L+1P) III

**Objective**

To teach the basic concepts of plant-microbe interactions.

**Theory**

UNIT I
Plant-microbe interactions, Endophytic and pathogenic interactions, Rhizosphere, Rhizoplane, Spermosphere and phyllosphere, Root exudates, Quorum-sensing in bacteria, Flow of signals in response to carbon substrates.

UNIT II
Legume –Rhizobium symbiosis, Frankia- Actinorhizal symbioses, Classification of nodulating bacteria, Formation of nodules in leguminous plants, Types of nodules, Genetics of nodulation and nitrogen fixation, *sym* genes, *nod* genes, *nif* genes and *fix* genes, NOD factors, Hydrogenases

UNIT III
Type three secretion systems, Plant growth promoting rhizobacteria (PGPR) and their direct and indirect mechanism of action, Biocontrol agents and their action mechanism.

UNIT IV
Mycorrhizae, Types of mycorrhizae and their interactions with plants, Biochemical/ molecular aspects.

**Practicals**

R:S ratio in soil & endorhizosphere, Isolation of rhizobia from root nodules, Collection and TLC analysis of root exudates for amino acids, Isolation and enumeration of phyllosphere microflora, Estimation of nitrogenase activity of rhizobia, Isolation of PGPR from soil (N₂ fixers, P-solubilizers, siderophore producers, HCN producers, antibiotics), MPN estimation of rhizobia from soil, % colonization of VAM in roots, Intrinsic antibiotic resistance pattern in rhizobia, Estimation of IAA production in microbes, PCR for microbial antibiotics

**Suggested Readings**


MB 512/ AC 512 NANOTECHNOLOGY IN CROP PROTECTION (2L+1P) II

Objective
To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology

Thoery

UNIT I

UNIT II
Effect of bioactive nano-materials on insect pests and beneficial insects.

UNIT III
Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi, bacteria and viruses with special reference to copper, sulfur etc. Interaction of bioactive nano-materials on plant pathogens including fungi, bacteria, virus etc.

UNIT IV
Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus. Identification and quantification of biotoxins effective in nano-doses.

UNIT V

UNIT VI

Practicals
Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests
Objective
To familiarize the students with the concepts of physiology of algae

Theory

UNIT I
Growth and synchrony, Factors regulating algal growth, Adaptive responses of cyanobacteria to abiotic stress, Circadian rhythms and their relevance in cyanobacteria, Toxin production by algae including cyanobacteria, Types/modes of their action and biosynthesis, Role of environmental/nutritional factors.

UNIT II
Respiration: Energetics, Glycolysis, Krebs cycle, Oxidative phosphorylation, Alternative pathways, Cyanobacterial respiration.

UNIT III
Photosynthesis: Light reactions, Photosystem I and II, Dark reactions, Biochemistry of carbon dioxide metabolism, Photorespiration, Chloroplast origin and evolution, Phycobilisome and phycobiliprotein structures, Carotenoids in cyanobacteria, Biosynthesis of cyanobacterial hemes, Chlorophylls and phycobilins, Chromatic adaptation.

UNIT IV
Cyanobacterial nitrogen fixation-an overview, Nitrogenase enzyme, its nature and properties, Heterocyst, its structure and function, Nitrogen fixation in non-heterocystous cyanobacteria, Assimilation of combined nitrogen, Amino acid metabolism, Environmental and nutritional factors influencing nitrogen fixation, Global regulatory mechanisms in nitrogen metabolism, Physiology of symbiotic associations of cyanobacteria, Hydrogen evolution, Microalgae as biofuel.

Practicals
Media preparation for microalgae and isolation, Biomass estimation, Pigment profile, Cellular constituents (Total soluble proteins and carbohydrates), Measurement of nitrogen fixation as acetylene reduction activity, Hydrogen production using Gas Chromatograph, Nitrate reductase and glutamine synthetase activity in cyanobacteria, Estimation of extracellular ammonia, Cell count measurement, Soil chlorophyll estimation through spectrophotometric analysis, Soil DNA extraction and analyses from inoculated soil microcosm/pot experiment, Inhibition assays for cyanobacterial toxins, Soil organic matter and nitrogen analysis

Suggested Readings
MB 602 INDUSTRIAL MICROBIOLOGY

Objective

To familiarize the students with the developments of industrial microbiology

Theory

UNIT I
Theory and principles of industrial fermentation, Fermentor design, Different types of fermentors used in industrial fermentation, Microbial culture selection, Strain development, The formation and extraction of fermentation product, C&N sources used for industrial fermentation.

UNIT II

UNIT III
Single cell protein production for use as food and feed, Organic acid, Vinegar production, Vitamin and related compounds (Carotenoid, Vitamin B₁₂, Riboflavin), Antibiotic production, Biotransformation, Bioplastics, Bioprocess cost evaluation.

Practicals

Amylase production by using Bacillus amyloliquefaciens and its assay, Protease production by using Bacillus isolate and its quantification, Wine production from grape juice and estimation of alcohol, Citric acid production from Aspergillus by surface culture method, Production of cellulase by SSF of rice straw through lignocellulolytic fungi: (a) Estimation of filter paper lyase activity (b) Estimation of carboxy methyl cellulase activity, Production and estimation of xylanase from rice straw through submerged fermentation, Functioning of bioreactor, Carotenoid production from yeast/cyanobacteria, Immobilization of microbial cells for enzyme production, Protease production from Bacillus subtilis by using soybean meal, Antibiotic production from a biocontrol agent.

Suggested Readings


MB 603 BACTERIAL PHYSIOLOGY-I  
(3L+1P) II

Objective
To teach the basic concepts of physiological processes in microorganisms-microbial growth requirement and pathways of energy generation

Theory

UNIT I
Introduction to Microbial Physiology, Microbial nutrition and Nutritional types, Metabolic diversity, Photoautotrophs, Photoheterotrophs, Chemoautotrophs, Chemoheterotrophs, Photolithoautotrophs, Chemolithoautotrophs, Photoorganoheterotrophs, Chemoorganoheterotrophs, Auxotrophs.

UNIT II

UNIT III
Energy yielding pathways in microorganisms, Aerobic respiration: Glycolysis, Substrate level phosphorylation, Electron transport chain and oxidative phosphorylation, Alternatives to glycolysis: Hexose mono-phosphate pathway (HMP), Entner – Doudoroff Pathway (ED pathway),
Tricarboxylic acid cycle (TCA cycle) and other mechanisms, Chemiosmotic mechanism of ATP generation, Obligate anaerobes, Aerotolerant anaerobes, Integration of metabolism, Catabolism of other kind of organic substrates, Anaerobic respiration, Dissimilatory and assimilatory reductions, Types of fermentation, Fermentation balances.

UNIT IV
Microbial photosynthesis, Diversity, Chlorophylls and bacterio-chlorophylls, Accessory pigments, Light-dependent reactions and light independent reactions, Carbon dioxide assimilation in prokaryotes, Bacteriorhodopsin and Halorhodopsin and their significance, Transport of nutrients into cell.

Practicals
Designing of media to support the growth of different nutritional groups of bacteria, Demonstration of specialized media for selection and differentiation of microorganisms, Diverse growth temperature and pH requirements of microorganisms, Cultivation of anaerobic microorganisms, Atmospheric oxygen requirements of microorganisms, Determination of viable and total number of cells, Preservation techniques, Diauxic growth.

Suggested Readings

MB 604 BACTERIAL PHYSIOLOGY-II (2L+1P) III

Objective
To teach the basic concepts of anabolic and catabolic reactions related to bacterial metabolism

Theory
UNIT I

UNIT II
Catabolic and anabolic reactions, Collision theory, Cell wall and its biosynthesis- Types, Peptidoglycan, Gram positive cell wall, Gram negative cell wall, Archaeal cell wall, Polysachharide biosynthesis, Lipid biosynthesis, Biosynthesis of nitrogenous compounds- Amino acid and proteins, Purine and pyrimidines, Nucleic acids.

UNIT III
Protein break down by microorganisms, Deamination, Transamination, Assimilation of complex carbohydrates- Cellulose, Hemicellulose, Starch, Pectin and Chitin, Nitrogen fixing micro-
organisms, Requirements of nitrogen fixation, Mechanism of nitrogen fixation, Nitrogenase enzyme, Biochemistry of hydrogenase enzyme and hydrogen assimilation.

UNIT IV
Secondary metabolism, Primary and secondary metabolites and their significance, Physiological response of microorganisms to salinity, Alkalinity, UV, Drought and heavy metals, Adaptive mechanisms employed to cope with stress, Pesticides: Types, Resistance to microbes and metabolism, Residual effects of pesticides.

Practicals
Study on enzyme kinetics, Tolerance and degradation of pesticides by microorganisms, Effect of salinity and alkalinity on microorganisms, Nitrogenase activity and nodulation pattern, Estimation of total soluble proteins, Protein profile through Poly-acrylamide Gel Electrophoresis, Ammonia liberation from nitrogenous compound and enzymatic conversion of ammonia to nitrates by microorganisms, Reduction of nitrates to nitrogen gas, Reducing sugars estimation, Separation of amino acids by TLC, Estimation of nitrate reductase and glutamine synthetase activity in prokaryotes.

Suggested Readings

MB 605 ALGAE IN AGRICULTURE AND INDUSTRY (3L+0P) III

Objective
To familiarize the students with the economic use of algae in agriculture and industry

Theory
UNIT I
Role of algae in fertility and productivity of soil, Production of growth promoting substances, P-solubilisation, Blue green algal biofertilizer: Production and quality control, BGA in reclamation of saline/sodic soils, Azolla: Production, utilization and economic importance.

UNIT II
Algae in aquatic environment, Sewage treatment, Bioindicators of pollution, Metal detoxification, Controlled photosynthesis and its application, Use of algae as food, feed, manure and energy, Therapeutic uses of algae, Phycocolloids: Production and use, Carragheenan, Agar-agar, Alginic acid and alginates.
UNIT III

Suggested Reading
Seaweed Research and Utilization in India, CMFRI Bulletin 41.

MB 606 APPLICATIONS OF MICROORGANISMS IN AGRICULTURE (1L+2P) III

Objective
To familiarize the students with the basic concepts and applied aspects regarding the use of microorganisms in agriculture

Theory
UNIT I
Principles of crop inoculation with microbial agents, Overview of microbial inoculants and their production, Carriers for inoculants: Types and their characteristics, Strain selection of bacteria and cyanobacteria for biofertilizer production and quality control, Mass multiplication: Methodology and constraints/benefits, Bulk production (small scale and commercial scale), Setting up of pilot scale inoculant production plants.

UNIT II

UNIT III
Biogas production technology, Methanogens, Methanotrophs and their applications. Silage production, Techniques of composting and vermi-compost and its evaluation.

Practicals
Isolation, purification and characterization of bacteria / cyanobacteria from soil, Isolation and identification of Phosphate Solubilizing Micro-organisms (PSMs), Qualitative and quantitative evaluation of phosphate solubilization, Hyphal/spore staining for AM fungi, Calculation of root infection, Mass production protocols for PSMs and AM fungi, Pretreatment, sterilization and
evaluation of carriers for inoculants; Preparation of bacterial biofertilizers, Testing of quality of prepared bacterial biofertilizers, Production technology of BGA biofertilizer, Microcosm studies to evaluate establishment of cyanobacterial strains, Testing of quality of prepared BGA biofertilizers; IAA production and seed germination test using the bacterial/cyanobacterial strains used as inoculants, Nitrogen fixation studies with inoculant organisms/ inoculants, Composting and silage production technology; Biogas production technology.

**Suggested Readings**


**MB 607 MICROBIAL GENETICS** *(3L+1P) II*

**Objective**

To teach the concepts related to the genetics of micro-organisms.

**Theory**

UNIT I

Principles of microbial genetics, Basic procedures and terminology, Cis-trans complementation, Genome organization in bacteria and viruses, Gene transfer, Transformation, Conjugation, Transduction and methods of gene mapping, Transposons and insertion sequences, Extra-chromosomal genetic elements, Plasmids and their inheritance, Genetic analysis of bacteriophages and cyanophages.

UNIT II

Gene, Genetic code, Operon concept and its regulation, Gene regulation and expression, Genetic engineering, Restriction enzymes, Vectors, Cloning genomic literary.

UNIT III

Recombinant DNA and mechanisms of recombination, Applications of rDNA, Safety issues and ethics in using rDNA, DNA replication, DNA Polymerases, Type of replication, Mutation and repair mechanisms, Protein synthesis and central dogma, Nucleic acid synthesis and sequencing.

**Practicals**

Isolation of genomic DNA and plasmid DNA, Curing of plasmid, Inducing mutation using chemical/UV rays (mutagenesis and isolation of mutants), Isolation of bacteriophage, One step growth experiment with λ phage, Preparation of genomic library and competent cells, PCR amplification and cloning of the PCR product, Conjugation and transformation experiments.
Suggested Readings


MB 608 IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE (3L+1P) I

Objective

To teach the basic concepts in immunology and its application in microbiological science

Theory

UNIT I
Historical perspective, Innate and acquired immunity, Specific and nonspecific immunity,

UNIT II
Cells and organs of immune system, Cellular and humoral immune response, Antigens, Antibodies, Immunoglobulin structure and function.

UNIT III
Antigen-antibody reactions, Complement system, Hybridoma and monoclonal antibodies, Organization and expression of immunoglobulin genes, Immune dysfunction, Auto-immunity, Immunodeficiency and hyper sensitivity, Vaccines, Serology in agriculture, Immunodiagnostic tests, Transplantation immunology.

Practicals

Ag-Ab reactions, Agglutination (blood grouping), Precipitation, Immunodiffusion, Western blotting, ELISA

Suggested Readings

MB 609 RECENT ADVANCES IN MICROBIAL BIOTECHNOLOGY (3L+1P) II

Objective
To expose the students to the advances in microbiology and to improve the understanding and expertise.

Theory
UNIT I
Role of microbes in bioindustries, Value addition, Production of recombinant vaccines and hormones, Biosensors, Bioflavours, Biowarfare, Bioremediation.

UNIT II
Microbial ore leaching (biomining), Microbial enzymes in clinical diagnostics, Metabolic pathway engineering, Yeast technology, Genetics and strain improvement for brewing, baking and distilleries.

UNIT III
Bioinformatics, Bioprospecting, Microbial diversity and global environment issue, IPR and biosafety, Genomics and Proteomics, Metagenomics for improvement of industrial fermentation.

Practicals
Isolation of metagenome from environmental sources, Development of environmental libraries, DGEE, 16S rDNA community analysis, Functional and sequence based analysis of clones, Bioremediation of recalcitrant compounds.

Suggested Reading
Advances in Applied Microbiology- Latest issues.
Advances in Biochemical Engineering and Biotechnology- Latest issues.
Nature Reviews in Microbiology.
Advances in Biotechnology.
Annual Review in Microbiology.
## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBB 501</td>
<td>PRINCIPLES OF BIOTECHNOLOGY</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MBB 502</td>
<td>FUNDAMENTALS OF MOLECULAR BIOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 503</td>
<td>MOLECULAR CELL BIOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 505</td>
<td>MOLECULAR GENETICS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 507</td>
<td>IMMUNOLOGY AND MOLECULAR DIAGNOSTICS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 510</td>
<td>BIOTECHNOLOGY LAB-1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MBB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBB 504</td>
<td>PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 509</td>
<td>BIOINFORMATICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MBB 511</td>
<td>BIOTECHNOLOGY-II</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MBB 601</td>
<td>MOLECULAR BREEDING</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 602</td>
<td>GENOMICS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>MBB 701</td>
<td>ADVANCES IN PLANT MOLECULAR BIOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBB 506</td>
<td>BIOSAFETY, IPR AND BIOETHICS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>MBB 508</td>
<td>INDUSTRIAL BIOTECHNOLOGY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>MBB 512</td>
<td>BIOTECHNOLOGY LAB-III</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MBB 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>MBB 702</td>
<td>ADVANCES IN GENETIC ENGINEERING</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 703</td>
<td>ADVANCES IN MOLECULAR BREEDING AND GENOMICS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MBB 704</td>
<td>ADVANCES IN STRESS GENOMICS</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

- **M.Sc.**: MBB 501, MBB 502, MBB 504, MBB 505, MBB 510, MBB 511, MBB 512, BIO 501, GP 500
- **Ph.D.**: MBB 601, MBB 602
MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Major Field : MBB for M.Sc. and Ph.D.
Minor Field : Ph.D. students shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own. M.Sc. students shall take one minor (9 credits of course work) from any of the other fields outside his/her own discipline.

DESCRIPTION OF COURSES

MBB 501 PRINCIPLES OF BIOTECHNOLOGY (3L+0P) I

Objective
To provide insight into basics and application of general biotechnology

Theory
UNIT I
The structure of DNA; Function of genes and genomes; Restriction enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; PCR and its applications;
UNIT II
Molecular markers and their applications; DNA sequencing;
UNIT III
Applications of gene cloning in basic and applied research; Genomics, transcriptomics and proteomics;
UNIT IV
Genetic engineering and transgenics, General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics;
UNIT V
Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Readings
Molecular biology (2005) by David P. Clark.
Molecular biology and Biotechnology (2009) by John M. Walker, Ralph Rapley

MBB 502 FUNDAMENTALS OF MOLECULAR BIOLOGY (3L+0P) I

Objective
To provide insight into fundamentals of molecular biology and study of molecular cell processes
Theory

UNIT I
Historical development of molecular biology; Nucleic acids as genetic material; chemistry and structure of DNA and RNA,

UNIT II
Genome organization in prokaryotes and eukaryotes; Chromatin structure and function,

UNIT III
DNA replication; DNA polymerases, topoisomerases, DNA ligase; Reverse transcriptase,

UNIT IV
Transcription process; RNA processing; RNA editing; Ribosomes; Structure and function; Organisation of ribosomal proteins and RNA genes,

UNIT V
Genetic code; Aminoacyl tRNA synthases; Translation and post-translational modifications, Operon concept; Attenuation of \textit{trp} operon

Suggested Readings

Molecular genetics by (1987) Stent and Calendar
Microbial Genetics (1994) by Stanley R. Maloy, David Freifelder, John E. Cronan
Genes (2008) by B Lewine
Molecular biology of the cell (2008) by Bruce Alberts
Molecular Biology of the Cell (2002) by Julian Lewis

MBB 503 MOLECULAR CELL BIOLOGY

Objective
To provide insight into fundamentals of cell structure, organization and function

Theory

UNIT I
General structure and constituent of cells; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, cell surface related function.

UNIT II
Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles

UNIT III
Organellar genomes and their manipulation; Ribosome in relation to cell growth and cell division; Cyto-skeletal elements; Water, protein and ion transport;

UNIT IV
Trafficking of biomolecules, Cell division and regulation of cell cycle; Signal transduction mechanisms.

Suggested Readings

Molecular Cell Biology (2007) Bruce Alberts
Plant Physiology (2008) by Taiz and Zieger
MBB 504 PLANT TISSUE CULTURE & GENETIC ENGINEERING (3L+0P) II

Objective
To provide insight into principles of plant cell culture and genetic transformation

Theory
UNIT I
History of plant cell / tissue culture; Culture media; Various types of culture; Callus, suspension, nurse, root, meristem, \(\text{in vitro}\) differentiation, organogenesis, somatic embryogenesis; Molecular basis of plant organ differentiation;

UNIT II
Plant growth regulators; Mode of action, effects on \(\text{in vitro}\) culture and regeneration; In vitro storage organ formation;

UNIT III
Micropropagation; Anther / microspore culture; Somaclonal variation; In vitro mutagenesis, protoplast culture; Somatic cell genetics and somatic hybridization; Embryo culture/wide hybridization; \(\text{In vitro}\) fertilization; Unit V: \(\text{In vitro}\) germplasm conservation; Cryopreservation; Production of secondary metabolites through \(\text{in vitro}\) culture;

UNIT IV
Plant genetic engineering: Definition and scope, methods of plant transformation, vectors for plant transformation,

UNIT V
Genetic and molecular analyses of transgenics, bioafety issues, testing of transgenics, regulatory procedures for commercial approval.

Suggested Readings
Plant Tissue Culture: Theory and Practice (1996) by Bhojwani and Razdan
Plant Tissue Culture, Development, and Biotechnology (2010) by Robert N. Trigiano and Dennis J. Gray

MBB 505 MOLECULAR GENETICS (3L+0P) I

Objective
To provide insight into molecular genetics of prokaryotes and eukaryotes organisms

Theory
UNIT I
Mendelian principles of inheritance, molecular genetic systems, genetic variation, mutation, physical, chemical and insertional mutagenesis, site-directed mutagenesis, recombination and repair,

UNIT II
Gene mapping and tagging, tag based gene isolation, fine structure analysis of genetic loci and complementation test, deletion mapping,
UNIT III
Organization of genes in prokaryotes and eukaryotes, gene and genome evolution, identification of cis-regulatory elements, transacting factors and regulation of gene expression at different levels.

UNIT IV
Deciphering of genetic code, gene-protein colinearity, gene-enzyme relationship, molecular gene concept. Plasmids and their inheritance

UNIT V
Introduction of genetic markers, classification and comparison of markers, basis of DNA polymorphism, principles & applications of genome mapping and DNA fingerprinting, genome analysis, classical and modern methods, principles of structural and functional genomic approaches.

Suggested Readings
Molecular Biology of the Cell (2008) by Alberts and Watson
Recombinant DNA (2006) by J Watson
Molecular Cell Biology (1999) by Lodish and Baltimore
Molecular Biotechnology (2009) by Glick & Pasternack

MBB 506 BIOSAFETY, IPR AND BIOETHICS (2L+0P) III

Objective
To provide insight into the biosafety aspects of GM crops and IPR related issues

Theory
UNIT I
Biosafety and Risk assessment issues; Health aspects; toxicology, allergenicity; Ecological aspects;
UNIT II
Regulations; National biosafety policy and law. The Cartagena Protocol on biosafety. The WTO and other international agreements; Cross border movement of germplasm; Risk management issues;
UNIT III
Monitoring strategies and methods for detecting transgenics; Risks, benefits and impacts of transgenics to human health, society and the environment; Bio-safety and bio-hazards; general principles for the laboratory and environmental bio-safety;
UNIT IV
Environment Impact Assessment; Gene flow in natural and artificial ecologies; Sources of gene escape; Ecological risks of genetically modified plants.
UNIT V
Implications of intellectual property rights rights on the commercialization of biotechnology products.

Suggested Readings
Theory of general ethics (2006) by Warwick Fox
MBB 507 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS

Objective
To provide insight into basic concepts of immunology, vaccine development, techniques for diagnostics and applications in agriculture and pharmaceuticals

Theory

UNIT I
History and scope of immunology; components of immune system: organs, tissues and cells,

UNIT II
Immunoglobulins chemistry, structure and functions; molecular organisation of immunoglobulins and classes of antibodies, antibody diversity; antigens, haptens, antigens- antibody interactions; immuno-regulation and tolerance; Allergies and hypersensitive response; immunodeficiency; vaccines;

UNIT III
Immunological techniques, Immunological application in plant science, monoclonal antibodies and their uses, molecular diagnostics.

UNIT IV
Introduction to the basic principles of molecular technology and techniques used in pathogen detection, Principles of ELISA and its applications in viral detection,

UNIT V
Basics and procedures of PCR, Real time PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Suggested Readings
Kuby Immunology (2006) by Thomas J. Kindt, Barbara A. Osborne, and Richard A. Golds

MBB 508 INDUSTRIAL BIOTECHNOLOGY

Objective
To provide insight into the industrial application of biotechnology and development of various products in mass scale for broad applications
Theory

UNIT I
Introduction, scope and historical developments. Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

UNIT II
Primary metabolism products, production of industrial ethanol as a case study, Secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics. Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries. Bio-transformations, Bio-augmentation with production of vitamin C as a case study.

UNIT III
Bioreactors, their design and types. Immobilized enzymes based bioreactors. Microencapsulation technologies for immobilization of microbial enzymes. Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein.

UNIT IV

UNIT V
Strategies for development of industrial microbial strains with scale up production capacities. Metabolic pathway engineering of microbes for production of novel product for industry.

Suggested Readings

Encyclopedia of industrial Biotechnology (2010) by M Flickinger
Manual of industrial Microbiology and Biotechnology (2010) by M.Demain
Industrial Biotechnology (2010) by Winsoetaert and Erick J Vandamme

MBB 509 BIOINFORMATICS (3L+1P) II

Objective
To provide information on basic principles of computational biology and statistical tools used for data analysis

Theory

UNIT I
Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.)

UNIT II
Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling
UNIT III
DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools,

UNIT IV
Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics.

Practicals
Different types of databases and database search and retrieval, DNA and protein sequence analysis, Similarity searching and multiple alignments, Gene annotation, Phylogenetic analysis, Sequence analysis, Protein structure prediction, Analysis of microarray data, Programming languages in bioinformatics

Suggested Readings
DNA and protein sequence analysis. A Practical approach (1997) by Bishop M.J., Rawlings C.J. (Eds.)
Bioinformatics Basics: Applications in Biological Science and Medicine (2005) By Hooman Rashidi, Lukas K. Buehler
Bioinformatics in the Post-Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine (2004) By Jeffrey Augen

MBB 510 BIOTECHNOLOGY LAB-I (0L+3P) I

Objective
To provide skills for routine and advanced experimentation techniques in plant molecular biology

Theory
UNIT I
Good lab practices, Growth of bacterial culture and preparation of growth curve

UNIT II
Biochemical techniques, Preparation of buffers and reagents, electrophoresis- agarose and PAGE (nucleic acids and proteins), Principle of centrifugation

UNIT III
Isolation of genomic and plasmid DNA from bacteria, Growth of lambda phage and isolation of phage DNA, Restriction digestion of plasmid and phage DNA

UNIT IV
Chromatographic techniques (TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography)

Suggested Readings

533
MBB 511 BIOTECHNOLOGY LAB-II

Objective
To provide hands on experience and skills in general molecular and biochemical laboratory techniques

Theory
UNIT I
Isolation of plant DNA, spectrophotometric and gel quantitation, restriction digestion, agarose gel electrophoresis, hybridization, autoradiograph development (conventional X-ray film and Phosphorimager) Dot blot analysis, Northern hybridization
UNIT II
Gene cloning and blue white selection.
UNIT III
PCR and optimization of factors affecting PCR, Synthesis and cloning of cDNA and RT-PCR analysis
UNIT IV
Western hybridization
UNIT V
Molecular markers (RAPD, SSR, AFLP etc) and their analysis

Suggested Readings
Methods in Biotechnology (2009) by John Walker
Protein Methods (1996) by Daniel M. Bollag, Michael D. Rozycki, Stuart J. Edelstein

MBB 512 BIOTECHNOLOGY LAB-III

Objective
To provide hands on experience in general laboratory techniques and high throughput data analysis

Theory
UNIT I
Real time PCR and interpretation of data
UNIT II
Case study of SSR markers (linkage map, QTL analysis etc), SNP identification and analysis
Unit III
Microarray studies and use of relevant software, Practical in the area of Proteomics (2D gels, mass spectrometry etc)
UNIT IV
RNAi (right from designing of construct to the phenotyping of the plant), Yeast 2-hybrid interaction
UNIT V
Immunology and molecular diagnostics: Ouchterlony double diffusion, Immunoprecipitation, Radial Immunodiffusion, Immunelectrophoresis, Rocket Immunelectrophoresis, Counter Current Immunelectrophoresis, ELISA, Latex Agglutination, Immunohistochemistry

Suggested Readings

MBB 601 MOLECULAR BREEDING
(Pre-requisite MBB 501)

(3L+0P) II

Objective
To provide insight into principles of plant breeding using molecular techniques

Theory
UNIT I
Principles of plant breeding; breeding methods for self and cross pollinated crops; heterosis breeding; limitations of conventional breeding; aspects of molecular breeding;

UNIT II
Development of sequence based molecular markers - SSRs and SNPs; advanced methods of genotyping;

UNIT III
Mapping genes for qualitative and quantitative traits; QTL mapping using structured populations; AB-QTL analysis; association mapping of QTL; fine mapping of genes/QTL; map based gene/QTL isolation and development of gene based markers;

UNIT IV
Methods of assessing genetic diversity & germplasm characterization, DNA fingerprinting and its application

UNIT V
Allele mining by TILLING and Eco-TILLING; use of markers in plant breeding; Marker assisted selection (MAS) in backcross and heterosis breeding; transgenic breeding; foreground and background selection; MAS for gene introgression and pyramiding; MAS for specific traits with examples.

Suggested Readings
Molecular biology and genomics (2007) by Cornel Mühlhardt
MBB 602 GENOMICS  
*(Pre-requisite MBB 501)*

**Objective**

To provide insight into the functional aspects of cell function by studying the genome as a whole with special emphasis on structural and functional genomics

**Theory**

UNIT I  
Structural genomics: large fragment genomic libraries, physical mapping of genomes, genome sequencing, sequence assembly and annotation, comparative genomics

UNIT II  
Functional genomics: DNA chips and their use in transcriptome analysis, qPCR, SAGE, MPSS

UNIT III  
Proteome analysis: protein structure and function, proteins as enzymes, protein purification, 2D mass spectrometry, metabolomics and iominics, Application of genomics in crop improvement

**Suggested Readings**

Genomes (2006) by TA Brown  
Evolutionary Genomics and Systems Biology (2010) by Gustavo Caetano  

MBB 701 ADVANCES IN PLANT MOLECULAR BIOLOGY  
*(Pre-requisite MBB 501)*

**Objective**

To provide in depth knowledge of recent developments of plant molecular biology and applications

**Theory**

UNIT I  
Model Systems in Plant Biology (Arabidopsis, Rice etc.) Forward and Reverse Genetic Approaches.

UNIT II  
UNIT III
Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis.

UNIT IV
Plant Developmental Processes, ABC Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms.

UNIT V
Abiotic Stress Responses: Salt, Cold, Heat and Drought.

UNIT VI

Suggested Readings


Molecular biology and biotechnology (2009) by John M. Walker, Ralph Rapley

Molecular biology: genes to proteins (2007) by Burton E. Tropp, David Freifelder

Plant Molecular Biology by Buchanan et al.

MBB 702 ADVANCES IN GENETIC ENGINEERING (3L+0P) III

(Pre-requisite MBB 501)

Objective
To provide indepth knowledge of recent developments in recombinant DNA and genetic engineering

Theory

UNIT I
General Overview of Transgenic Plants; Case studies: Genetic Engineering of Herbicide Resistance, Transgenic Plants Resistant to Insects/pests,

UNIT II
Genetic engineering of abiotic stress tolerance, Engineering Food Crops for Quality, Genetically engineered pollination control, Induction of male sterility in plants.

UNIT III
Molecular Farming of Plants for Applications in Veterinary and Human Medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts;
UNIT IV
Recent developments in plant transformation strategies; Role of RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway Engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants; Field studies with transgenic crops;

UNIT V
Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Suggested Readings
Principles of Gene Cloning (1994) by Old and Primrose
Molecular biology of the cell (2007) by Bruce Alberts

MBB 703 ADVANCES IN MOLECULAR BREEDING AND GENOMICS (3L+0P) III
(Pre-requisite MBB 501)

Objective
To provide indepth knowledge of recent developments in molecular breeding and genomics

Theory
UNIT I
Mapping genes and QTLs, statistical concepts in QTL mapping, high-throughput genotyping using automated platforms, genetic and physical mapping of genomes, study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies

UNIT II
Marker assisted breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection, whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB

UNIT III
Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction

Unit IV
Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein-protein interactions

UNIT V
Study of the metabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.
Suggested Readings

Proteome Analysis - David W. Speicher
Molecular Biology and Genomics – C. Mulhardt
Genomes – T. A. Brown
Molecular Marker Systems in Plant Breeding and Crop Improvement - H. Lörz and G. Wenzel
Statistical Genomics - B. H. Liu
Molecular biology and biotechnology (2009) by John M. Walker, Ralph Rapley
Genomes (2006) by TA Brown

MBB 704 ADVANCES IN STRESS GENOMICS (3L+0P) III

(Pre-requisite MBB 602)

Objective

To provide advanced knowledge on genomics with reference to abiotic and biotic stress resistance in plants

Theory

UNIT I
Stress resistance/tolerance genes from model plants such as *Arabidopsis* and rice, as well as from extremophiles; stress tolerance mechanisms.

UNIT II
Genomics: transcriptomes, small RNAs and epigenomes; functional genomics: transfer of resistance genes to model plants and validation of gene function

Unit III
Bioinformatics approaches to determine gene function and networks in model plants under stress

Suggested Readings

Current Review articles and research papers
## 17 NematoLOGY

### TRIMESTER WISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 501</td>
<td>General Nematology</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NEMA 505</td>
<td>Nematological Techniques</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NEMA 503</td>
<td>Structural and Functional Organization of Nematodes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NEMA 507</td>
<td>Fundamentals of Nematode Physiology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 604</td>
<td>Advanced Molecular Nematology</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>NEMA 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 502</td>
<td>Fundamentals of Nematode Biosystematics</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NEMA 508</td>
<td>Nematode Ecology</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 506</td>
<td>Nematode Diseases of Crops</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>NEMA 511</td>
<td>Nematode Parasites of Invertebrates</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 512</td>
<td>Principles of Integrated Nematode Management</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 513/</td>
<td>NANO TECHNOLOGY IN CROP PROTECTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AC 512/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL PATH 521/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENT 512/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MB 512</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEMA 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 504</td>
<td>Taxonomy of Plant Parasitic Nematodes</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 509</td>
<td>Interactions of Plant Parasitic Nematodes with Other Micro-Organisms</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 601</td>
<td>Advances in Nematodes Systematics</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>NEMA 510</td>
<td>Nematode Management</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
NEMA 605/ PLANT HEALTH DIAGNOSTIC AND MANAGEMENT  2  2  
ENT 611
NEMA 691  SEMINAR  1  0

Core Courses

**M.Sc.:** NEMA 501, NEMA 502, NEMA 503, NEMA 505, NEMA 507, NEMA 508, NEMA 605/Ento 611

**Ph.D.:** NEMA 501, NEMA 502, NEMA 503, NEMA 505, NEMA 506, NEMA 507, NEMA 508, NEMA 512, NEMA 601, NEMA 604, NEMA 605/Ento 611
NEMATOLOGY

Major Field : Nematology

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

NEMA 501 GENERAL NEMATOLOGY  (2L+2P) I

Objective
To project the importance of nematodes in agriculture and impart basic knowledge on broad aspects of plant nematology.

Theory

UNIT I
Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

UNIT II
Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

UNIT III
Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

UNIT IV
Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

UNIT V
Principles and practices of nematode management; integrated nematode management.

UNIT VI
Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Practicals
Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.
Suggested Readings

Parvatha Reddy 2009. Laboratory and Field Manual for Plant Nematology Stadium press
Southey, J.F. 1986 Laboratory manual to work with plant and soil nematodes

NEM 502 FUNDAMENTALS OF NEMATODE BIOSYSTEMATICS (2L+2P) II

Objective

To sensitize the students on the theory and practices of classifying organisms with special emphasis on Phylum Nematoda.

Theory

UNIT I
Principles of Nematode systematics

UNIT II
Taxonomic position of nematodes and their relationships with allied groups; Classification and diagnosis of Nematodes upto ordinal rank (Secernentea); Classification and diagnoses of Nematodes upto ordinal rank (Adenophorea).

UNIT III
Nematode parasites of Vertebrates and Invertebrates.

UNIT IV
Classification of Plant Parasitic Nematodes; Classification of order Tylenchida and diagnoses of its Sub-orders, superfamilies, families and important genera; Orders Aphelenchida, Dorylaimida and Triplonchida and diagnosis of their important genera.

UNIT V
Molecular taxonomy
Practicals
Identification of soil nematodes belonging to diverse orders, viz., Tylenchida, Dorylaimida, Aphelenchida, Mononchida, Enoplida, Monhysterida, Arseolaimida, Cephalobida, Rhabditida, Diplogasterida; Processing of nematode specimens and preparation of permanent mount; Processing of animal parasitic nematodes for permanent mounts; Isolation of Thelastomatids from cockroaches and entomopathogenic nematodes from soil; Identification of important plant parasitic nematodes.

Suggested Readings

NEMA 503 STRUCTURAL AND FUNCTIONAL ORGANIZATION OF NEMATODES
(2L+2P) I

Objective
Familiarization with morphology, anatomy, histology, ultra-structure and functions of various organs and systems to enable the students to understand biology, physiology, evolutionary trends and classification of nematodes.

Theory
UNIT I
Introduction and general organization of nematode body; Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.
UNIT II
Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.
UNIT III
Reproductive system- Variations in female and male reproductive systems, types of reproduction, spermatogenesis and oogenesis
UNIT IV
Types and structure of excretory-secretory systems; nervous system and associated sense organs.
UNIT V
Embryogenesis, Cell lineage and postembryonic development; Process of hatching and moulting.

Practicals
Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.
Suggested Readings


NEMA 504 TAXONOMY OF PLANT PARASITIC NEMATODES (2L+1P) III

Objective

Development of skills in the identification of plant parasitic nematodes up to genera and species levels.

Theory

UNIT I
Classification of Phylum Nematoda- Orders of Class Adenophorea and Secernentea; Diagnosis of Order Tylenchida- Sub order Tylenchina, Hoplolaimina and Criconematina; Infraorders Tylenchata and Anguinata- their families and genera; Diagnosis of Aphelenchida, Dorylaimida and Triplonchida
UNIT II
Diagnosis of genera and families of Suborders Hoplolaimina and Criconematina.
UNIT III
Orders Aphelenchida, Dorylaimida and Triplonchida with emphasis on plant parasitic genera.

Practicals

Identification of common plant parasitic nematodes belonging to Orders Tylenchida, Dorylaimida and Aphelenchida up to generic level; and up to species level for major nematode pests (root-knot, cyst nematodes etc.) of crops.

Suggested Readings


NEMA 505 NEMATOLOGICAL TECHNIQUES (2L+2P) I

Objective

Understanding the principles, theoretical aspects and developing skills in nematological techniques.
Theory

UNIT I
Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.

UNIT II
Methods of survey, surveillance and sampling for nematodes; Extraction of active and sedentary nematodes from soil and plant tissues; Nematode population estimation.

UNIT III
Principles and techniques of killing, anaesthetizing, fixing, clearing and mounting (temporary or permanent) of nematodes; preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes; Sketching and measurement of nematodes using camera Lucida/drawing tube and image analyzer; Microphotography of nematodes.

UNIT IV

UNIT V
Spectrophotometry, electrophoresis, PCR, Chromatography, Centrifugation

Practicals
Baermann's funnel technique; Cobb's sieving and decanting technique; Oostenbrink elutriation technique; Cotton wool filter technique, Two flask Technique; Estimation of nematode population in soil; Picking tools and nematode handling; Root incubation method; Centrifugation floatation technique; Root knot nematode- Eggmass collection and their hatching, Extraction of root knot with NaOCl; Inoculation of nematodes in pots and maintenance of nematode culture; Observation on and extraction of different stages of root knot nematodes from roots; Lactophenol method for staining of nematodes in plants; Byrd's method for staining of nematodes in plants; Microscope Handling and taking photos through microscope; Cyst extraction with Fenwick can; Cyst extraction through Sieve; Cyst population estimation; Drawing and measuring nematodes; Temporary mount preparation; Permanent mount preparation special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections; collection of root exudates, preparation of exhibits of nematode diseased plant material, in vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques. Protein extraction and estimation, DNA extraction and estimation, PAGE, Agarose gel electrophoresis, DNA amplification using PCR.

Suggested Readings
Objective

To know the diseases and their symptoms caused by various plant parasitic nematodes in different field crops, horticultural and plantation crops.

Theory

Causal organism, distribution, host range, biology, nature of damage, symptoms, interaction with other organisms and management of major diseases caused by important nematodes in different crops:

UNIT I

**Cereal crops** (Rice, wheat, barley, oat, maize, sorghum): Ear-cockle and tundu disease of wheat, molya disease of wheat and barley; rice-root nematode, root-knot and cyst nematodes, ufra and white tip disease of rice; lesion and cyst nematodes of maize and sorghum.

UNIT II

**Pulses, oilseed, Cash, and fibre crops** (Pigeonpea, mungbean, cowpea, chickpea, groundnut, castor, soybean, sunflower, sesame, Sugarcane, sugarbeet, Cotton, jute): Pigeonpea cyst nematode, root-knot, reniform nematodes, lesion, lance nematodes, sugarbeet cyst and soybean cyst nematode problems.

UNIT III

**Vegetable crops** (Tomato, brinjal, chillies, carrot, onion, garlic, okra, cucurbits, potato): root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode; nematode problems in protected cultivation.

UNIT IV

**Horticultural and Ornamental crops** (Citrus, grapes, peach, strawberry, papaya, mushroom, rose, chrysanthemum, zinnia, gladiolus, tuberose, crossandra, jasmine): root-knot disease, reniform nematode; slow decline of citrus, Nematode problems in mushroom.

UNIT V

**Plantation crops & Medicinal and aromatic plants** (Banana, pepper, betelvine, coconut, arecanut, palm, cocoa, tea, coffee, rubber, condiments): burrowing nematode infestation in banana, spices and condiments, root-knot and lesion nematodes of coffee and tea, red ring disease of coconut, pine wilt disease.

Practicals

Study of symptoms of cyst, root-knot, lesion, earcockle, citrus, burrowing, reniform, stem and bulb, white tip, mushroom, leaf and bud, golden nematode damage in different crop plants. Visual field diagnosis of nematode problems through study tours.

Suggested Readings


Perry, R N and Moens, M 2006. Plant Nematology, CABI May 2006


**NEM 507 FUNDAMENTALS OF NEMATODE PHYSIOLOGY (2L+1P)**

**Objective**

To understand the basic mechanism of host finding, metabolic pathways, growth and development in nematodes.

**Theory**

UNIT I
Principles of physiology. History and importance of nematode physiology in management of plant parasitic nematodes.

UNIT II
Cell structure, Cell organelles, structure of cell organelles, Physiological functions of cell organelles; Chemical composition of nematodes. Pseudocoelomic fluid and its function.

UNIT III
Host finding mechanism, Feeding mechanisms and physiology, Hydrolytic enzymes of nematodes and their role in physiopathology of host.

UNIT IV
Metabolism of carbohydrates, proteins and fatty acids; Physiology of digestion; Physiology of excretion, osmoregulation, permeation dynamics, steroid and hormonal regulation in nematodes

UNIT V
Physiology of growth, development, reproduction, molting and hatching

**Practicals**

Solutions, buffers, Isolation of nucleic acids and proteins from plants and nematode juveniles, quantification of nucleic acids and proteins from plants and nematode juveniles, molecular weight estimation of nucleic acids and proteins on agarose and polyacrylamide gels, RFLP of plant and nematode DNA, RAPD of nematode and plant DNA using PCR technique
Suggested Readings


---

**NEMA 508 NEMATODE ECOLOGY**

**Objective**

To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

**Theory**

UNIT I
Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.

UNIT II
Role of nematodes in the food web; habitat and niche characteristics; community analysis, ecological indices, population estimation models

UNIT III
Effects of abiotic and biotic factors on nematodes; Environmental extremes and nematode behaviour, survival strategies in nematodes and nematodes as bioindicators.

UNIT IV
Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

UNIT V
Impact of climate change on nematode pest problem.

**Practicals**

Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.

**Suggested Readings**


Michael J. Wilson and Thomas Kakouli Duarte 2009. *Nematodes as environmental indicators*. CABI Publication


**NEMA 509 INTERACTIONS OF PLANT PARASITIC NEMATODES WITH OTHER MICRO-ORGANISMS**

(2L + 1P) III

**Objective**

To understand the interaction of plant-parasitic nematodes with bacteria, fungi, viruses and other organisms.

**Theory**

UNIT I
Concepts, importance and types of interactions

UNIT II
Nematode – nematode interactions

UNIT III
Interaction of plant-parasitic nematodes with wilt causing, root rot and other fungal pathogens

UNIT IV
Interaction of plant-parasitic nematodes with bacteria

UNIT V
Plant-parasitic nematodes – virus interactions

UNIT VI
Interaction with other microorganisms.

**Practicals**

Interaction studies between plant-parasitic nematodes and plant pathogenic fungi or bacteria.
Suggested Readings


NEMA 510 NEMATODE MANAGEMENT (3L+2P) III

Objective

Theory and practice of nematode management to prevent yield losses of agricultural crops.

UNIT I
Principles and Concept of nematode management in crops.

UNIT II
Components of nematode management; Cultural: Tillage methods, cropping system and pattern, flooding, solarization, summer ploughing, soil amendments, antagonistic and cover crops; Physical: heat, steam, hot water treatment, irradiation; Biological: Fungi, bacteria and other bioagents with their utilizations; Chemical: Types, formulations, doses, mode of action and fate of nematicides; Host resistance in nematode management.

UNIT III
Factors affecting the nematode management; Integrated nematode management; Novel methods of nematode management.

UNIT IV
Legal aspect of nematode management: Quarantine and disinfections methods

UNIT V
Probit analysis and calculation for LD$_{50}$ values

Practicals

Calculation of dose of nematicides, Types of chemical nematicides and their application methods, *In vitro* and *In vivo* testing of nematicides against nematodes, observation on mortality of nematodes, application and dosage of organic amendments, application and dosage of bioagents (fungal and bacterial) for nematode management.

Suggested Readings


Objective

To sensitize about the use of nematodes for the biological control of insects, other arthropod and invertebrate pests of crops.

Theory

UNIT I
Beneficial nematode fauna- predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode-insect associations; taxonomic characteristics of nematode parasites of insects.

UNIT II
Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids, allantonematids and Iotonchids.

UNIT III
Entomopathogenic nematodes- *Steinernematids* and *Heterorhabditids*, their morphological characteristics, taxonomic status, biology, nematode-bacterium symbiosis and virulence mechanism.

UNIT IV
Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

UNIT V
Entomopathogenic nematodes- Ecological considerations, compatibility with various agrochemicals and their use in IPM.

Practicals

Isolation of EPN from soil by baiting; Collection of insects and detection of nematodes; General morphology and taxonomic outline of EPN; General microscopic features of Mermithids, Rhabditids, Thelastomatids, Diplogasterids, Tylenchids etc.; Killing, fixing, preparation of permanent mounts of EPN; Isolation and culturing of symbiotic bacteria; Formulation of EPN and symbiotic bacteria; Laboratory bioassay of EPN/bacteria against insects.

Suggested Readings


Objective

To familiarize the students with principles of Nematode pest management, including concept and philosophy of Integrated Pest Management (IPM). Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I
History and growth of IPM

UNIT II
Concept, ecological principles, economic threshold level and consideration of IPM

UNIT III
Tools of pest management and their integration, legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practicals

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment-direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses, Computation of EIL and ETL; crop modeling; designing and implementing of IPM system.

Suggested Readings


Objective

To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and to acquaint them with nanotechnology.

Thoery

UNIT I

UNIT II
Effect of bioactive nano-materials on insect pests and beneficial insects.

UNIT III
Different types of nano-compounds and their use in the management of plant disease incited by pathogenic fungi, bacteria and viruses with special reference to copper, sulfur etc, Interaction of bioactive nano-materials on plant pathogens including fungi, bacteria, virus etc.

UNIT IV
Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus. Identification and quantification of biotoxins effective in nano-doses.

UNIT V

UNIT VI

Practicals

Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests.

Suggested Reading

Objective

Apprising of ultrastructural, cytogenetical, biochemical and molecular approaches in nematode systematics using SEM and TEM.

Theory

UNIT I
Importance of ultrastructure of nematode body wall- cuticle, hypodermis and muscles; nematode feeding apparatus, and other parts of alimentary canal in nematode systematics.

UNIT II
Importance of ultrastructure of nematode sense organs, reproductive and excretory secretory systems in nematode systematics.

UNIT III
Preparation of illustrations, keys and compendia for nematode species and other taxa.

UNIT IV
Recent advances in nematode identification- molecular, biochemical, immunodiagnostic, molecular characterization and DNA finger-printing techniques.

UNIT V
Databases and computer aided nematode identification programmes - NEMISYS (NEmatode Identification SYStem), NEMAID etc.

Practicals

Detailed studies of morphological structures and identification of plant parasitic nematodes up to species level. Drawing and measurements of nematodes, preparation of compendia and keys. Identification of species/races of root-knot and cyst nematodes using PAGE.

Suggested Readings


NEM 604 ADVANCED MOLECULAR NEMATOLOGY

Objective

To understand the advances in gene expression, plant defense system, host resistance, host recognition survival and ageing of nematodes at molecular level.
Theory

UNIT I
Nucleic acids – structure and functional properties, replication, transcription, translation, protein synthesis

UNIT II
Caenorhabditis elegans – model nematode for nematode genetics, physiology and genomics.

UNIT III
Plant defense systems, cytological and biochemical changes in host plants induced by nematode feeding

UNIT IV
Resistance, genetics of resistance, molecular basis of host resistance, cloned resistance genes against plant parasitic nematodes, molecular changes in nematode feeding cells.

UNIT V
Host recognition, chemoreception, survival and ageing

UNIT VI
RNA interference, promoters for specific gene expression and novel approaches for nematode management

Suggested Reading


Perry, R.N. and Wright, D.J. 1998. The physiology and biochemistry of freeliving and plant parasitic nematodes. CABI, Wallingford, UK.

Perry, R.N. and Moens, M. 2006. Plant Nematology. CABI, Wallingford UK.


Series: PLANT CELL MONOGRAPHS 15. Springer-Verlag, Germany.


NEMA 605/ENT 611 PLANT HEALTH DIAGNOSTICS & MANAGEMENT (2L+2P) III

(Multidisciplinary Courses to be Operated by the Division of Entomology)

Objective

To familiarize the students with different abnormalities caused by insect, pathogens, nematodes, weeds and imbalance use of plant nutrients. Also, develop the confidence in them to handle plant protection problems faced by the farmers/growers.
Theory

UNIT I
Introduction to the plant health clinic: concept, importance, infrastructure etc. Identification of important beneficial insects (parasitoids, predators, pollinators and others of economic importance). Principles of pest management; Injury caused by different type of insects to the plants by feeding, oviposition, sheltering or any other means.

UNIT II
Screening of damaged material for establishing the identity of casual agent viz.; insect, microbe, nematode, mites, rodents, vertebrates, competitive plant as well as nutritional or any other physiological disorders.

UNIT III
Important Plant parasitic nematodes and their symptoms produced on major field, fruit, ornamental and plantation crops; Damage caused by important nematodes causing root knot, ear-cockle and other diseases in different crops and their management.

UNIT IV
Molecular approaches for viral, bacterial and fungal diseases with regards to diagnostics and management.

UNIT V
Symptoms of diseases caused by imbalances in plant nutrients

UNIT VI
Identification of problematic weeds and their management.

Practicals

Suggested Readings

# Plant Genetic Resources

## Trimester Wise Distribution of Courses

### I trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGR 500</td>
<td>Biodiversity and Plant Genetic Resources</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PGR 507</td>
<td>Information Management in Plant Genetic Resources</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 508</td>
<td>Plant Taxonomy</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 509</td>
<td>Plant Biosecurity</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PGR 600</td>
<td>Advances in Exploration and Germplasm Collecting</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 608</td>
<td>Advanced Economic Botany</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 607/</td>
<td>Regulatory Mechanisms and Intellectual Property Rights</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GP 607</td>
<td>Property Rights</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGR 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGR 501</td>
<td>Exploration and Germplasm Collecting</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 504</td>
<td>Principles and Practices of Germplasm Regeneration and Evaluation</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 506</td>
<td>Economic Botany</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 601</td>
<td>Advances in Seed Physiology in Relation to Germplasm Conservation</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 602</td>
<td><em>In Vitro</em> Conservation and Cryopreservation</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PGR 603</td>
<td><em>In Situ</em> Conservation of Plant Biodiversity</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 605</td>
<td>Principles and Methods in Analyses of Molecular Diversity</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PGR 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III trimester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 013</td>
<td>Economic Botany and Plant Genetic Resources</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PGR 502</td>
<td>Germplasm Exchange and Plant Quarantine</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PGR 503</td>
<td>Principles and Methods of Germplasm Conservation</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 505</td>
<td>Biotechnology in Plant Genetic Resource Management</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PGR 604</td>
<td>Advances in Germplasm Evaluation and Utilization</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Hours</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>PGR 606</td>
<td>ECOLOGY AND BIODIVERSITY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 609</td>
<td>ADVANCED PLANT TAXONOMY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PGR 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses:**

**M.Sc.:** PGR 500, PGR 501, PGR 502, PGR 503, PGR 504, PGR 505, PGR 506, PGR 508, PGR 509, GP 500, GP 520, AS 501, PGS 503
PLANT GENETIC RESOURCES

Major Field : Plant Genetic Resources

Minor Fields : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 013 ECONOMIC BOTANY AND PLANT GENETIC RESOURCES (1L+1P) III

Objective

This course is aimed at understanding the economic uses on plant species and potential of plant species as a natural resource or raw material for use in crop improvement.

Theory

UNIT I
Origin and history of agriculture; dynamics of domestication; centres of plant origin and diversity.

UNIT II
Patterns of variation; classification of cultivated plants; concept of gene pool; geographical distribution of crops of Indian origin.

UNIT III
Principles of PGR exploration and collection; introduction, acclimatization and utilization; principles of plant quarantine; principles and strategies for germplasm conservation; ex situ and in situ methods.

UNIT IV
Components of genebank: seed genebank, field genebank, in vitro repository, cryo genebank; DNA libraries, herbarium.

UNIT V
Policy issues: assessing economic values, conflict over ownership, management and use; data documentation.

Practicals

Preparation of herbarium; recording the data for characterization and evaluation of genetic resources in the field; Processing of samples of genetic resources for long-term conservation: testing the viability and seedling vigour, testing of moisture content, equilibration of moisture content, packaging of sample for long-term conservation in Seed Genebank; in vitro conservation of genetic resources: preparation of culture medium, sterilization and inoculation of explants, maintenance of cultures in the In vitro Genebank; data documentation, demonstration of database on plant genetic resources.
Suggested Readings


PGR 500 BIODIVERSITY AND PLANT GENETIC RESOURCES (2L+0P) I

**Objective**

To provide an overview of global biodiversity, agrobiodiversity and agricultural intensification, and an understanding of basic science and management issues related to plant genetic resources including policy.

**Theory**

UNIT I
Biodiversity-an overview; genetic, species and ecosystem diversity; determinants of biodiversity.

UNIT II
Higher plant diversity, species richness and endemism.

UNIT III
Biodiversity and agricultural intensification: agriculture as friend and foe of biodiversity, harmonizing biodiversity conservation and agricultural development, policy considerations along the interface between biodiversity and agriculture.

UNIT IV
Agro-biodiversity and plant genetic resources; origin and history of agriculture; dynamics of domestication; centers of crop plant origin and diversity; geographical distribution of crops of Indian origin.

UNIT V
An overview of plant genetic resources management (importance and usefulness of germplasm, germplasm conservation, threat of genetic vulnerability, global concerns etc.).

UNIT VI
Managing plant genetic resources: Basic science issues (genetic vulnerability and crop diversity, crop diversity-institutional responses, *in situ* conservation of genetic resources, the science of collecting genetic resources, the science of managing genetic resources, using genetic resources, biotechnology and germplasm conservation etc.).
UNIT VII
Managing plant genetic resources: policy issues (exchange of genetic resources: quarantine, IPR; genetic resources: assessing economic value; conflicts over ownership, management and use; national and international treaties/legislations: CBD, IT-PGRFA, GPA, PVP&FR Act, Biodiversity Act etc.).

Suggested Readings

PGR 501 EXPLORATION AND GERMPLASM COLLECTING (2L+1P) II

Objective
To provide information about science of germplasm collecting.

Theory
UNIT I
History and importance of germplasm exploration; distribution and extent of prevalent genetic diversity; phyto-geographical regions/ecological zones and associated diversity; mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II
Concept of population and gene pool, variations in population and their classification, gene frequencies in populations, rare and common alleles, gene pool sampling in self- and cross-pollinated and vegetatively propagated species, non-selective, random and selective sampling strategies.

UNIT III
Strategies and logistics of plant exploration and collection, coarse and fine grid surveys, practical problems in plant exploration, use of *in vitro* methods in germplasm collection.

UNIT IV
Ethnobotanical aspects of PGR, crop botany, farming systems, collecting wild relatives of crop plants.

UNIT V
Post-exploration handling of germplasm collections, collection and preservation of specimens, importance and use of herbaria and preparation of herbarium specimens.
UNIT VI
Present status and future strategies in collecting of major crops of Indian origin such as rice, maize, sorghum, sesame, brassica, okra, eggplant, cotton, mango, etc.

Practicals
Plant exploration and germplasm collecting; documenting passport data; use of flora and maps; collecting vegetatively propagated species; local field visit for recording of ethnobotanical information/notes; post exploration handling of germplasm accessions; collecting wild relatives of crop plants; preparation, maintenance and use of herbarium; local field visit for herbarium collection; report writing on germplasm collecting missions.

Suggested Readings
Other relevant books/serials and IPGRI publication etc. and original papers

PGR 502 GERMPLASM EXCHANGE AND PLANT QUARANTINE (3L+2P) III

Objective
To provide information about germplasm exchange and plant quarantine including exchange of genetically modified plants.

Theory
UNIT I
History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange.

UNIT II
Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT III
Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities.

UNIT IV
Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.
UNIT V
Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practicals
Inventory of IQ/ EQ samples; joint inspection for pest detection; history, principles, objectives and relevance of Plant Quarantine; seed –borne pests of quarantine significance; quarantine in relation to integrated pest management; salvaging of infested germplasm; seed treatment and other prophylactic treatments and facilities; domestic quarantine; seed-health certification.

Suggested Readings
Richardson, M.J. 1990. An Annotated list of seed-borne diseases (Fourth Edition). International Seed Testing Association, P.O. Box 412. CH 8046 Zurich, Switzerland.

PGR 503 PRINCIPLES AND METHODS OF GERMPLASM CONSERVATION (2L+1P) III

Objective
To impart knowledge on crop germplasm conservation with particular emphasis on seed genebanks.

Theory
UNIT I
In situ and ex situ conservation: concept of biosphere reserves, gene sanctuaries, on-farm conservation, field genebanks, botanical gardens, herbal gardens, in vitro repositories and cryo-banks.
UNIT II
Short-, medium- and long-term conservation, concept of base, active and working collections, seed structure and function, physiological and genetic changes during storage, theories of aging, viability equations, predicting storage life of seeds, dormancy and germination.
UNIT III
Genebank management: acquisition, accessioning and processing of germplasm samples for storage, genebank standards for various crops, ISTA, AOSA, IPGRI guidelines, monitoring and regeneration of plant germplasm.
UNIT IV
Design of storage facilities, maintenance and operation of storage modules.

UNIT IV
Information management in genebanks, strategies for revival and rescue of rare genetic material.

Practicals
Seed structure and morphology; seed germination and seedling evaluation; seed viability test, seed sampling and purity analysis, seed dormancy and dormancy breaking treatments, moisture testing methods, vigour testing methods and seed leachate analysis, accelerated aging of seeds and their assessment, seed processing and storage in Gene Bank.

Suggested Readings
Thomoson, J.R. 1979. *An Introduction to seed Technology*.

**PGR 504 PRINCIPLES AND PRACTICES OF GERMPLASM REGENERATION AND EVALUATION**

*(2L+1P)* II

**Objective**
To educate students about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

**Theory**

UNIT I
Germplasm management systems: global scenario; genetic variation in crop plants and management of germplasm collections.

UNIT II
Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces.

UNIT III
Germplasm characterization/evaluation procedures; evaluation of germplasm for specific traits; key issues for the improvement of characterization, evaluation and use of plant genetic resources; concept of core collection.
UNIT IV
Measuring diversity using agromorphological data; gene markers and their use in PGR management.

UNIT V
Evaluation and maintenance of wild relatives of crop plants; genetic enhancement/pre-breeding and use of alien/unadapted genetic resources in crop improvement.

Practicals
Field layout and experimental designs, recording field data on germplasm evaluation in different agri-horticultural crops, biochemical and phyto-chemical evaluation of crop germplasm, data processing, documentation, analysis of diversity and cataloguing.

Suggested Readings

PGR 505 BIOTECHNOLOGY IN PLANT GENETIC RESOURCE MANAGEMENT (3L+2P) III

Objective
To provide information on use of biotechnology in germplasm conservation including molecular characterization and conservation technologies.

Theory
UNIT I

UNIT II
Plant Cryopreservation-Introduction, Principle of cryotolerance, Techniques of cryopreservation: slow cooling, desiccation, pregrowth, encapsulation-dehydration, vitrification, droplet freezing, Cryoprotectants, Cryopreservation of seeds and pollen, Cryopreservation of in vitro cultures, Application of in vitro cryopreservation techniques in monocots and dicots - case studies,
Management of *in vitro* and cryobanks, Genetic stability of *in vitro* conserved and cryopreserved germplasm, Importance of database for *in vitro* and cryopreserved germplasm.

UNIT III
The need for plant germplasm characterization; introduction to different techniques for plant germplasm characterization; biochemical and molecular marker techniques for germplasm characterization and evaluation; recent advances in molecular genetic diversity analysis –use of SNPs and microarrays; data handling and statistical analysis; analysis of genetic diversity; marker assisted evaluation of core collections; conservation of genomic resources; molecular markers for gene bank management; detection of adventitious transgenics.

Practicals

- Preparation of stock solutions; media preparation; preparation of explants and culture initiation in monocots and dicots; meristem isolation and culture establishment; subculture of shoots in monocots and dicots, hardening and field establishment of plantlets; preparation of cryoprotectant solutions and regrowth media; cryopreservation of *in vitro* cultures- isolation of explants and pretreatment.
- Encapsulation-dehydration technique; encapsulation-vitrification technique; assessing genetic stability of *in vitro* conserved and cryopreserved germplasm.
- Basic techniques in molecular biology; isolation of Genomic DNA from leaves; purification of DNA Quantification of DNA; PCR; RAPD, ISSR, demonstration of RFLP, AFLP, STMS; data Handling and Statistical Analysis.

Suggested readings


Henry, R.J. (Editor) *Plant Genotyping: The DNA Fingerprinting of Plants*, Publisher: CABI Publishing.


Objective
To study the relationship between people and plants including anthropology, botany and environmental conservation.

Theory
UNIT I
Origin and history of agriculture, domestication and adaptations of cultivated plants.
UNIT II
Taxonomy, reproductive systems and breeding behaviour of crop plants.
UNIT III
Origin, evolution, botany, cultivation, use, genetic resource activities and utilization of genetic diversity of important crops, viz., cereals, millets, legumes, forage and fodder crops, medicinal and aromatic plants, beverages, oil yielding plants, spices and condiments, wood and timber yielding taxa, fumitory and masticatory plants, vegetable crops, sugar, starch and cellulose yielding plants, rubber yielding plants, insecticidal and herbicidal plants, fruits and nuts, flowering agents, gums and resins, fiber yielding plants, under-utilized and under-exploited plants, new crops, pseudocereals, important taxa in agro-forestry, horticulture and floriculture, processing and use of crop residues.

Practicals
Botanical microtechniques for the study of structure, development and biochemical status of plant parts; structure of economic important plant parts; case studies on adaptations during domestication-Solanum species; histochemical localization of chemical constituents in economically important plant parts; identification and status of economically important plant parts in different groups of plants.

Suggested readings
An Introduction to Modern Economic Botany. By Maiti RK and Singh VP, 2006 Eastern Book Corporation, Delhi
Economic Botany in the Tropics. By Kochhar (Third edition), Macmillan Publishers, India
PGR 507 INFORMATION MANAGEMENT IN PLANT GENETIC RESOURCES (2L+1P) I

Objective
To train the students in germplasm data base management using modern tools and softwares.

Theory
UNIT I
Statistical techniques in management of germplasm, developing core collection, estimation of sample size during plant explorations, impact of sampling on population structure.

UNIT II
Sequential sampling for viability estimation, introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and nomograms, estimation of sample size for storage and viability testing.

UNIT III
Germplasm documentation; basics of computer and operating systems, database management system, use of statistical softwares, pictorial and graphical representation of data; Introduction to communication network.

Practicals
Experimental designs and data analysis; viability equations, sampling strategies, data documentation, cataloguing.

Suggested Readings


PGR 508 PLANT TAXONOMY (2L+1P) I

Objective
To educate about the relationships between plants and their evolution, especially at the higher levels and actual handling of plant specimens.

Theory
UNIT I
Classical and modern species concepts, differentiation and evolution of species and biosystematics: Classical & modern species concepts, variation within species, population genetics, phenotypic plasticity, environmental effects on populations, differentiation and evolution of species, biosystematics; Modern evidences: Morphology and Anatomy; Modern evidences: Embryology and Palynology; Modern evidences: Biogeography and Cytotaxonomy; Modern evidences: Comparative studies on phytochemistry, Chemotaxonomy; Modern evidences: Molecular taxonomy
methods; Numerical methods in taxonomy; Biosystematic approaches in plant taxonomy- some Indian case studies.

UNIT II
Taxonomy of cultivated plants: Taxonomy of cultivated plants with particular emphasis on Indian groups: Hybrids, domesticated species, wild-cultivated continuum; Tools of taxonomy for identification of plant species and variation patterns therein; Field and herbarium methods; Floristic and monographic works; Systematic and evolutionary studies.

UNIT III
Taxonomic databases: Taxonomic databases and documentation methods.

Practicals

- Classical and modern species concepts and biosystematics - Morphology and anatomy; Comparative studies on phytochemistry, Chemotaxonomy; Field and herbarium methods; Floristic and monographic work; Practical methods for elucidating and proving hypotheses relating to plant speciation; Numerical taxonomy-practice and procedures; Biosystematic studies and their role in improving plant taxonomies; Infraspecific categories in relation to population biology
- Taxonomic databases- Taxonomic databases and documentation methods in relation to plant genetic resources
- Taxonomy of crop plants- Taxonomy of cultivated species, domesticated species, wild-cultivated continuum; problems and their resolution; newer methods of analysis and interpretation

Suggested Readings


PGR 509 PLANT BIOSECURITY

Objective

To educate about protecting the economy, environment and plant health from pests and disease including preventing new pests and diseases from arriving, and helping to control outbreaks when they do occur.
Theory

UNIT I
History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases.

UNIT II
National Regulatory Mechanism and International Agreements/ Conventions viz. Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/ World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III
Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings
Original articles and websites

PGR 600 ADVANCES IN EXPLORATION AND GERMPLASM COLLECTING (2L+1P) I

Objective
To provide information on ecogeographic surveys, sampling strategies and legal issues involved in germplasm collecting.

Theory

UNIT I
Genetic diversity of PGR, genetic principles of diversity and its distribution.

UNIT II
Indicators of diversity, assessing the threats of genetic erosion; eco-geographic surveys: planning, collection and analysis of eco-geographic data, outputs of eco-geographic surveys.

UNIT III
Germplasm collecting legal issues and the FAO code of conduct, participatory approaches to collecting including indigenous knowledge.

UNIT IV
Sampling strategies theory and practice, strategies for wild species.

Practicals
- Collecting ecogeographic data, use of GIS in biodiversity mapping and collecting; analysis of ecogeographic data
- Exposure to use of flora/maps, study of wild/weedy species aids to taxonomic identification
- Genetic diversity analysis: morphological / physiological characterization, biochemical/ molecular characterization
Suggested Readings


Other relevant books/serials and IPGRI publication etc. and original papers

---

**PGR 601 ADVANCES IN SEED PHYSIOLOGY IN RELATION TO GERMPLASM CONSERVATION**  
(2L+1P) II

**Objective**

To provide an insight into physiological processes governing seed quality and its survival in relation to germplasm conservation and seed science and technology.

**Theory**

**UNIT I**

Seed as genetic material for conservation; seed structure, development and physiological maturity; seed germination and growth; mobilization of reserves and their control processes.

**UNIT II**

Seed storage behaviour and their importance in conservation; post-collection care, see processing for short, medium and long-term storage

**UNIT III**

Seed germination, viability and vigour; concept and testing methods for assessment of vigour and longevity; seed dormancy and methods for breaking dormancy; mid-storage treatments; invigoration techniques and seed hardening.

**UNIT IV**

Seed storage for long-term conservation and factors affecting seed longevity; seed moisture content, storage temperature and their influence on storability; artificial aging and controlled deterioration test; ultra-desiccation techniques for germplasm conservation.

**UNIT V**

Physiological, biochemical and genetic indices of seed deterioration, seed conservation and exchange.

**Practicals**

Identification of seeds based on seed morphology and structure; Testing seed viability and vigour; Seed Longevity and accelerated ageing test in different types of seeds; Determining causes for dormancy, hard seededness and physiological immaturity; Developing short and medium-term conservation strategies for difficult-to-store seeds; Seed quality enhancement through seed priming; Ultra-desiccation of seeds in relation to seed longevity; Biochemical manifestation of seed deterioration.
Suggested Reading


PGR 602 *IN VITRO CONSERVATION AND CRYOPRESERVATION* (2L+2P) II

Objective

To equip students with skills in using tissue culture and cryopreservation techniques for conservation and management of PGR.

Theory

UNIT I

*In vitro* techniques in PGR management; *in vitro* clonal propagation for germplasm conservation; somaclonal variation and its implication in PGR conservation; *in vitro* collecting; meristem culture, virus indexing and elimination, *in vitro* exchange and its international guidelines.

UNIT II

Techniques of *in vitro* conservation of tropical and temperate crops under slow/normal growing conditions; tissue culture in circumventing crossability barriers embryo rescue technique, rescue and survival of rare and endangered species; management of large *in vitro* collections; concept of active and base *in vitro* genebanks.

UNIT III

History of plant cryopreservation; structural, physiological and biochemical basis of desiccation and freezing sensitivity of plant cells, tissues and organs; cryoprotectants and their mode of action, factors affecting cryoprotection.
UNIT IV
Methods of cryopreservation – conventional slow cooling and vitrification-based methods; factors influencing success in cryopreservation importance of pre-treatments, pre-conditioning of explant donor plants, regrowth media and culture conditions; advances in cryogenic protocols; status of application of cryopreservation in PGR conservation, application in pharmaceutical industry, forest breeding and production of transgenics.

UNIT V

Practicals
- Preparation of stock solutions; media preparations; preparation of explants and culture initiation in monocots and dicots; meristem isolation and culture establishment; subculture of shoots in monocots and dicots, hardening and field establishment of plantlets; preparation of cryoprotectant solutions and regrowth media; cryopreservation of in vitro cultures- isolation of explants and pretreatment.
- Encapsulation-dehydration technique; encapsulation-vitrificaion technique; assessing genetic stability of in vitro conserved and cryopreserved germplasm.
- Cryobanking of germplasm, effect of duration and temperature of cryopretectant treatment on shoot tips, effect of cold hardening - isolation of shoot tips in dicot, cryopreservation-vitrification technique, effect of thawing treatment on regrowth.
- Demonstration of embryo rescue technique/ virus indexing.

Suggested Readings
PGR 603 IN SITU CONSERVATION OF PLANT BIODIVERSITY (2L+1P) II

Objective
To impart knowledge about in situ/on-farm conservation of crop diversity and type of information necessary for such interventions.

Theory
UNIT I
Complementary strategies for plant biodiversity conservation.

UNIT II
In situ conservation of wild species in nature reserves, in situ conservation components, factors influencing conservation value, national plan for in situ conservation.

UNIT III
In situ conservation of agro-biodiversity on-farm: importance of on-farm conservation initiatives, overview of the types of information necessary in the design of an on-farm conservation programme.

UNIT IV
Practical design and implementation aspects of on-farm conservation.

Practicals
• Ecogeographical surveys and inventory.
• Estimation of genetic diversity in traditional agroecosystems on farm, matrix ranking of farmer selection criteria.
• Factors influencing conservation value.

Suggested Readings

Engels, J.M.M. 1995. In situ conservation and sustainable use of plant genetic resources for food and agriculture in developing countries. IPGRI/DSE.


Objective

To impart theoretical and practical knowledge on recent advances in crop germplasm evaluation and use.

Theory

UNIT I
Limitation in use of germplasm: Limitations in use of germplasm collections and necessity of germplasm evaluation, advances in methodology of germplasm evaluation and predictive methods for identification of useful germplasm.

UNIT II
Evaluation of crop germplasm for value addition: Evaluation of germplasm against biotic/abiotic stresses; quality attributes and other value addition traits.

UNIT III
Management and utilization of crop germplasm: Concept of core collection; Molecular markers and their use in characterization and use of genetic resources; Germplasm enhancement/pre-breeding and use of wild relatives in crop improvements, Molecular tagging of QTLs and its role in utilization of germplasm resources.

UNIT IV
Harmonising agro-biodiversity conservation and agricultural development: New crops of the future; PGR management: complementarity in ex situ-in situ (on-farm) approaches and participatory plant breeding.

Practicals

- Management and utilization of crop germplasm: Exercise for developing core set
- Evaluation of crop germplasm for value addition
- Evaluation of crop germplasm against biotic/abiotic stresses
- Evaluation of germplasm for quality traits
- Biochemical/molecular characterisation of germplasm
- Experiments on wide hybridization

Suggested Readings


PGR 605 PRINCIPLES AND METHODS IN ANALYSES OF MOLECULAR DIVERSITY  
(2L+2P) II

Objective
To provide insight into organization and structure of genetic variation in plant populations and practical skills in molecular diversity analysis.

Theory
UNIT I
Organization and structure of genetic variation in natural populations, organization and evolution of eukaryotic genome.

UNIT II
Molecular verses other conventional methods for assessing genetic variation; sampling for molecular analyses, functional polymorphism, uses and applications of molecular markers in PGR - analysis of genetic diversity, identification of gaps in collection, evaluation and characterization etc.

UNIT III
Biochemical and molecular markers, molecular cytology, principles of RFLPs, PCR based techniques, AFLPs, SNPs and DNA sequencing; statistical treatment of the molecular data and interpretation; recent advances: emerging techniques, their applicability and uses.

Practicals
• The Hardy-Weinberg principle and estimating allele frequencies in populations; Inbreeding and self-fertilization
• Testing for departures from Hardy-Weinberg proportions
• The Wahlund Effect and Wright’s F-statistics
• Analyzing the genetic structure of populations; Quantitative genetics ; Introduction to Linkage disequilibrium and association analysis
• Molecular evolution
• The neutral theory of molecular evolution
• Detecting selection on nucleotide polymorphisms
• Patterns of selection on nucleotide polymorphisms
• Tajima’s D, Fay and Wu’s H, and Zeng et al.’s E
• Evolution in multigene families
• Phylogeography
• Methods in numerical taxonomy
• Cladistics
Suggested Readings


PGR 606 ECOLOGY AND BIODIVERSITY

(2L+2P) III

Objective

To educate students about interdisciplinary scientific study of the distributions, abundance and relations of organisms and their interactions with the environment, and the study of ecosystems.

Theory

UNIT I
Origin and diversity of life, adaptations, basic elements of plant ecology, ecological components, population ecology- populations and life history, growth and limits.

UNIT II
Community ecology- species interactions, role of behaviour, interactions and structure.

UNIT III
Ecosystems- concept of ecosystems, ecological balance, vegetation dynamics, productivity and nutrient cycling.

UNIT IV
Conservation ecology, seed ecology, nature conservation and environmental management, ecosystem restoration, biogeography and evolution.

UNIT V
Biodiversity functioning- genetic adaptations, population irruptions/crisis in nature, community change and ecosystem regulation.

UNIT VI
Biodiversity conservation-geographical patterns in biodiversity, habitat fragmentation and conservation areas.

UNIT VII
Biodiversity management and exploitation-biodiversity resources and their harvesting, impact of physical and biotic factors on sustainability- case studies, impact of biotic and climatic factors on biomes and biodiversity- pollution and over-exploitation.
Practicals

- Adaptations in plants, ecological components, survey of local biodiversity (field study), ecological status of various species (field study)
- Population and community patterns- case studies on local flora
- Identification of alien species and their impact assessment, study of protected areas restoration of threatened species
- Bioresources and their harvesting, impact assessment of pollution and over-exploitation on targeted taxa

Suggested Readings

Conservation Biology : Research priorities for the next Decade, edited by Soule and Orians (2001)

PGR 607 REGULATORY MECHANISMS AND INTELLECTUAL PROPERTY RIGHTS
(3L+1P) I

Objective

To educate students about concepts and instruments of intellectual property rights, plant breeder's rights, farmer's rights, access and benefit sharing, international treaties and national legislation related to plant genetic resources.

Theory

UNIT I

Concept of intellectual property, need for IP protection, Dimensions and nature of IPR, conflicting community interest with private right. Forms of IPR, patents, copyright, trademark, design, trade secret/ confidential information, GI registration. Process of obtaining an IPR, World Intellectual Property Organization, patent cooperation treaty (PCT).
UNIT II
Plant breeder’s rights, protection of plant varieties, UPOV; registration of plant varieties and essentially derived varieties, duration and effect of registration; traditional knowledge systems, farmer’s rights, folklore, code of conduct, access and benefit sharing; compulsory license; plant varieties protection appellate tribunal; finance, accounts and audit; infringement, offenses, penalties and procedure.

UNIT III
International instruments concerning agro-biodiversity, Agenda 21, convention on biological diversity (CBD), FAO and global system of PGR, the international treaty on plant genetic resources for food and agriculture (ITPGR), Global Plan of Action, TRIPS agreement and IPR protection of life forms, geographical appellations.

UNIT IV
Multilateral agreement on trade in goods - relevance to agriculture, agreement on agriculture (AOA); agreement on application of sanitary and phytosanitary measures (SPS), international plant protection convention, agreement on technical barriers to trade (TBT). Plant quarantine, biosafety related issues.

UNIT V
National legislations related to biodiversity conservation and IPR protection.

Practicals
• Patent Information Search
• Patent Drafting
• Opinion on Patentability
• Patent Infringement

Suggested readings

Use of Biodiversity: Access to Genetic Resources and Benefit Sharing by Kerry Ten Kate and Sarah A Laird; Earthscan 2002.


e-reading: www.icar.org.in/files/reports/other-reports/icar-ipmttcguide.pdf

Websites
www.wto.org  www.geographicindications.com
www.cbd.int  www.patentoffice.nic.in
www.uspto.gov
www.wipo.int
www.nif.org.in
plantauthority.gov.in
nbaindia.org
PGR 608 ADVANCED ECONOMIC BOTANY (2L+1P) I

Objective
To apprise students about economic uses of plants including fields such as ethnopharmacology as well as potential new commercial crops.

Theory
UNIT I
Structure, development and chemical constituents of plant parts- cereals, pulses and oilseeds, vegetables, fruits, nuts.

UNIT II
Origin, evolution and interrelations of crop taxa- cereals, pulses and oilseeds, vegetables, fruits, nuts, ornamental plants, underutilized plants.

UNIT III
Economic uses and commercial importance of crop plants- cereals, pulses and oilseeds, vegetables, fruits, nuts, ornamental plants, underutilized plants.

UNIT IV
Importance of plants with respect to society and environment- Social and religious significance of plants in environmental amelioration.

Practicals
Structure, development and chemical constituents of plant parts-cereals, pulses and oilseeds, vegetables, fruits, nuts, ornamental plants, underutilized plants.

Suggested Readings
Plants for human consumption. By Kunel, G
Plants and human affairs. By Schultes, RE

PGR 609 ADVANCED PLANT TAXONOMY (2L+1P) III

Objective
To apprise students about the identification and classification of plants including taxonomic databases and documentation systems.
Theory

UNIT I
Classical and modern species concepts, differentiation and evolution of species and biosystematics: Classical & modern species concepts, variation within species, population genetics, phenotypic plasticity, environmental effects on populations, differentiation and evolution of species, biosystematics; Modern evidences: Morphology and Anatomy; Modern evidences: Embryology and Palynology; Modern evidences: Biogeography and Cytotaxonomy; Modern evidences: Comparative studies on phytochemistry, Chemotaxonomy; Modern evidences: Molecular taxonomy methods; Numerical methods in taxonomy; Biosystematic approaches in plant taxonomy- some Indian case studies.

UNIT II
Taxonomy of cultivated plants: Taxonomy of cultivated plants with particular emphasis on Indian groups: Hybrids, domesticated species, wild-cultivated continuum; Tools of taxonomy for identification of plant species and variation patterns therein; Field and herbarium methods; Floristic and monographic works; Systematic and evolutionary studies.

UNIT III
Taxonomic databases: Taxonomic databases and documentation methods.

Practicals

• Classical and modern species concepts and biosystematics - Morphology and anatomy; Comparative studies on phytochemistry, Chemotaxonomy; Field and herbarium methods; Floristic and monographic work; Practical methods for elucidating and proving hypotheses relating to plant speciation; Numerical taxonomy-practice and procedures; Biosystematic studies and their role in improving plant taxonomies; Infraspecific categories in relation to population biology.

• Taxonomic databases- Taxonomic databases and documentation methods in relation to plant genetic resources.

• Taxonomy of crop plants- Taxonomy of cultivated species, domesticated species, wild-cultivated continuum; problems and their resolution; newer methods of analysis and interpretation.

Suggested Readings

582
TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL PATH 501</td>
<td>MYCOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 502</td>
<td>PLANT VIROLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 503</td>
<td>PLANT BACTERIOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 505</td>
<td>DETECTION AND DIAGNosis OF PLANT DISEASES</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>PL PATH 507</td>
<td>DISEASES OF FIELD AND MEDICINAL CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 508</td>
<td>DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 510</td>
<td>SEED HEALTH TECHNOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 511</td>
<td>CHEMICALS IN PLANT DISEASE MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 516</td>
<td>PRINCIPLES AND PRACTICES OF IDM/IPM</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PL PATH 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 011</td>
<td>CROP DISEASES AND THEIR MANAGEMENT</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 504</td>
<td>PRINCIPLES OF PLANT PATHOLOGY</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PL PATH 506</td>
<td>PRINCIPLES IN PLANT DISEASE MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 509</td>
<td>DISEASES OF VEGETABLES AND SPICE CROP</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 521/AC 512/ENT 512/NEMA 513/MB 512</td>
<td>NANOTECHNOLOGY IN CROP PROTECTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 515</td>
<td>BIOCONTROL OF PLANT DISEASES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 517</td>
<td>MUSHROOM PRODUCTION TECHNOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 601</td>
<td>ADVANCED MYCOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 602</td>
<td>ADVANCED VIROLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 603</td>
<td>ADVANCED BACTERIOLOGY</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 607/ENT 611</td>
<td>PLANT HEALTH DIAGNOSTICS AND MANAGEMENT</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PL PATH 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>M.Sc.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL PATH 512</td>
<td>ECOLOGY OF SOIL BORNE PLANT PATHOGENS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 513</td>
<td>DISEASE RESISTANCE IN PLANT</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PL PATH 514</td>
<td>INSECT VECTOR OF PLANT VIRUSES AND OTHER PATHOGENS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 518</td>
<td>EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 519</td>
<td>POST HARVEST DISEASES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 520</td>
<td>PLANT QUARANTINE</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PL PATH 604</td>
<td>MOLECULAR BASIS OF HOST PATHOGEN INTERACTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PL PATH 605</td>
<td>PRINCIPLES AND PROCEDURES OF CERTIFICATION</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>PL PATH 606</td>
<td>PLANT BIOSECURITY AND BIO SAFETY</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PL PATH 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### Core Courses

**M.Sc.:** PL PATH 501, PL PATH 502, PL PATH 503, PL PATH 506  
**Ph.D.:** PL PATH 601, PL PATH 602, PL PATH 603
PLANT PATHOLOGY

Major Fields:
- Mycology
- Fungal Pathology
- Plant Bacteriology
- Plant Virology

Minor Fields:
Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 011 CROP DISEASES AND THEIR MANAGEMENT (1L+1P) II

Objective
To provide basic knowledge on the plant diseases and their management caused by fungi, bacteria and viruses.

Theory
UNIT I
Milestones in Plant Pathology and common terminology, Economic importance and classification of plant diseases, Symptoms produced by plant pathogens, Koch’s postulates and epidemiology
UNIT II
Historical development in Plant Bacteriology, Structure and classification of phytopathogenic bacteria
UNIT III
Milestone in Plant Virology and symptoms of plant virus infections, Morphology and transmission of plant viruses
UNIT IV
Fungal diseases of wheat and rice and their management, Fungal diseases of maize and their management, Fungal diseases of pulses and oilseeds and their management, Fungal diseases of vegetables and fruits and their management
UNIT V
Diseases caused by bacteria in rice, mango, citrus, and their management, Diseases caused by bacteria in cotton and temperate fruits and their management
UNIT VI
Detection of plant viruses. Viral diseases and their management, Important viral diseases of plant and their management

Practicals
Identification of fungi, bacteria, fungal diseases, bacterial diseases, Isolation of fungi, bacteria
Suggested Readings


PL PATH 501 MYCOLOGY (2L+1P) II

Objective

To provide basic information regarding, nomenclature, historical development, classification of fungi. Different structures produced by fungi and their identification.

Theory

UNIT I
Historical introduction to Mycology, definition of different terms, basic concepts.

UNIT II
Importance of Mycology in Agriculture, relation of fungi to human affairs, history of mycology.

UNIT III
Morphology of reproductive structures and conidiogenous cells, Spore types, Saccardo's spore grid, groups and its taxonomic bearing, Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi.

UNIT IV
The comparative morphology, ultrastructure, characters of different groups of fungi up to generic level: (a) Myxomycota and (b) Eumycota- i) Mastigomycotina ii) Zygomycotina, iii) Ascomycotina, iv) Basidiomycotina, v) Deuteromycotina. Lichens types and importance, fungal genetics and variability in fungi.

Practicals

Detailed comparative study of different groups of fungi; collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi.

Suggested Readings


Objective

To provide knowledge in history of plant viruses, their biological properties, diagnostics and management

Theory

UNIT I
History of plant viruses, composition and structure of viruses.

UNIT II
Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship.

UNIT III
Virus nomenclature and classification, Structure of plant virus, genome organization, replication and movement of viruses.

UNIT IV
Isolation and purification, estimation of virus titre and purity, electron microscopy, protein and nucleic acid based diagnostics.

UNIT V
Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions.

UNIT VI
Origin and evolution, mechanism of resistance, genetic engineering, ecology, and management of plant viruses.

Practicals

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy, spectrophotometry and ultratomy, PCR, preservation of virus specimens, preparation of herbrium

Suggested Readings


---

PL PATH 503 PLANT BACTERIOLOGY

Objective

To provide basic knowledge on biology, classification and nomenclature, survival, preservation of phytopathogenic prokaryotic bacteria, phytoplasma, bdelbovibrios and bacteriophages.
Theory

UNIT I
History of bacteriology, nomenclature and classification of bacteria, bacteriophages-morphology, types and uses, mycoplasma and bdellovibrios

UNIT II
Bacterial cell-morphology, organelles and their functions, cell wall structure and chemistry, endospore and its formation, composition and function, flagellar structure, arrangements, movements

UNIT III
Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya.

UNIT IV
Plasmids, bacterial conjugation, transduction and transformation

UNIT V
Important bacterial diseases: Bacterial leaf blight of rice, bacterial blight of pomegranate, cotton bacterial blight, bacterial wilt of solanaceous vegetables, soft rot of vegetables and black rot of crucifers.

UNIT VI
Management strategy for bacterial diseases, survival and dissemination of bacteria.

Practicals
Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics

Suggested Readings
Bradbury, J.F. and Saddler, G.S. A Guide to Plant Pathogenic Bacteria. CABI.
Frobisher, M. 1944. Fundamentals of Bacteriology, W. B. Sauners Company.

PL PATH 504 PRINCIPLES OF PLANT PATHOLOGY (3L+0P) II

Objective
To appraise the principles and methodologies used in Plant Pathology
Theory

UNIT I
Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases, disease caused by phanerogamic parasites

UNIT II
Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development, modern detection methods.

UNIT III
Host parasite interaction, recognition concept and infection, symptomatology, disease development-role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors, induced resistance, Altered plant metabolism as affected by plant pathogens.

UNIT IV
Genetics of resistance; ‘R’ genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

UNIT V
Disease management strategies.

Suggested Readings


PL PATH 505 DETECTION AND DIAGNOSIS OF PLANT DISEASES (1L+2P)

Objective

To impart knowledge on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Theory

UNIT I
Biological, serological and nucleo-based techniques for the detection of virus and virus like pathogens,
UNIT II
Fungal disease diagnosis-symptomatology, collection of samples and their preservation, Koch's postulates, isolation techniques, purification and single spore isolation, inoculation technique and creation of artificial epiphytotics of fungal pathogens, long term storage and preservation of fungal cultures, molecular detection of fungal pathogens, data collection, compilation and scientific writing

UNIT III
Symptoms of bacterial diseases and characteristics of phytopathogenic bacteria, isolation of phytopathogenic bacteria from rhizosphere and phyllospheres, bacterial stains and staining methods, techniques for purification and pathogenicity

Practicals
Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens, preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida. Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of references.

Suggested Readings


PL PATH 506 PRINCIPLES IN PLANT DISEASE MANAGEMENT (2L+1P) II

Objective
To teach strategies and methods of plant disease management.

Theory
UNIT I
Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

UNIT II
Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures.

UNIT III
History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

Practicals
In vitro and in vivo evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

Suggested Readings
Objective

To provide knowledge on major diseases and management of field and medicinal crop diseases

Theory

UNIT I
Diseases of Cereal crops- wheat, barley, rice, pearl millet, sorghum and maize-economic importance, symptoms and disease cycle, epidemiology and management

UNIT II
Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean.

UNIT III
Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

UNIT IV
Diseases of Cash crops- cotton, sugarcane.

UNIT V
Diseases of Fodder legume crops- berseem, oats, guar, lucerne, cowpea.

UNIT VI
Medicinal crops- plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera.

Practicals

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops

Suggested Readings


PL PATH 508 DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS  (2L+1P) I

Objective

To provide knowledge on major diseases of fruits, plantation, ornamental plants and their management

Theory

UNIT I
Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry,
citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm and management of the fruits diseases, post harvest diseases of major fruits in storage and transit

UNIT II
Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

UNIT III
Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, orchids, marigold, chrysanthemum and their management, post harvest diseases of ornamentals in storage and transit.

Practicals
Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops, fruits and ornamental plants Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

PL PATH 509 DISEASES OF VEGETABLES AND SPICE CROPS (2L+1P) II

Objective
To impart knowledge about symptoms, epidemiology of different diseases of Vegetables and spices and their management.

Theory
UNIT I
UNIT II
Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.

UNIT III
Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger.

Practicals
Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Suggested Readings

PL PATH 510/SST 510 SEED HEALTH TECHNOLOGY

Objective
To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/losses and management.

Theory
UNIT I
History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

UNIT II
Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

UNIT III
Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.
UNIT IV
Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical
Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

Suggested Readings

PL PATH 511 CHEMICALS IN PLANT DISEASE MANAGEMENT (2L+1P) I

Objective
To provide knowledge on the principles and use of chemicals in plant disease management in different crops

Theory
UNIT I
History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals.

UNIT II
Classification of chemicals used in plant disease control and their characteristics.

UNIT III
Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals.

UNIT IV
Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

UNIT V
Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides.

UNIT VI
General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practicals
Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, bactericides and nematicides; in vitro evaluation techniques, preparation of different
concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals

**Suggested Readings**

Farm Chemicals Handbook. (A global guide to crop protection produced yearly with information on all pesticides plus fertilizers, sources and regulatory information. Available at www.meisterpro.com)


---

**PL PATH 512 ECOLOGY OF SOIL-BORNE PLANT PATHOGENS**

**Objective**

To impart knowledge on soil-plant disease relationship.

**Theory**

UNIT I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents.

UNIT II

Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

UNIT III

Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

**Practicals**

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms. Isolation and identification of different biocontrol agents.
Suggested Readings


PL PATH 513 DISEASE RESISTANCE IN PLANTS (2L+0P) III

Objective

To impart knowledge on disease resistance mechanisms in plants.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

UNIT II

Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Suggested Readings


Garraway, M.O. 1984. *Fungal nutrition and physiology*, Evans, Robert Church, Wiley.


**PL PATH 514  INSECT VECTOR OF PLANT VIRUSES AND OTHER PATHOGENS**

*(1L+1P) III*

**Objective**

Provide knowledge on transmission of viruses by vectors, their biological & molecular interaction and management

**Theory**

UNIT I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

UNIT II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

UNIT III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

UNIT IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

UNIT V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

**Practicals**

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors-aphids, leafhoppers and whiteflies.

**Suggested Readings**


Objective
To provide knowledge on principles, methods, mechanism of bio-control agents and their use against plant diseases

Theory
UNIT I
Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

UNIT II
Types of biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

UNIT III
Characterization and evaluation of bioagents, case example of successful bioagents (bacterial and fungal bioformulation), variability and characterization of bioagents important characteristics like competitive saprophytic ability, pesticide resistance

UNIT IV
Commercial production of antagonists, Improvisation, genetic engineering, delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practicals
Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen in vitro and in vivo conditions. Study of cfu/g.

Suggested Readings

Boland, G.J. and David, L.1998. Plant microbe interactions and Biological Control. Kuykendall Marel Dekker, INC.


Objective

To impart knowledge to the students on principles and practices of integrated disease/pest management in different crops.

Theory

UNIT I
History, concept and philosophy of IDM/IPM, Current status (National and International) of IPM implementation.

Agricultural Pests of national importance, Major past epidemics, Survey and Surveillance and crop loss assessment; Important Weeds and their management, Agroecosystems, habitat management and conservation of natural enemies and their significance in IDM/IPM, Cultural, Mechanical and Physical Control Measures, genetic resistance / GM crops with special emphasis on cotton, rice, maize, soybean, tomato, canola etc. scouting / Economic Injury Levels / Action thresholds / Pheromone Monitoring and mass trapping of pests of rapeseed mustard, pearl millet, vegetable and fruits

UNIT II
Bio-pesticides / bio-agents / botanicals / Quality parameters, registration, mass production and their integrated field use against different insect pests/diseases/nematodes etc.

UNIT III

UNIT IV
Concept of environmental Impact Quotient (EIQ), regulatory and Quarantine Measures, Quality control of IPM Inputs, forecasting of important pests in the country and Pest Risk Analysis

UNIT IV
Base line studies for identification of crop based problems and socio-economic benchmarks; synthesis and development of IDM/IPM modules, data recording, on-farm validation and promotion of IPM, including important case studies and impact analysis, expert Systems in IDM/IPM, On-line Monitoring, role of media and information technology including Networking solutions; future trends in Pest management

Practicals

Diagnosis of key pests and their natural enemies, demonstration of field preparation, cultural practices such as solarization / mulching etc., pesticide dosage calculations and Economic threshold levels for major pests; determination of Environmental Impact Quotient (EIQ), preparation methods for Neem based and other locally produced IPM inputs/formulations and their use, bioassay / field evaluation methods for major biocontrol agents and other eco-friendly inputs, Scouting/Agroecosystem analysis and use of traps / lures mass production technologies for bioagents, exercises in synthesis of IDM/IPM modules, procedures and methodology for IDM/IPM validation/implementation of IDM/IPM programmes: collection of baseline information, field Excursion to IDM/IPM validation sites/fields, rice, vegetables, cotton, statistical Procedures in IPM, Forecasting/
Forewarning / Simulation Models, use of Information Technology in IDM/IPM and decision support system, exercise in Pest Risk Analysis, GIS/GPS in digitization of hotspot maps

Suggested Reading

Ca, Romeno and Rehman. T. Elsevier. 2003. Multiple criteria analysis for Agricultural decision. NY.
Koul, O., Dhaliwal, G.S. and Cuperus, G.W. 2004. Integrated Pest Management. CABI.
Quality Control and Production of Biological Control agents: Theory and Test Procedures. CABI.
Singh, Amerika, Sardana, H.R. and Sabir, N. 2004. Validated IPM technologies. NCIPM, (Eds.) New Delhi,

PL PATH 517 MUSHROOM PRODUCTION TECHNOLOGY (2L+1P) II

Objective

Biodiversity in mushroom fungi, edible, poisonous and medicinal mushrooms. Structure and classification of mushrooms and their economic importance. Spawn production technology and cultivation of different types of mushrooms under seasonal and environmentally controlled conditions.

Theory

UNIT I
Historical development of mushroom cultivation and present status, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.

UNIT II
Life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.

UNIT III
Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.
UNIT IV
Facilities for setting up mushroom farm for seasonal and environmentally control cultivation, requirement and maintenance of temperature, relative humidity, CO\textsubscript{2}, ventilation in cropping rooms, cultivation technology of \textit{Agaricus bisporus}, \textit{Pleurotus} sp., \textit{Calocybe indica}, \textit{Lentinus edodes} and \textit{Ganoderma lucidum}.

UNIT V
Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practicals
Preparation of spawn, compost, spawning, casing, harvesting and post harvest handling of edible mushroom; identification of various pathogens, competitors of various mushroom

Suggested Readings

PL PATH 518 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES (2L+1P) III

Objective
To provide knowledge with the principles of epidemiology and its application in disease forecasting.

Theory
UNIT I
Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis.

UNIT II
Common and natural logarithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens.

UNIT III
Survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV
Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.
Practicals
Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, computerized data analysis, function fitting, model preparation and validation.

Suggested Readings


PL PATH 519 POST HARVEST DISEASES (2L+1P) III

Objective
To provide knowledge on post harvest diseases, factors governing post harvest problems, stages of diseases development, integrated approach in disease management and quality control.
Theory

UNIT I
Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as preharvest and post-harvest, merits and demerits of biological/phytoextracts in controlling post-harvest diseases.

UNIT II
Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.

UNIT III
Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists. Isolation, characterization and maintenance of pathogens, role of different storage.

UNIT IV
Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarius for each product and commodity.

Practicals
Isolation characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens in vivo and in vitro conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested Readings

PL PATH 520 PLANT QUARANTINE (2L+0P) III
(To be operated by NBPGR)

Objective
To provide knowledge on the principles and the role of Plant Quarantine at National and International level.
Theory

UNIT I
Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

UNIT III
Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfection/salvaging of infected material.

UNIT IV
WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

PL PATH 521/AC 512/ENT 512/NEMA 513/MB 512 NANOTECHNOLOGY IN CROP PROTECTION (2L+1P) II

Objective
To enable students to acquire expertise and skill to develop agrochemical formulations with nanoparticles and acquaint them with nanotechnology

Theory

UNIT I

UNIT II
Effect of bioactive nano-materials on insect pests and beneficial insects.

UNIT III
Different types of nano compounds and their use in the management of plant disease incited by pathogenic fungi, bacteria and viruses with special reference to copper, sulfur etc, Interaction of bioactive nano-materials on plant pathogens including fungi, bacteria, virus etc.
UNIT IV
Nematodes: Plant pathogenic and entomopathogenic nematodes, life cycle, Efficacy of nano chemicals against nematodes, Biotoxins from Xenorhabdus and Photorhabdus Identification and quantification of biotoxins effective in nano-doses.

UNIT V
Microbes: Microbes of agricultural importance. Life cycle: genesis, growth, reproduction, identification and quantification. Nanotechnological application in microbiology

UNIT VI

Practicals
Identifications, and quantification of agricultural chemicals in conventional and nano formulations, Size determination, Quality of nano-formulations: Cold test, emulsion stability test, and suspensibility tests

Suggested Reading

PL PATH 601 ADVANCED MYCOLOGY (2L+1P) II

Objective
To provide deep insight of fungal systematic, fungal structures and their role in identification. Recent developments in fungal classification including chemo and molecular taxonomy. Genetics and variability among fungi and their economic and industrial importance.

Theory
UNIT I
General introduction, historical development and advances in mycology.

UNIT II
Recent taxonomic criteria, morphological criteria for classification. Serological, Chemical (chemotaxonomy), Molecular and Numerical (Computer based assessment) taxonomy.

UNIT III
Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi.

UNIT IV
Population biology, pathogenic variability/vegetative compatibility.

UNIT V
Practicals


Suggested Readings


PL PATH 602 ADVANCED VIROLOGY (2L+1P) II

Objective

To provide knowledge in recent advancement in study of plant viruses and their management

Theory

UNIT I
Introduction to Advanced Virology Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains.

UNIT II
Production PAb and hybridoma, nucleo-based diagnostic technique, Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction, Rolling Circle replication.

UNIT III
Genome organization, gene expression in Gemini viruses, mechanism of replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-, poty-, bromo, cucummo, ilar and tospoviruses.

UNIT IV
Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions.

UNIT V
Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI
Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.
Practicals

Purification of virus(es), SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance, nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

Suggested Readings


PL PATH 603 ADVANCED BACTERIOLOGY (2L+1P) II

Objective

To provide advanced knowledge on characterization, identification of bacteria, pathogenesis, mechanism of disease development and recent approach in bacterial disease management.

Theory

UNIT I  
Nomenclature, characteristics and classification of bacteria, Ultrastructures and biology of bacteria.

UNIT II  
Fastidious bacteria, mechanism of soft rot (*Erwinia* spp.) development, mechanism of crown gall formation (*Agrobacterium tumefaciens*), Mechanism of wilt (*Ralstonia solanacearum*) development.

UNIT III  
Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development, epidemiology in relation to bacterial plant pathogens

UNIT IV  
Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, effector protein, survival, colonization ability of bacteria, bacterial EPS and their role as disease determinant

UNIT V  
Plasmid biology, molecular variability among phytopathogenic procarya and possible host defense mechanism(s), genetic engineering for management of bacterial plant pathogens-gene silencing, RNAi technology.

UNIT VI  
Polyclonal and monoclonal antibodies against phytopathogenic bacteria, PCR based detection of plant pathogenic bacteria, use of advanced techniques in quarantine, PRA, development of diagnostic kit.

UNIT VII  
Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management, endosymbionts for host defence.
Practicals

Pathogenic studies and race identification; plasmid profiling of bacteria; fatty acid profiling of bacteria; RAPD profiling of bacteria and variability status; Endospore, Flagiler staining; test for secondary metabolite production, cyanides, Extracellular Polymeric Substance, siderophore; specific detection of phytopathogenic bacteria using species/pathovar specific primers, basic techniques in diagnostic kit development, molecular tools to identify phytoendosymbionts

Suggested Readings


PL PATH 604 MOLECULAR BASIS OF HOST PATHOGEN INTERACTION (2L+1P) III

Objective

To provide knowledge on host pathogen interaction and its application at molecular level.

Theory

UNIT I
Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.

UNIT II
Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction.

UNIT III
Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral induced gene silencing.

UNIT IV
Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

UNIT V
Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.
Practical

Protein, DNA and RNA isolation, Plasmids extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation.

Suggested Readings


PL PATH 605 PRINCIPLES AND PROCEDURES OF CERTIFICATION (1L+0P) III

*(Course to be taken in NBPG)*

Objective

To provide the information on regulation of pathogens for import/export as well as movement in the country

Theory

UNIT I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control.

UNIT II

Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health etc.

UNIT III

Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. Methods used in certification of seeds, vegetative propagules and *in vitro* cultures. Accreditation of seed testing laboratories. Role of seed/planting material health certification in national and international trade

Suggested Readings


Objective
To provide knowledge on regulations of import/export of plant material, sanitary and phytosanitary issues, quarantine.

Theory
UNIT I
History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

UNIT II
National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III
Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings

Objective
To familiarize the students with different abnormalities caused by insect, pathogens, nematodes, weeds and imbalance use of plant nutrients. Also, develop the confidence in them to handle plant protection problems faced by the farmers/growers.

Theory
UNIT I
Introduction to the plant health clinic: concept, importance, infrastructure etc. Identification of important beneficial insects (parasitoids, predators, pollinators and others of economic importance). Principles of pest management.

UNIT II
Injury caused by different type of insects to the plants by feeding, oviposition, sheltering or any other means.

UNIT III
Screening of damaged material for establishing the identity of casual agent viz.; insect, microbe, nematode, mites, rodents, vertebrates, competitive plant as well as nutritional or any other physiological disorders.
UNIT IV
Important Plant parasitic nematodes and their symptoms produced on major field, fruit, ornamental and plantation crops.

UNIT V
Damage caused by important nematodes causing root knot, ear-cockle and other diseases in different crops and their management.

UNIT VI
Molecular approaches for viral, bacterial and fungal diseases with regards to diagnostics and management.

UNIT VII
Symptoms of diseases caused by imbalances in plant nutrients

UNIT VIII
Identification of problematic weeds and their management.

Practicals
Identification of symptoms caused by important insect pests. Preparation of pesticide stock solution and safe handling of agrochemicals. Disease diagnostic kit and related basic facilities. Identification of common diseases. Types of plant parasitic nematodes, demonstration of pathogenicity of root knot nematode on tomato and vegetables, Root knot index calculation. Symptoms of Molya disease and Ear-cockle disease of wheat. Management methods to manage nematode diseases in crop

Suggested Readings
## 20 Plant Physiology

### TRIMESTERWISE DISTRIBUTION OF COURSES

#### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 006</td>
<td>CROP MORPHOLOGY AND PHYSIOLOGY</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PP 501</td>
<td>PRINCIPLES OF PLANT PHYSIOLOGY-I</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>PP 502</td>
<td>PLANT DEVELOPMENTAL BIOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PP 506</td>
<td>PHYSIOLOGY OF CROP PLANTS- II</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PP 507</td>
<td>PHOTOSYNTHESIS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PP 601</td>
<td>TECHNIQUES IN PLANT PHYSIOLOGY -I</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>PP 602</td>
<td>RESPONSES OF PLANTS TO ABIOTIC STRESSES</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP 503/ES 503</td>
<td>GLOBAL CLIMATE CHANGE AND AGRICULTURE</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PP 504</td>
<td>HORMONAL REGULATIONS OF PLANT GROWTH AND DEVELOPMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PP 505</td>
<td>PHYSIOLOGY OF GROWTH AND YIELD</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PP 508</td>
<td>PHYSIOLOGY OF PLANT MINERAL NUTRITION</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>PP 603</td>
<td>PRINCIPLES OF PLANT PHYSIOLOGY – II</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PP 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP 509</td>
<td>PHYSIOLOGY OF CROP PLANTS-I</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PP 604</td>
<td>TECHNIQUES IN PLANT PHYSIOLOGY -II</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>PP 605</td>
<td>PLANT METABOLISM</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PP 607/AG 607</td>
<td>PHYSIOLOGY AND BIOCHEMISTRY OF HERBICIDES ACTION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PP 608/SST 608</td>
<td>PHYSIOLOGY OF SEEDS</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
PP 617/ PHYSIOLOGY OF RIPENING AND SENESCENCE 2 1
PHT617
PP621/ GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS 3 2
HORT 621
PP 691 SEMINAR 1 0

Core Courses

M.Sc.: PP 501, PP 505, PP 508, PP 601, PP 603 and BIO 501
Ph.D.: PP 505, PP 602 and PP 605
PLANT PHYSIOLOGY

Major Field : Plant Physiology
Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 006 CROP MORPHOLOGY AND PHYSIOLOGY (1L+1P) I

Objective

To acquaint non-agriculture students with basics of plant morphology and physiological processes occurring in the plant.

Theory

UNIT I
Plant cell structure and function, morphology and anatomy of root, stem, leaf and flower
UNIT II
Pollination, fertilization, embryology, seed and its physiology.
UNIT III
Plant growth and development, plant growth regulators
UNIT IV
Water relations, photosynthesis, respiration and mineral nutrition in plants

Practicals

Anatomical features of root, stem, leaf and flower, cell structure, taxonomical description of flower, emasculation and artificial pollination, growth analysis, water relations, measurements of chlorophylls, photosynthesis and respiration, nutrient deficiency symptoms in crop plants.

Suggested Readings

PP 501 PRINCIPLES OF PLANT PHYSIOLOGY-I
(4L+1P) I

Objective
To acquaint the students with the basic concepts of plant physiology and their application in agriculture.

Theory

UNIT I
Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

UNIT II

UNIT III

UNIT IV
Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT V
UNIT VI

UNIT VII

Practicals

Suggested Readings

PP 502 PLANT DEVELOPMENTAL BIOLOGY  (3L+1P) I
Objective
To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory
UNIT I
Shoot, leaf and root development – Organization of shoot/root apical meristem
UNIT II
Floral induction and development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation
UNIT III
Senescence and programmed cell death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.
UNIT IV
Photomorphogenesis, phototropism, photonasty and leaf movement, chlorophyll synthesis, light control of plant development – Discovery of phytochromes and cryptochromes, their structure,
biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

UNIT V
Special aspects of plant development and differentiation – Regeneration and totipotency; Organ differentiation and development, Sex determination in plants; Self-incompatibility and its genetic control; Heterosis and apomixis.

Practicals

Suggested Readings


PP 503/ES 503 GLOBAL CLIMTE CHANGE AND AGRICULTURE (2L+IP)

Objective
To impart theoretical and practical knowledge about the evidence, causes and impact of climate change and its adaptation and mitigation options

Theory
UNIT I
Definition and concept of climate change and variability; global warming and dimming; science and politics of climate change and international conventions; evidence, scenario and causes of climate change

UNIT II
Greenhouse gases and mechanism of their production and emission from various agro-ecosystems, source and sinks of GHG; warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases
UNIT III
Impact assessment of rise in atmospheric temperature and CO₂ on growth, physiological processes, productivity and quality of different crops, soil health, water availability, insect pest dynamics, crop-weed competition, milk and inland and marine fish production; climate change and loss of biodiversity; spatial and temporal changes in agricultural production in context of climate change.

UNIT IV
Evidence and causes of global dimming; causes of global dimming; impact assessment of global dimming on crop productivity, quality and crop-pest interaction.

UNIT V
Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on crops. International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints and govt. strategies and policies on climate change management.

Practicals
Measurement of CO₂ from crop fields, measurement of CH₄ from crop fields, measurement of N₂O from crop fields, measurement of O₃ from crop fields, recent techniques for assessing the impact of high temperature on crops, recent techniques for assessing the impact of CO₂ fertilization on crops, recent techniques for assessing the impact of elevated O₃ on crops, modelling impact of high temperature and CO₂ on crop yield, modelling impact of high temperature on soil and water, modelling impact of high CO₂ on soil and water.

Suggested Readings
IPCC Assessment Report 2007
Climate change Journal Climate Change: Source, impact and policy, Proceeding of 2nd World Climate Conference. Ed. by J. Jager and H.L. Ferguson, Cambridge University Press, 1993
Greenhouse gas emission from agricultural system, Published by IPCC-USEPA
Climate change and global crop productivity ed. by K.R. Reddy and H.F. Hodges
CABI Publishing

PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT
(3L+1P) II

Objective
To apprise the students about structure and function of plant growth regulators.

Theory
UNIT I
UNIT II
Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene and Brassinosteroids. Hormone mutants and transgenic plants in understanding role of hormones.
UNIT III
UNIT IV
Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practicals
Quantification of hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue.
Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins-bioassays-GA effect on germination of dormant seeds, Cytokinin- bioassays- estimation using immunoassay technique, cytokinin effect on apical dominance and senescence, ABA bioassays estimation using immunoassay technique. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico- chemical techniques- effect on breaking dormancy in sunflower and groundnut.

Suggested Readings

PP 505 PHYSIOLOGY OF GROWTH AND YIELD (2L+1P) II

Objective
To impart knowledge regarding growth and yield analysis of crops, yield models-and yield prediction.

Theory
UNIT I
Crop growth analysis and techniques, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation.
UNIT II
Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of degree days and crop growth duration.
UNIT III
Canopy architecture, light interception, attenuation of light through crop canopy, energy use efficiency of different canopies. LAI, LAD. Concept of critical and optimum LAI. Plant ideotypes,

UNIT IV
Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index.

UNIT V
Yield structure analysis, theoretical and actual yields. Simple physiological yield models and yield prediction.

Practicals

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA partitioning efficiency HI, measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized. Computer applications in plant physiology, crop productivity and modeling.

Suggested Readings


PP 506 PHYSIOLOGY OF CROP PLANTS – II (2L+0P) I

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT I
Origin, evolution and distribution of crop, adaptability of crop to different agro climatic conditions. Specific case studies: Oilseeds: rapeseed mustard, groundnut and sunflower. Pulses: mungbean, pigeonpea, soybean cowpea and chickpea

UNIT II
Crop characteristics-growth and development (both vegetative and reproductive), physiological processes governing productivity
UNIT III
Influence of climatological factors (water, temperature, photoperiod and light) on crop growth attributes and physiological processes.

UNIT IV
Special problems of each crop, crop ideotype concept and source sink relationship

Suggested Readings

PP 507 PHOTOSYNTHESIS (2L+0P) I

Objective
To impart knowledge about physiological and molecular aspects of photosynthesis in plants.

Theory
UNIT I
Historical perspective, primary processes in plant photosynthesis, energy transfer, fluorescence, biogenesis and molecular genetics of chloroplast, chloroplast structure and function, chlorophyll biosynthesis
UNIT II
Pigment protein complexes, photosynthetic electron transport, ATP synthesis, oxygen evolution
UNIT III
Carbon fixation, evidences for carbon fixation cycles, metabolism of carbon compounds, photo-regulation of enzymes of carbon fixation, crassulacean acid metabolism,
UNIT IV
Photorespiration and RuBP carboxylase/oxygenase,
UNIT V
Environmental regulation of photosynthesis, genetics and evolution of photosynthesis, photosynthesis and crop productivity, conceptual approaches of expressing C4 photosynthesis genes in C3 spp., biotechnological approaches for improving photosynthetic rate, carbon isotope discrimination concept.

Suggested Readings
Objective
To impart knowledge about physiological and molecular aspects of mineral nutrition in plants.

Theory
UNIT I

UNIT II
Characteristics of ion uptake by the roots. Interaction between the ions, radial transport across the roots, ion uptake along the roots, mechanisms of ion release into the xylem, xylem transport, phloem transport, nutrient cycling between shoots and roots, remobilization of mineral nutrients.

UNIT III
Uptake of gases through stomata, uptake of solutes, foliar application of mineral nutrients, leaching of mineral elements from leaves. Availability in soil/atmosphere and crop requirements, nutrient release and immobilization, nitrification and denitrification.

UNIT IV
Translocation and metabolic functions of macro and micro elements, optimum requirement, visible morphological and anatomical effects, cellular and sub-cellular effects, effect on metabolism, beneficial elements.

UNIT V
Growth and morphology of roots, architecture, allelopathy, variation in nutrient use efficiency and in nutrient requirements, nutrient toxicity response

UNIT VI
Ionomics and transporters, screening and selection techniques, molecular regulation and breeding for improved mineral ion transport/uptake and nutrient use efficiency.

Practicals
Diagnosis by visible symptoms, plant analysis, histochemical and biochemical methods, plant analysis vs. soil analysis, treatment of disorders, importance of root characteristics.

Suggested Readings
PP 509 PHYSIOLOGY OF CROP PLANTS-I  

Objective  
To impart knowledge of physiological aspects of different crop plants.

Theory  
UNIT I  
Origin, evolution and distribution of crop, adaptability of crop to different agro climatic conditions (specific case studies of important cereal crops like wheat, rice, barley, maize, sorghum and minor millets).

UNIT II  
Crop characteristics-growth and development (both vegetative and reproductive), physiological processes governing productivity

UNIT III  
Influence of climatological factors (water, temperature, photoperiod and light) on crop growth attributes and physiological processes.

UNIT IV  
Special problems of each crop, crop ideotype concept and source sink relationship.

Suggested Readings  

PP 601 TECHNIQUES IN PLANT PHYSIOLOGY-I  

Objective  
To impart recent practical training to study various physiological processes in plants.

Practicals  
Measurement of osmotic potential, water potential, relative water content, principles of psychrometry and pressure chamber, measurement of transpiration, photosynthesis by infra red gas analyzer, A/Ci curves, respiration, light interception, ion leakage, effect of ABA on stomatal conductance, isolation and separation of photosynthetic pigments, principles of spectrophotometry and colorimetry, determination of the stomatal index of the leaf, basic methods pertaining to plant growth analysis, estimation of amino acids, proteins, sugars, oil content, ion leakage, estimation of nitrate content, activities of nitrate reductase and glutamine synthetase, effect of water potential and temperature on seed germination.

Suggested Readings  
Objective
To apprise the students regarding abiotic stress to plant and its physiological and molecular basis.

Theory
UNIT I
Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress. Interactions between biotic and abiotic stresses.

UNIT II
Drought stress: Physiological, biochemical and molecular mechanism, strategies to alleviate drought stress, signal transduction mechanism, Drought in relation to MAS and QTL, Role of ROS/antioxidants, ABA, Cytokinin and other hormones.

UNIT III

UNIT IV
Salinity stress: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, breeding for salt resistance.

UNIT V
Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of phytochelatins (heavy metal binding proteins).

Practicals
Determination of water status of plants: RWC, pressure chamber and psychrometry, determination of osmotic potential by osmometer, stomatal conductance, canopy temperature by infra-red thermometer, creation of nutrient deficiency and assessment of root characteristics, chlorophyll content index by chlorophyll meter, root biomass by root capacitance meter, heat tolerance and membrane integrity.

Suggested Readings
PP 603 PRINCIPLES OF PLANT PHYSIOLOGY-II

Objective
To impart knowledge cell structure and function and physiological aspects of nitrogen metabolism, respiration, lipids, enzymes and secondary metabolites in plants.

Theory
UNIT I
Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell organelles, i.e. mitochondria, chloroplast, microbodies, vacuole, nucleus, ER; cell membrane structure and function. Protein trafficking and import into organelles.

UNIT II
Nitrogen fixation, nitrate reduction and ammonia assimilation, amino acids and ureides biosynthesis.

UNIT III
Fatty acid and lipid biosynthesis and degradation in membranes, plastids and endoplasmic reticulum.

UNIT IV
Respiration- energetics of respiration, formation of ATP and reducing power in the light, photophosphorylation, anabolic and catabolic role of citric acid cycle, respiration of lipids, proteins, carbohydrates and amino acids, physiological function of alternate pathway, dark respiration in green cells, fermentation.

UNIT V
Enzymes definition and classification, enzyme kinetics. Secondary metabolites-terpenes, phenols and alkaloids.

Suggested Readings

PP 604 TECHNIQUES IN PLANT PHYSIOLOGY- II (1L+3P) III

Objective
To impart recent practical training to study various physiological processes in plants.

Practicals
Enzyme estimation and purification procedure, principal and operation of spectrophotometer, infra red gas analyzer, chlorophyll fluorescence, use of stable and radio isotopes, gas chromatography, high pressure liquid chromatography, nitrogen estimation by kjeldhal method, micronutrient estimation by AAS, gel electrophoresis, western blotting, in vitro culture techniques, isolation of genomic and plasmid DNA, isolation and quantification of RNA, PCR and RT-PCR techniques and concept of phytotron.
Suggested Readings


PP 605 PLANT METABOLISM (3L+0P) III

Objective
To impart advance knowledge of carbohydrate, lipid, and nitrogen metabolism.

Theory
UNIT I
Biosynthesis and degradation of hexose phosphate, biosynthesis of sucrose and its utilization, translocation, breakdown and storage, respiratory metabolism, glycolate pathway, pentose phosphate pathway, localization and evidence for its operation.

UNIT II
Starch synthesis, accumulation and breakdown in seeds during germination and in leaves, regulation of starch metabolism. Organic acid synthesis and its regulation, crassulacean acid metabolism and its regulation.

UNIT III
Classification of lipids and fatty acids - major, minor and unusual fatty acids. Fatty acids synthesis, chain elongation and unsaturated fatty acid biosynthesis. Lipid biosynthesis - triglycerides, phospholipids, glycolipids. Membrane lipid structure and function. Fat metabolism during germination and seed development- Beta oxidation, glyoxylate cycle, alpha oxidation.

UNIT IV
Nitrogen cycle, nitrogen fixation, nitrification and denitrification, nitrate and ammonia assimilation and regulation, transamination, amino acid synthesis, non-protein amino acids synthesis, nitrogen redistribution in cell, nitrogen inter conversion and transport during plant development, nodule metabolism, protein synthesis and its metabolism, sulphur metabolism. Biosynthesis and breakdown of nucleic acids.

Suggested Readings

Objective

To provide the students up-to-date knowledge on herbicide physiology and biochemistry and recent approaches in weed management including biotechnological methods.

Theory

UNIT I
Weed biology and ecology; allelopathy and allelochemicals; management options; weed economic thresholds; use of models for improved competition studies.

UNIT II
Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides, and impact of environmental and plant factors.

UNIT III
Physiological, biochemical and molecular mechanism of action of different groups of herbicides. Metabolic pathway of herbicide degradation in plants and soil.

UNIT IV
Selectivity of herbicides - physiological and molecular mechanism; herbicide non-target toxicity. Herbicide residue and its management in cropping systems.

UNIT V

UNIT VI
Herbicide resistant crops - prospects, molecular and tissue culture approaches for development of herbicide resistant crops.

List of Practicals


Suggested Readings


**PP 608/SST 608 PHYSIOLOGY OF SEEDS**

(2L+1P) III

**Objective**

To apprise students regarding seed germination, dormancy, physiological processes involved in regulation of seed development and physiological processes governing seed quality and its survival.

**Theory**

**UNIT I**

Introduction, importance of seeds, seed structure and function, chemical composition of seeds, seed development and maturation - physiological and molecular aspects; hormonal regulation of seed development, desiccation tolerance and sensitivity in relation to seed longevity, LEA protein.

**UNIT II**

Physiological and biochemical changes during seed maturation, assimilate movement to seeds, storage of carbohydrates, proteins and fats in seeds and biosynthesis.

**UNIT III**

Seed germination, factors influencing, breakdown and mobilization of stored products, carbohydrates, fat, protein, respiration and pathways of interconversion, control processes in the mobilization of food reserves, hormonal control of germination.

Seed dormancy, different types, environmental influences, mechanisms and control including phytochrome, method for breaking seed dormancy.

**UNIT IV**

Factors influencing loss of seed viability during storage, physiological and biochemical changes associated with seed ageing, theories of seed ageing, seed viability and its evaluation, seed storage, protection from water, temperature and contaminants, desiccation tolerance and sensitivity in relation to seed longevity.
UNIT V
Seed vigour, concept, importance, measurement; seed invigoration, methods, physiological and molecular basis of seed invigoration, effect of vigour on field emergence and yield, seed hardening.

Practicals
Chemical composition of seeds, testing seed vigour and viability, breaking of seed dormancy and germination, seed invigoration and priming treatments, accelerated ageing treatments, seed imbibition and leakage, enzyme activities during germination, sink ability of ovules, seed respiration.

Suggested Readings

PP 617/PHT 617 PHYSIOLOGY OF RIPENING AND SENESCENCE (2L+1P) III

Objective
To impart knowledge about physiological and molecular changes during senescence and ripening.

Theory
UNIT I
Environmental factors influencing senescence, ripening and post harvest life of fruits, flowers and vegetables.
UNIT II
Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products.

UNIT III
Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

UNIT IV
Ethylene biosynthesis, perception and molecular mechanism of action. Regulatory role of ethylene in senescence and ripening. Biotechnological approaches to manipulate ethylene biosynthesis and action.

UNIT V

Practicals
Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening, determination of reactive oxygen species and scavenging enzymes, Measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, Cellulases, pectin methyl esterases, polygalacturonase, etc.

Suggested Readings

**PP 621/ HORT 621 GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS (3+2) III**

Objective
To teach about the growth and development processes of horticultural crops, knowledge of basic physiological and molecular processes affecting growth, flowering and production of quality produce.
Theory

UNIT I
Defining growth and development; physical and physiological aspects of growth, germination, juvenility, root and leaf differentiation,

UNIT II
Flowering, fruit set and development, fruit maturity and ripening, abscission, senescence of horticultural crops: Factors influencing flowering, photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.

UNIT III
Biosynthesis of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassino-steroids, synthetic growth inhibitors, morphactins, methyl jasmonates, salicylic acid, polyamines, etc. their mode of action.

UNIT IV
Role of plant growth promoters and inhibitors on physiological processes like seed and bud dormancy, fruit thinning, fruit drop, sex expression modification in cucurbits and induction of parthenocarpy; plastochrom,

UNIT V
Water relations, stress physiology in relation to drought, temperature and salts, quality improvement in fruits, vegetables and flowers.

Practicals
Visit to Physiology laboratory; Testing of seed germination and breaking dormancy in seeds; Study on fruit set and fruit growth. Estimation of tissue macro- and micro-nutrients; Estimation of enzymes; Estimation of chlorophyll, carotenoids and other pigments. Bioassay of plant hormones; Use of HPLC and GC for estimation of phyto-hormones; Application of GRs in fruit thinning and control of fruit drop; sex expression and induction of parthenocarpy in horticultural crops; Use of PGRs in ornamental crops. Light manipulation in protected cultivation.

Suggested Readings
Moore, T.C. *Biochemistry and physiology of plant hormone.*
## TRIMESTERWISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT 501</td>
<td>Fundamentals of Post Harvest Technology of Horticultural and Arable Crops</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 502</td>
<td>Applied Food Engineering</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 503</td>
<td>Laboratory Techniques for Food Crops</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PHT 504</td>
<td>Technology of Plantation Crops and Spices</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PHT 602</td>
<td>Process Plant Design</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PHT 603</td>
<td>Advances in Food Processing and Quality Management</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 601/</td>
<td>Export Oriented Horticulture</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>HORT 601</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHT 630/</td>
<td>Heat and Mass Transfer</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AE 630</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHT 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT 511</td>
<td>Technology of Milk and Milk Products</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PHT 611</td>
<td>Post Harvest Processing of Cereals, Pulses and Oilseeds</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PHT 612</td>
<td>Post Harvest Management of Horticultural Crops</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 613</td>
<td>Food Chemistry</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PHT 614</td>
<td>Principles and Practices of Food Handling and Packaging</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AGR 009</td>
<td>Principles of Post Harvest Technology</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PHT 631/</td>
<td>Drying and Dehydration</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 631</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHT 691</td>
<td>Seminar</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT 521</td>
<td>Technology of Meat, Poultry and Fish Processing</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PHT 621</td>
<td>Processing of Horticultural Crops</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHT 624</td>
<td>Advanced Storage Engineering</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
PHT 623  DESIGN OF FOOD PROCESSING EQUIPMENTS  2  1  
PHT 617/ PHYSIOLOGY OF RIPENING AND SENESCENCE  2  1  
PP 617  
PHT 530/ ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS  2  1  
AE 530  
PHT 622/ VALUE ADDITION IN ORNAMENTAL CROPS  1  1  
FLA 622  
PHT 691  SEMINAR  1  0  

Core Courses  
M.Sc.: PHT 501, PHT 502, PHT 503  
Ph.D.: PHT 603, PHT 614
POST HARVEST TECHNOLOGY

Major Fields:  
Post Harvest Technology of Horticultural Crops  
Post Harvest Engineering and Technology

Minor Field:  
Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.  
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR-009 PRINCIPLES OF POST HARVEST TECHNOLOGY (IL+1P) II

Objective
To acquaint with the basics of post harvest management of perishables and durable crops.

Theory
UNIT I  
History and role of post harvest technology; principles and methods of food preservation.

UNIT II  
Post harvest technology of durables (rice processing, wheat milling, oil extraction, pulse milling etc.); Post harvest handling (harvesting, sorting, grading and packaging) of perishables i.e. fruits, vegetables and flowers.

UNIT III  
Food storage systems; ripening and senescence of horticultural crops; Post harvest treatments for quality retention of horticultural crops; spoilage of fruits & vegetables, methods to reduce decay.

UNIT IV  
Processing of fruits and vegetables (canning, dehydration, freezing and value added products).

Practicals
Acquaintance with basic PHT equipment, Determination of TSS and acidity, Packaging, Visual identification of spoilage, Specific gravity, and Texture analysis, On- Farm storage of fruits and vegetables, Respiration, Processing of F&V to value added products, Demonstration on PHT of cereals, pulses.

Suggested Readings
Preservation of Fruits & Vegetables by Siddappa et al. 1999. ICAR, New Delhi  
PHT 501 FUNDAMENTALS OF POST HARVEST TECHNOLOGY OF HORTICULTURAL & ARABLE CROPS

Objective

To acquaint with different methods of food preservation, different groups of micro-organisms associated with food, sensory quality parameters, and methods of sensory evaluation of foods.

Theory

UNIT I
Composition of food and nutritive value of horticultural and arable crops. Methods of preservation, Contamination and spoilage of foods, spoilage of fresh fruits, vegetables, cereals and other crops, spoilage of various processed products, canned foods, dehydrated and frozen foods, pickles, chutneys and cereal products, intrinsic and extrinsic parameters that affect microbial growth and their control measures.

UNIT II
Classification of microorganisms and their sources in food, various types of fermentation and their utilization, microbial examination of foods. Food borne diseases and poisoning.

UNIT III
Food safety and quality, importance of hygiene and sanitation.

UNIT IV
Importance of micro organisms in industrial fermentation process and production of various by-products, production of vinegar, Fermented beverages, bread and traditional food products.

Practicals


Suggested Readings

James, M.J., Loessner, M.J. and David, A. 2005. Modern Food Microbiology. 7th Ed. Golden Food Science Text Studies

PHT 502 APPLIED FOOD ENGINEERING

Objective

To acquaint with basic principles of Food Engineering and transport processes, and unit operations associated with engineering applications.
Theory

UNIT I
Cleaning of raw food materials and related equipment, sorting and grading methods and equipment,

UNIT II
Size reduction and screening of solid food materials, filtration and separation, centrifugation, extraction and leaching, mixing and emulsification.

UNIT III
Heat processing (blanching, pasteurization and sterilization), Kinetics of biological reactions - kinetics of reactions occurring in processed foods, reaction velocity constant, order of reaction; application of Arrhenius equation to biological reactions, process of heat transfer, modes of heat transfer and overall heat transfer; Fourier's law, heat exchange equipment; determination of the process time based on region of greatest temperature lag; the process equivalence in terms of minutes at 121.1°C, evaporation and freezing- common methods and equipment.

UNIT IV
Drying of food grains, mass transfer, molecular diffusion and diffusivity, handling and storage.

Practicals

Cleaning of food materials, Blanching, pasteurization, and sterilization. Sorting & grading, size reduction, screening, mixing, filtration, centrifugation, extraction and leaching, mechanical extraction of oil, evaporation, freezing, drying, storage.

Suggested Readings


PHT 503 LABORATORY TECHNIQUES FOR FOOD CROPS

Objective

To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labelling.

Theory

UNIT I
Safety aspects of lab, sampling procedure for quantitative analysis, determination of moisture, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce and processed foods, TSS, Sp. gravity, pH and acidity,
UNIT II
Spectrophotometry, nondestructive determination of colour, ascorbic acid, sugars, and starch in food crops.

UNIT III
Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultrafiltration, Application of nuclear techniques in harvested produce.

UNIT IV
Microscopy, Ion leakage as an index of membrane permeability, determination of biochemical components in cereals, pulses and oilseeds. Importance of ethylene, quantitative estimation of rate of ethylene evolution by fruits and vegetables, using gas chromatograph (GC). Micropropagation techniques in horticultural crops, sensory analysis techniques, control of test rooms, products and panel.

Practicals
Determination of moisture, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce and processed foods, TSS, Sp. gravity, pH and acidity; nondestructive determination of colour, ascorbic acid, sugars, and starch in food crops; estimation of rate of ethylene evolution by fruits and vegetables, using gas chromatograph (GC), determination of biochemical components in cereals, pulses and oilseeds.

Suggested Readings
Thompson, A.K. 1995 Post harvest Technology of fruits and vegetables. Blackwell Sciences

PHT 504 TECHNOLOGY OF PLANTATION CROPS AND SPICES (2L+0P) I

Objective
To provide an understanding of the science and technology for processing of coffee, tea, cocoa products and spices.

Theory
UNIT I
Coffee: Occurrence, chemical constituents; harvesting, fermentation of coffee beans; changes taking place during fermentation; drying; roasting process, flow sheet for the manufacture of coffee powder; instant coffee technology; chicory chemistry; quality grading of coffee.
UNIT II
Tea: Occurrence, chemistry of constituents; harvesting; types of tea – green, oolong and CTC; chemistry and technology of CTC tea; manufacturing process for green tea and black tea manufacture; instant tea manufacture; quality evaluation and grading of tea.

UNIT III
Cocoa: Occurrence, chemistry of the cocoa bean; changes taking place during fermentation of cocoa bean; processing of cocoa bean; cocoa powder; cocoa liquor manufacture; chocolates–types, chemistry and technology of chocolate manufacture; quality control of chocolates.

UNIT IV
Major spices: Pepper, cardamom, ginger, chili and turmeric–oleoresins and essential oils; method of manufacture; chemistry of the volatiles; enzymatic synthesis of flavour identicals; quality control; fumigation and irradiation of spices.

UNIT V
Other spices: Cumin, coriander, cinnamon, fenugreek, garlic, mace, clove, mint and vanilla; present trends in synthesis of volatiles; microbial and chemical contaminants, plant suspension cultures.

Suggested Readings

PHT 511 TECHNOLOGY OF MILK AND MILK PRODUCTS (2L+0P) II

Objective
To acquaint with techniques and technologies of testing and processing of milk into various products and by products.

Theory
UNIT I
Present status of milk & milk products in India and Abroad; market of milk, composition of milk of various species, quality evaluation and testing of milk, procurement, transportation and processing of market milk, cleaning & sanitization of dairy equipments. Special milks such as flavoured, sterilized, recombined & reconstituted toned & double toned.

UNIT II
Condensed milk- definition, methods of manufacture, evaluation of condensed & evaporated milk; dried milk- methods of manufacture of skim & whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder.

UNIT III
Cream: Definition, classification, composition, cream separation, sampling, neutralization, sterilization, pasteurization & cooling of cream, evaluation, defects in cream; butter- definition, composition, classification, methods of manufacture, theories of churning, evaluation, defects in butter.
UNIT IV
Ice cream: Definition, composition and standards, nutritive value, classification, methods of manufacture, evaluation, defects in ice cream, and technology aspects of softy manufacture.

UNIT V
Cheese: Definition, composition, classification, methods of manufacture, cheddar, Gouda, cottage and processed cheese, evaluation, defects in cheese. Indigenous milk products, present status, method of manufacture of yoghurt, dahi, khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi etc; probiotic milk products.

Suggested Readings

PHT 521 TECHNOLOGY OF MEAT, POULTRY AND FISH PROCESSING (2L) III

Objective
To provide an understanding of the technology for handling, processing, preservation and by-product utilization of meat, poultry and fish products processing.

Theory
UNIT I
Meat composition from different sources; muscle structure and compositions; post-mortem muscle chemistry; meat colour and flavours; meat microbiology and safety.

UNIT II
Modern abattoirs, typical layout and features, ante-mortem handling and design of handling facilities; hoisting rail and traveling pulley system; stunning methods; steps in slaughtering and dressing; offal handling and inspection; inedible by-products; operational factors affecting meat quality; effects of processing on meat tenderization; abattoir equipment and utilities

UNIT III
Chilling and freezing of carcass and meat; canning, cooking, drying, pickling, curing and smoking; prepared meat products like salami, kebabs, sausages, sliced, minced, corned; intermediate moisture and dried meat products; meat plant hygiene – GMP and HACCP. Packaging of meat products.

UNIT IV
Poultry industry in India, measuring the yields and quality characteristics of poultry products, microbiology of poultry meat, spoilage factors; lay-out and design of poultry processing plants, plant sanitation; poultry meat processing operations, equipment used – defeathering, bleeding, scalding etc.; packaging of poultry products, refrigerated storage of poultry meat, by products – eggs, egg products, whole egg powder, egg yolk products, their manufacture, packaging and storage.
UNIT V
Commercially important marine products from India; product export and its sustenance; basic biochemistry and microbiology; preservation of postharvest fish freshness; transportation in refrigerated vehicles; deodorization of transport systems; design of refrigerated and insulated trucks; grading and preservation of shell fish; pickling and preparation of fish protein concentrate, fish oil and other by products.

Suggested Readings

PH 530/AE 530 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS (2L+1P) III

Objective
To acquaint and equip the students with different techniques of measurement of engineering properties and their importance in the design of processing equipments.

Theory
UNIT I
Biological materials, uniqueness in relation to other materials; physical characteristics viz. dimensions, density, volume, porosity and surface area.

UNIT II
Concept of rheology; rheological equations for stress and strain; visco-elastic characteristics of food materials;

UNIT III
Aerodynamic and hydrodynamic properties; thermal, electrical and optical properties.

UNIT IV
Applications of engineering properties in design and operation of agricultural equipment and systems.

Practicals
Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, firmness and hardness of grain, fruits and stalk.

Suggested Readings


**PHTR 601/HORT 601 EXPORT ORIENTED HORTICULTURE**

(3L+1P) I

**Objective**

To acquaint the students with the export oriented requirements of horticultural crops.

**Theory**

UNIT I

India’s position and potentiality in world trade; export promotion zones in India.

UNIT II

Scope, produce specifications, quality and safety standards for export of fruits *viz.* mango, grape, litchi, pomegranate, walnut, cashewnut *etc.*, vegetables *viz.*, onion, chilli, okra, bitter gourd, gherkin *etc.*, flowers *viz.*, rose, carnation, chrysanthemum, gerbera, specialty flowers *etc.*, cut green and foliage plants,

UNIT III

Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

UNIT IV

Seed and planting material; hi-tech nurseries, implications of PVP.

**Practicals**

Export promotion zones for vegetables and export of fresh vegetables and their products; quality standards of vegetables for export purpose; practical on quality standards of major flower for exports; quality standards of planting material and seeds; Hi-tech nursery in floriculture; quality standards of major fruits for exports; practical on ISO specifications and HACCP for export of fruits; Sanitary and phytosanitary measures during export of horticultural produce; post harvest management chain of horticultural produce for exports.

**Suggested Readings:**


PHT 602 PROCESS PLANT DESIGN (2L+1P) I

Objective
Introduce students to the methodology of project formulations and the implementation procedures and strategic planning of new projects.

Theory
UNIT I
Plant design concepts and general design considerations; plant location - location factors and their interaction with plant location, location theory models.

UNIT II
Computer aided selection of the location; feasibility analysis and preparation of feasibility report; plant size-factors affecting plant size and their interactions, estimation of breakeven and economic plant size; product and process design.

UNIT III
Process selection; process flow charts, computer aided development of flow charts; equipment selection including economic analysis of equipment, alternatives; plant layout including computer aided development and evaluation, layout symbols; planning and design of service facilities, human resource.

UNIT IV
Packaging and marketing system; hygienic design aspects and workers’ safety; functional design of plant building and selection of building materials; estimation of capital investment, analysis of plant costs and profitabilities; management techniques in plant design including applications of network analysis; preparation of project report and its appraisal.

Practicals
Preparation of a model detailed project report for a small scale food processing unit, case studies of various food products, projections planning, analysis for financial and technical feasibilities of the projects.

Suggested Readings

PHT 603 ADVANCES IN FOOD PROCESSING AND QUALITY MANAGEMENT (3L+1P) I

Objective
To develop an insight among the students about the existing modern techniques to aware them about their methodology and applications in food processing as well as to acquaint with food quality parameters and control systems, food standards, regulations, specifications.
Theory

UNIT I
Introduction to quality, importance of quality, management principles, estimation of quality parameters, quality and business environment.

UNIT II
Quality management standards, ISO/BIS, PFA, AGMARK and QMS standards, quality system components and their requirements., Food safety and standards, hazard analysis and critical control points (HACCP), Codex alimentarius, total quality management (TQM), statistical processed control, quality auditing.

UNIT III
Recent advances in processing technologies, aseptic processing, individual quick freezing and cryogenic freezing, high pressure technology, heat and ultrasound, high voltage pulse technology, irradiation, membrane technology, microwave heating, enzymes, natural antimicrobial agents, food additives, fermentation, minimal processing. Principles of food biotechnology, genetic modification of microorganisms in the food industry (lactic acid bacteria, yeasts and moulds), production of high valued food products by microorganisms viz. enzymes, organic acids, SCP, antibodies, nutritional additives, flavors, pigments.

Practicals
Testing and evaluation of quality attributes of raw and processed foods; detection and estimation of food additives and adulterants; quality assurance procedure, GMP, GAP documentation. Preparation of quality policy & documentation, application of HACCP to products, preparation of HACCP chart; preparation of documentation & records, visit to units with ISO systems; visit to Units with HACCP certification; visit to units implementing GMP, GAP; mini-project on preparation of a model laboratory manual.

Suggested Readings
Barbosa-Canovas 2002. Novel Food Processing Technologies. CRC.

PHT 611 POST HARVEST PROCESSING OF CEREALS, PULSES AND OIL SEEDS (2L+1P) II

Objective
To acquaint with production and consumption trends, structure, composition, quality evaluation, and processing technologies for product development and value addition of various cereals, pulses and oilseeds.
Theory

UNIT I
Objectives and requirements of processing; raw grain characteristics and quality.

UNIT II
Wheat milling - products and by-products; roller flour milling; separation of milled products; manufacture of bakery products, pasta products and various processed cereal-based foods; manufacture of whole wheat atta, blended flour and fortified flour.

UNIT III
Rice milling technology; by-products of rice milling and their utilization; parboiling of rice-technology and effect on quality characteristics; processed products based on rice;

UNIT IV
Corn: Types and nutritive value; dry and wet milling, manufacture of value-added products; processing of barley, oats, sorghum and millets.

UNIT V
Legumes and oilseeds: composition, anti-nutritional factors, processing and storage; processing of oilseeds, construction and working mechanism of different extraction equipments like single stage extraction, multiple stage static bed system, bollmann extractor, hildebrandt extractor; assessment of processed product quality; packaging of processed products.

Practicals
Cleaning & grading of raw grains, grain drying, parboiling of paddy, paddy milling and separation, cleaning & grading of grains, pulse milling and separation, cleaning & grading of milled pulse, pre-treatments for oil extraction, oil extraction, separation of milled products product quality assessment, plant layout & design, packaging for processed products. Physicochemical and rheological properties; conditioning of wheat; milling of wheat and rice by laboratory mill; parboiling of rice; puffing and popping of grains; experimental parboiling and assessment of degree of polishing; extraction of oil using expeller and solvent extraction methods; visit to related processing industries.

Suggested Reading

PHT 612 POST HARVEST MANAGEMENT OF HORTICULTURAL CROPS (3L+1P) II

Objective
To acquaint with the proper handling technologies of fruits and vegetables to reduce post harvest losses.
Theory

UNIT I
Maturity indices of horticultural crops, composition and structure of fruits and vegetables and their significance with post harvest management.

UNIT II
Harvesting and its relationship with quality, sorting and grading, pre-harvest crop management practices and their influence on quality during storage and marketing.

UNIT III
Respiration, ethylene in post-harvest biology, artificial ripening and de-greening of fruits. Physiology of ripening and senescence. Storage system: on-farm storage-evaporatively cooled stores, ventilated storage, pit storage etc. Refrigerated storage refrigeration cycle, controlled/modified atmosphere, hypobaric storage.

UNIT IV
Application of growth regulators for quality assurance, post-harvest treatments: pre cooling, heat treatments (hot water, hot air and vapor heat), fungicides & biologically safe chemicals, irradiation, curing, pulsing etc. Packing line operations, packaging of horticultural produce. Transportation-rail, road, sea, air. Codex norms for export of perishables.

UNIT V
Post harvest diseases of Hort. Products infection process, factors affecting it; modern methods of controlling decay (use of microbial antagonists their mode of action etc.

Practicals

Morphological features of some selected fruits and vegetables; maturity indices, harvesting techniques of fruits, field visit & identification of spoilage of fruits and vegetables, on-farm storage/chilling injury, pre-cooling, CA- treatment post harvest treatments to Hort. produce, pre cooling and storage of fruits and vegetables; studies on pre-treatments of selected fruits; use of chemicals for ripening and enhancing shelf life of fruits and vegetables, various storage systems and structures; pre packaging of fruits; GC for ethylene estimation. Pre packaging of vegetables; physiological disorders-chilling injury of banana and custard apple, Electrolyte leakage/membrane permeability/RWC HPLC analysis.

Suggested Readings


PHT 613 FOOD CHEMISTRY (2L+1P) II

Objective
To acquaint with properties and role of various constituents in foods, interaction and changes during processing and with importance of various foods and nutrients in human nutrition.
Theory

UNIT I
Basic knowledge on major food components and their chemical reactivity with focus on water and ice. Carbohydrates, lipids, amino acids, proteins.

UNIT II
Enzymes, minerals, phenolics, flavonoids, colourants, flavours, chemical additives, food contamination and toxic substances. Interaction of constituents in food systems; changes during storage and processing; browning reactions in foods.

UNIT III
Chemistry of fruits, vegetables, cereals, legumes, oilseeds; essential nutrients- sources, functions, deficiency diseases; requirements and recommended dietary allowances.

Practicals


Suggested Readings


PHT 614 PRINCIPLES AND PRACTICES OF FOOD HANDLING AND PACKAGING

(2L+1P) II

Objective

To acquaint the students with packaging methods, packaging materials, packaging machineries, modern packaging techniques etc.

Theory

UNIT I
Handling requirements and equipment for agricultural products involved at various stages of total food chain; packaging and transport of semi processed, processed and frozen food produce.
UNIT II
Packaging materials, their structural qualities and performance including moisture and gas transmission; selection of packaging materials for various food products; methods and equipment for filling and packaging of liquid, semisolid and solid foods.

UNIT III
Design and testing of packages; newer concepts in packaging - edible film, modified/controlled atmosphere, aseptic, barrier film and retortable plastic packaging; package labeling tools and techniques. Active and intelligent packaging, and their techniques. Packaging-flavour interactions. Factors affecting flavour absorption, role of the food matrix, role of differing packaging materials.

Practicals
Packaging of fresh produce, packaging of semi-processed produces, packaging of processed product. CA & MA storage, design considerations, handling equipments, package testing & evaluation, field visit.

Suggested Readings

**PHT 617/PP 617 PHYSIOLOGY OF RIPENING AND SENESCENCE (2L+1P) III**

**Objective**
To impart knowledge about physiological and molecular changes during senescence and ripening.

**Theory**
UNIT I
Environmental factors influencing senescence, ripening and post harvest life of fruits, flowers and vegetables.

UNIT II
Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products.

UNIT III
Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

UNIT IV
Ethylene biosynthesis, perception and molecular mechanism of action; regulatory role of ethylene in senescence and ripening, biotechnological approaches to manipulate ethylene biosynthesis and action.
UNIT V

Practicals
Physiological and biochemical changes during senescence and ripening, estimation of ethylene during senescence and ripening, determination of Reactive Oxygen Species and scavenging enzymes, measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, cellulases, pectin methyl esterases, polygalacturonase, etc.

Suggested Readings
Khan, N.A. 2006. Ethylene action in plants. Springer Verlag.

PHT 621 PROCESSING OF HORTICULTURAL CROPS (3L+1P) III

Objective
To acquaint with methods of preservation of fruits and vegetables and development of various process products.

Theory
UNIT I
Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.
UNIT II
Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.
UNIT III
Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

UNIT IV
Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

UNIT V
Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of fruits and vegetables wastes and their uses, utilization of by-products from fruits and vegetables processing industries.

Practicals

Suggesting Readings
Desrosier, N.W. and James, N. 2004. The Technology of Food Preservation. 4th Ed. CBS.

PHT 622/FLA 622 VALUE ADDITION IN ORNAMENTAL CROPS (1L+1P) III

Objective
To acquaint the students about the scope and ways of value addition in ornamental crops.

Theory
UNIT I
Importance, opportunities and prospects of value addition in floriculture; national and global scenario; production and exports, supply chain management

UNIT II
Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aromatherapy; pigment and natural dyes extraction technology, sources, uses and trade
UNIT III
Pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and uses preparation of products like gulkand, rose water, gulroghan, attar, pankhuri;

UNIT IV
Floral craft including bouquets, garlands, flower arrangements etc. tinting (artificial colouring) of flower crops; Women empowerment through value added products making.

Practicals
Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils. Pigment and natural dyes extraction technology; pharmaceutical and neutraceutical compounds from flower crops; preparation of products like gulkand, rose water, gulroghan, attar, pankhuri: petal embedded handmade paper making, floral craft including bouquets, garlands, flower arrangements etc.; tinting (artificial colouring) of flower crops.

Suggested Readings

PHT 623 DESIGN OF FOOD PROCESSING EQUIPMENTS (2L+1P) III

Objective
To introduce basic equipment design and various process control mechanisms and related engineering aspects.

Theory
UNIT I
Applications of engineering design to food processing equipment; design parameters and codes, materials selection;

UNIT II
Design of storage and pressure vessels, material handling equipment - belt, bucket, screw, apron, chain and pneumatic conveyors, heat exchangers- shell and tube and plate heat exchangers, seed processing equipment - air screen and rotary cleaners, grading equipment and seed treaters.
UNIT III
Process characteristics, controller characteristics, closed loop system, pneumatic and electric controllers, final controlling elements, control valves, valve sizing, electronic actuators, motor drives and controls, introduction to programmable logic controllers (PLC): internal structure, interfacing with sensors and actuators, binary logic diagrams and ladder diagrams, choosing a PLC system.

Practicals
Design of pressure vessels, design of material handling equipment, design of heat exchangers, design of spherical vessels, design of shell and tube, design of seed processing equipment, design of dryers, visit of a food processing plant.

Suggested Readings
Fuller 2004. *New Food Product Development - from Concept to Market Place*. CRC.

**PHT 624 ADVANCE STORAGE ENGINEERING**

**Objective**
Expose the students to the large scale handling and storage mechanism of grains, engineering operations and the control of physical, chemical and biological spoilage during storage of grains.

**Theory**

UNIT I
Physico-chemical and thermal properties of grains - grain dimensions, bulk density, true density, porosity, coefficient of friction, angle of repose, thermal conductivity and aerodynamic properties. humidity, % relative humidity, humid heat, deterioration index, wet bulb temperature, use of psychrometric charts,

UNIT II
Grain drying, equilibrium moisture content. Storage environment and its interaction with stored products, factors/parameters influencing the shelf life of the stored products; storage practices (including fumigation) and structures (traditional and modern) for food grains;

UNIT III
Climatograph and deterioration index. modeling of metabolic activities and prediction of storage life, quality deterioration mechanisms and their control;

UNIT IV
Design of bulk storage and aeration system, analysis of heat, moisture and gas transfer in bulk storage structures; quality analysis of stored produce; bag storage structures, their design and management.
Practicals

Determination of bulk density, true density and porosity of grains, determination of angle of repose and coefficient of friction, measurement of water activity of grains, determination of grain moisture content, identification of storage insects-pests, determination of EMC, determination of grain hardness, study of designs of storage bins and godowns as per capacity requirement, visit to storage lab. Plotting of sorption isotherm and calculation of EMC, computation of doses of insecticides in ware house, visit of commercial godowns, identification of common storage insect.

Suggested Readings


PHT 630/AE 630 HEAT AND MASS TRANSFER (3L+0P) I

Objective

To acquaint and equip the students with the principles of heat and mass transfer and its applications in food processing.

Theory

UNIT I
Modes of heat and: uni- and multi-directional heat conduction; principles of conservation; boundary layer and turbulence: momentum and energy equations;

UNIT II
Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods.

UNIT III
Radiative heat transfer and its governing laws, its applications in food processing.

UNIT IV
Mass transfer; heat and mass transfer analogy; molecular diffusion of fluids; mass transfer operations; absorption; adsorption; extraction-exchange and leaching.

Suggested Readings


**PHI 631/AE 631 DRYING AND DEHYDRATION**  
*(2L+1P) II*

**Objective**
To acquaint and equip the students with drying and dehydration of grains and seeds and the design features of the equipments used.

**Theory**
UNIT I
Kinetics of moisture sorption and desorption, mechanism of moisture transport.

UNIT II
Theory of drying, drying rate calculation, methods of drying grains, seeds and forage crops, dehydration techniques for different food products,

UNIT III
Effect of drying and dehydration on physico-chemical compositions.

**Practical**
Determination of moisture content by direct and indirect methods, determination of drying characteristics under sun, mechanical (tray type, fluidized bed type) of grains, seeds, study of different types of dryers (LSU, batch, RPEC etc)

**Suggested Readings**
## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST 501</td>
<td>FLORAL BIOLOGY, SEED DEVELOPMENT &amp; MATURATION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 502</td>
<td>SEED PRODUCTION: PRINCIPLES AND PRACTICES</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SST 510/PATH 510</td>
<td>SEED HEALTH TECHNOLOGY</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SST 513</td>
<td>SEED STORAGE AND DETERIORATION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 601</td>
<td>HYBRID SEED PRODUCTION</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SST 604</td>
<td>DUS TESTING FOR PLANT VARIETY PROTECTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 012</td>
<td>BASICS OF SEED TECHNOLOGY</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SST 503</td>
<td>SEED PRODUCTION IN FIELD CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 506</td>
<td>SEED LEGISLATION AND CERTIFICATION</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SST 508</td>
<td>SEED QUALITY TESTING</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SST 511/VSC 511</td>
<td>PRINCIPLES AND TECHNIQUES IN VEGETABLES SEED PRODUCTION</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>SST 514</td>
<td>SEED MARKETING AND MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 516</td>
<td>PLANT QUARANTINE</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>SST 603</td>
<td>TESTING FOR GENUINENESS AND PURITY OF CULTIVERS</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SST 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST 512</td>
<td>SEED PRODUCTION IN PASTURE, FORAGE AND GREEN MANURE CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 515</td>
<td>EMERGING TRENDS IN SEED QUALITY ENHANCEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SST 517</td>
<td>SEED ENTOMOLOGY</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SST 521/FLA 521</td>
<td>PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Hours</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>SST 543</td>
<td>SEED PROCESSING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AE 543</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SST 605</td>
<td>ADVANCES IN SEED SCIENCE RESEARCH</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>SST 608</td>
<td>PHYSIOLOGY OF SEEDS</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>PP 608</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** SST 501, SST 502, SST 506, SST 508, and SST 510

**Ph. D.:** SST 601, SST 604
SEED SCIENCE AND TECHNOLOGY

Major Field : Seed Science and Technology
Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 012 BASICS OF SEED TECHNOLOGY (1L+1P) II

Objective
To provide basic knowledge of seed science & technology required for understanding the techniques of seed production in crops and seed quality measurement.

Theory
UNIT I
Seed as a basic input in agriculture, seed development in cultivated plants; classification of crop plants in relation to mode of reproduction; concept and importance of genetic purity in seed production; seed production in self- and cross-pollinated crops.
UNIT II
Seed certification principles, purpose and procedure and identification of crop varieties.
UNIT III
Seed testing, seed sampling, physical and genetic purity, seed germination and vigour, moisture testing and use of tolerance test in seed testing. Seed storage behavior and desiccation tolerance.

Practicals
Visit of seed production plots of field crops and vegetables. Seed quality measurement viz. physical and genetic purity testing, identification of weed seeds, germination and vigour testing, moisture testing and seed health testing.

Suggested Readings
Objective
To refresh the basic knowledge of seed development and structures and apprise students with its relevance to production of quality seed.

Theory
UNIT I
Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and mega-sporogenesis; micro and mega gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology.

UNIT II
Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.

UNIT III
Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.

UNIT IV
Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practicals
Study of floral biology of monocots and dicots; micro-sporogenesis and mega-sporogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

Suggested Readings
Objective
To introduce the basic principles of quality seed production.

Theory
UNIT I
Seed as a basic input in agriculture, quality concept and importance of genetic purity in seed production; life span of varieties and factors responsible for their deterioration.

UNIT II
Steps in the development, evaluation, release, notification and maintenance of varieties; classification of crop plants in relation to the mode of reproduction and its modification for hybrid seed production.

UNIT III
Principles of hybrid seed production viz. isolation, synchronization of flowering, field inspection, rogueing etc.; special agronomical practices for seed production and effect of environment before harvest on seed quality; male sterility and self incompatibility in hybrid seed production, role of insect pollinators and their management for hybrid seed production, ecology and dynamics of pollinators.

UNIT IV
Seed quality control system and organization, suitable seed production areas, seed village concept; agencies responsible for seed production, seed industry in India, custom seed production, role of seed growers and seed producers in hybrid seed production.

Practicals
Seed production in rice and maize (varieties and hybrids), pollination in hybrid seed production plots of rice and maize, visit to Bajra and cotton seed production plots, visit to vegetable seed production field, hybrid seed production in cauliflower. Emasculation and pollination in bitter gourd and brinjal. Visit to seed production companies and certification agencies. Visit to seed processing units.

Suggested Readings
SST 503 SEED PRODUCTION IN FIELD CROPS

(Pre-requisite SST 502)

Objective
To impart a comprehensive knowledge of seed production in field crops with adequate practical training.

Theory
UNIT I
Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.

UNIT II
Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc; methods and techniques of quality seed production in cross-pollinated cereals and millets.

UNIT III
Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green garm, black garm, field beans, peas etc.).

UNIT IV
Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).

UNIT V
Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

Practicals
Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in cotton, detasseling in corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc.

Suggested Readings


Objective
To apprise students with the legislative provisions and processes and the mechanisms of seed quality control.

Theory

UNIT I
Historical development of Seed Industry in India; Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control-concept and objectives; Central Seed Certification Board (CSCB).

UNIT II
Regulatory mechanisms of seed quality control-organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control; the Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004 etc. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India.

UNIT III
Seed Certification-history, concept and objectives of seed certification; seed certification agency/organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (I.M.S.C.S.) general and specific crop standards including GM varieties, field and seed standards; planning and management of seed certification programmes-eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc.

UNIT IV
Field Inspection-principles, phases and procedures; reporting and evaluation of observations; pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes.

UNIT V
Introduction to WTO and IPRs; Plant Variety Protection and its significance; UPOV and its role; DUS testing-principles and applications; essential features of PPV & FR Act, 2001 and related Acts.

Practicals
General procedure of seed certification; identification of weed and other crop seeds as per specific crops; field inspection at different stages of a crop and observations recorded on contaminants and reporting of results; inspection and sampling at harvesting/threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.
Suggested Readings

**SST 508 SEED QUALITY TESTING**

(3L + 2P) II

**Objective**
To provide a comprehensive knowledge on all aspects of seed quality evaluation and their relevance to crop performance.

**Theory**

UNIT I
Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA - and its role in seed testing. Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory.

UNIT II
Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable varieties (ODV); determination of test weight and application of heterogeneity test.

UNIT III
Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results.

UNIT IV
Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy. Viability and vigour testing: definition and importance of viability tests; different viability tests; quick viability test (TZ-test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.
UNIT V
Genetic purity testing: objective and criteria for genetic purity testing; types of test; laboratory, growth chamber and field testing based on seed, seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests.

UNIT VI
Seed health Testing: field and seed standards; designated diseases, objectionable weeds - significance of seed borne disease vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes. Testing of GM seeds and trait purity, load of detection (LOD). Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practicals
Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agronomic crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests applicable in various crops; species & cultivar identification; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases, blotter methods, agar method and embryo count methods; testing coated / pelleted seeds.

Suggested Readings

**SST 510 / PATH 510 SEED HEALTH TECHNOLOGY**

(3L+2P) I

**Objective**
To acquaint the students with principles and practices of seed health testing and management of seed borne diseases.

**Theory**
UNIT I
History and economic importance of the seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical nonocotyledonous and dicotyledonous infected seeds.
UNIT II
Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogen.

UNIT III
Seed certification and tolerance limits, types of losses caused by seed borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed borne pathogens. Epidemiological factors influencing the transmission of seed borne diseases, forecasting of epidemics through seed borne infection.

UNIT IV
Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed borne pathogen / diseases and procedure for healthy seed production, seed health testing, methods for detecting micro-organism.

Practicals
Conventional and advance technique in the detection and identification of seed –borne fungi, bacteria and viruses. Relationship between seed borne infection and expression of the disease in the field.

Suggested Readings

SST 511 / VSC 511 PRINCIPLES AND TECHNIQUES OF VEGETABLES SEED PRODUCTION
(4L +1P) II

Objective
To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training

Theory
UNIT-I
Importance and present status of vegetable seed industry; intellectual property rights and their implications; new seed policies; DUS testing principles and procedure; impact of PVP on growth of seed industry.

UNIT-II
Genetical and agronomical principles of seed production; categories of seed and their maintenance; seed certification; seed standards; seed act; plant quarantine and quality control

UNIT-III
Seed morphology and development in vegetable seeds; agro-techniques for vegetable seed production; environmental factors related to flowering/bolting in vegetable crops; floral biology; pollination systems and breeding techniques related to vegetable seed production in different crops; isolation distances; roguing; selection procedures and criteria for seed production; hybrid seeds; seed extraction methods; maintenance breeding in vegetable crops.
Practicals

Field visit to division of vegetable science and seed science & technology and CPCT. Seed production technology of cucurbits, solanaceous vegetables and cole crops in open, under poly-house & low tunnel. Crossing & emasculation and pollination systems in different vegetable crops. Seed production techniques of cauliflower, peas, French bean, winter bean, Dolichos bean, okra, onion, brinjal, chilli, capsicum, carrot, turnip, and radish. Floral biology, determining of planting ratios for hybrid seed production and maintenance of varieties and parental lines.

Suggested Reading:


**SST 512 SEED PRODUCTION IN PASTURE, FORAGE AND GREEN MANURE CROPS**

(2L +1P) III

**Objective**

To apprise about the basic requirements and methods of quality seed production in forage, pasture and green manure crops.

**Theory**

UNIT I

Important pasture and forage legume crops in India; seed requirement and production; classification of forage, pastures and green manure crops; pollination behavior.

UNIT II

Factors influencing seed production; maintenance of varietal purity, generation systems of seed multiplication self pollinated crops; seed production in apomictic grasses.

UNIT III

Methods and techniques of seed production in important grasses, pastures, legumes and green manure crops; apomictic seed.

UNIT IV

Selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting, pelleting, fertilizer and manure requirement, isolation distance, weed control, pollination and seed setting, seed shattering, seed maturity and stage of harvest, seed collection, economics of seed production of important fodder crops.
UNIT V
Seed processing, seed treatment, seed storage, seed viability of grasses and leguminous crops.

Practicals
Study of flower structure, seed collection and identification, characteristics of forage, pastures and green manure crops; maturity indices for harvest, seed testing- sampling, purity, moisture, germination and dormancy, seed treatments.

Suggested Readings


**SST 513 SEED STORAGE AND DETERIORATION** (2L +1P) I

**Objective**
To provide understanding of the mechanism of seed ageing during storage, factors affecting it and its control.

**Theory**

UNIT I
Life span of seeds of plant species; classification of seeds on the basis of storage behaviour; orthodox and recalcitrant seeds; types of storage; kinds of seed storage (open, bulk, controlled, hermetic, germplasm, cryopreservation); soil seed bank; terminology; survival curve of seed.

UNIT II
Factors affecting seed storability- biotic and abiotic and pre- and post harvest factors affecting seed longevity; the effects of packaging materials, storage fungi and insects, seed treatment and fumigation and storage environmental conditions on seed storability; moisture equilibrium in seeds; hysteresis effect; thumb rules; selection of suitable areas/places for safe storage; prediction of relative storability and longevity of seed lots, viability equations and nomographs.

UNIT III
Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and related theories; different changes associated with the loss of vigour and viability during storage; application of physiological and biochemical techniques for evaluation of seed ageing; genetics of seed viability; effect of seed ageing on crop performance; maintenance of viability and vigour during storage; seed amelioration techniques, mid storage corrections etc.

UNIT IV
Storage methods- requirement of storage facilities in India; types and storage structures available in the country and their impact on short and long term storage; methods of safe seed storage including eco-friendly techniques used in various group of crops viz. cereals, pulses, oilseeds, fibers,
forages and vegetables; operation and management of seed stores; fruit storage; viability loss during transportation and interim storage.

Practicals
To study the effect of storage environmental factors (RH, SMC and temperature) on seed longevity; to study the effect of packaging materials, seed treatment and fumigation on storability; prediction of storability and longevity of seed-lots by using viability equations and nomographs; standardization of accelerated ageing (AA) technique for assessing the seed storability of various crops; estimation of carbohydrates, proteins, fats, enzyme activities, respiration rate and nucleic acids in fresh and aged seeds; use of eco-friendly products and amelioration techniques to enhance quality of stored seeds, visit to seed stores.

Suggested Readings

SST 514 SEED MARKETING AND MANAGEMENT (2L +1P) II

Objective
To apprise students about the seed supply system, concepts and principles of effective marketing of seed and strengths and weaknesses of the seed sector.

Theory
UNIT I
Importance and promotion of quality seed, formal and informal seed supply systems. Basic concepts of marketing with special reference to seed; importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector role of seed association / federation in seed trade.

UNIT II
Demand and supply of seed; Role of seed replacement rate (SRR), seed multiplication ratio (SMR), cost of production and returns; determining seed needs; seed pricing and price policy, seed processing and / packaging, demand forecasting.

UNIT III
Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins.
UNIT IV
Salient features of national seed policies, role of various sectors/agencies in efficient seed marketing, quality control and assurance programme. Responsibilities of seed companies and dealers under Seed Act, EXIM policies for seed trade etc.

Practicals
Statutory requirements in seed business including R&D, estimation of cost of seed production, marketing costs and margins of seeds of different crops, case studies to compare public & private sectors in different conditions, impact analysis, seed pricing, cost benefit ratio, economic feasibility of seed industry etc.

Suggested Readings

SST 515 EMERGING TREND IN SEED QUALITY ENHANCEMENT (2L+1P) III

Objective
To update knowledge on seed quality enhancement technologies and their application.

Theory
UNIT I
Concept and significance of seed quality enhancement; physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology and factors affecting seed enhancement treatments.

UNIT II
Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pre-germination, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.

UNIT III
Synthetic seeds – Aim and scope for synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryo-preservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

Practicals
Seed treatments – methods and techniques, equipments required for seed treatment, film coating; seed invigoration /priming - hydration and dehydration, PEG priming, solid matrix priming, bio priming, effects of priming; methods for hydrogel encapsulation of artificial endosperm, hydrophobic coating etc.; protocols for production of synthetic seeds, Visit to leading Seed Companies to study the seed treatment processes.
Suggested Readings


**SST 516 PLANT QUARANTINE**

*(2L+0P) II*

**Objective**

To apprise students about the economic significance of plant quarantine, principles and concepts, and plant quarantine operations in Indian context.

**Theory**

UNIT I
History and economic significance of plant quarantine; principles and concepts; scope and prospects; plant quarantine operations in Indian context.

UNIT II
New policy on seed development in India; international spread of seed-borne diseases due to export & import; pest risk analysis concept in plant quarantine; role of plant quarantine in preventing and / checking the spread of insect & plant pathogen, nematodes.

UNIT III
Export & import plant quarantine; domestic quarantine, its weakness and measures for its strengthening; plant protection convention and international cooperation in plant quarantine; problems in assessing the overall effectiveness of plant quarantine; techniques for the detection of insects/mites, nematodes, fungal and bacterial pathogens, viruses and salvaging of infested / infected germplasm.

**Suggested Readings**


**SST 517 SEED ENTOMOLOGY**

*(1L + 1P) III*

**Objective**

To apprise about the role of insects in seed production and their effect on seed quality during storage.

**Theory**

UNIT I
Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.
UNIT II

UNIT III
Major insect pests of principal crops and their management practices. Methods of insect pest control. Classes of pesticides, their handling and safe use on seed crops.

UNIT IV
Storage insect pests infecting seeds, their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation.

UNIT IV
Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures – domestic and commercial.

Practicals
Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis-à-vis loss of seed quality. Safe handing and use of fumigants and insecticides; safety measures in fumigating and disinfecting, exposure period, aeration etc. the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application.

Suggested Readings


SST 521 / FLA 521 PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS
(2L+1P) III

Objective
To impart basic knowledge about the importance of planting material and production of seed in important flower crops grown in India.

Theory
UNIT I
Scope and importance of planting material in flower crops;
UNIT II
Global and Indian scenario in planting material and flower seed production, propagation techniques, nursery management,

UNIT III
Propagation structures, sanitary and phyto-sanitary issues, plug plant production, nursery standards, Hi-tech nurseries micropropagation of ornamental plants,

UNIT IV
F1 hybrid seed production advantages, steps involved in hybrid seed production, methods in production of F1 hybrids in different flowers like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc., pollination behavior and isolation, pollination management,

UNIT V
Use of incompatibility, use of male sterility, maintenance of variety, seed production in open pollinated crops.

Practicals
Demonstration of propagation techniques; Nursery management techniques; Plug plant production; Steps involved in hybrid seed production; Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc

Suggested Readings

SST 543 / AE 543 SEED PROCESSING
(2L +1P) III

Objective
To impart knowledge on the principles and techniques of seed processing for quality upgradation and of storage for maintenance of seed quality.

Theory
UNIT I
Introduction: Principles of seed processing; methods of seed drying including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage; loss of viability in important agricultural and horticultural crops, viability equations and application of nomograph.

UNIT II
Seed cleaning equipment and their functions: Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines; seed blending.
UNIT III
Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant.

UNIT IV
Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfections, identification of treated seeds; Packaging: principles, practices and materials; bagging and labeling.

UNIT V
Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation.

Practicals
Operation and handling of mechanical drying equipments; effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds; seed extraction methods; seed processing equipments; seed treating equipments; visit to seed processing plant and commercial controlled and uncontrolled Seed Stores.; seed quality upgradation; measurement of processing efficiency; seed blending, bag closures; study of orthodox, intermediary and recalcitrant seeds; evaluating seed viability at different RH and temperature levels and packaging materials; prediction of storability by accelerated ageing controlled deterioration tests.

Suggested Readings

SST 601 HYBRID SEED PRODUCTION (2L + 2P) I
Objective
To provide a comprehensive knowledge and practical exposure to hybrid seed production in field crops and vegetables.

Theory
UNIT I
Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.
UNIT II
Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

UNIT III
Techniques of hybrid seed production - emasculation and crossing; use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines.

UNIT IV
Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

Practicals
Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows / blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots etc.

(Pre-requisite: SST 502)

Suggested Readings

SST 603 TESTING FOR GENUINENESS AND PURITY OF CULTIVERS (2L +2P) II

Objective
To provide hands-on training on various field and laboratory methods of testing cultivar purity.

Theory
UNIT I
Objective of cultivar purity test, general principles and methods involved. Use and limitations of laboratory, green house and field plot methods in determination of genuineness of cultivars; a case study in hybrid cotton, reporting of results and inference.

UNIT II
Chemical-biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein, isozymes etc, use of chromatography for analysis of secondary compounds etc.

UNIT III
DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties.
UNIT IV
Use of computer-based machine vision (MVT) for varietal identification and purity testing

Practicals
Chemical and biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, use of chromatography for analysis of secondary compounds.

Suggested Readings

SST 604 DUS TESTING FOR PLANT VARIETY PROTECTION (2L +1P) I

Objective
To provide a comprehensive understanding of DUS testing, its conduct and significance to PVP.

Theory
UNIT I
Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions; General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties; Protection of Plant Varieties and Farmers’ Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003.
UNIT II
Criteria for protection of new varieties of plants; principles and procedures of Distinctness, Uniformity and Stability (DUS) testing; test guidelines, planting material, duration, testing options, varieties of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.
UNIT III
Assessment of DUS characters based on morphological, biochemical and molecular markers; statistical procedures; computer software for use in DUS testing; impact of PVP on growth of seed industry; practical exercise of DUS testing in rice, wheat, pearl-millet, maize, rose and cauliflower.

Practicals
Morphological description of plant parts and plant; character expression and states, recording observation and interpretation of data; chemical tests and markers applicable for DUS tests and case study of selected crops.

Suggested Readings
SST 605 ADVANCES IN SEED SCIENCE RESEARCH (2L + 0P) III

Objective
To provide knowledge on the advances in various aspects of seed science & their application in seed technology.

Theory
UNIT I
Physiological and molecular aspects of seed development and control of germination and dormancy; gene expression during seed development; desiccation and stress tolerance and conservation; prediction of seed dormancy and longevity using mathematical models; structural changes in membranes of developing seeds during acquisition of desiccation tolerance; dehydration damage and repair in imbibed seeds, seed biotechnology; genetic analysis and QTL mapping of germination traits; seed ageing and ethylene production; recent accomplishments in seed enhancement research and application of nanotech.

UNIT II
Modern techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fingerprinting and other molecular techniques and their utilization; techniques for improving seed quality; proteomic analysis; seed priming, coating, pelleting and synthetic seeds; GM seeds and their detection, terminator technology (GURT).

UNIT III
Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

UNIT IV
Seed production of self incompatible and apomictic plant species; recent developments in seed laws, policies and seed certification system in India and its comparison with OECD seed certification schemes; IPR systems and PVP internationally.

Suggested Readings

SST 608 / PP 608 PHYSIOLOGY OF SEEDS (2L +1P) III

Objective
To apprise students regarding seed germination, dormancy, physiological processes involved in regulation of seed development and physiological processes governing seed quality and its survival.

Theory
UNIT I
Introduction, importance of seeds, seed structure and function, chemical composition of seed, seed development and maturation – physiological and molecular aspects; hormonal regulation of seed development, desiccation tolerance and sensitivity in relation to seed longevity, LEA protein.
UNIT II
Physiological and biochemical changes during seed maturation assimilate movement to seeds, storage of carbohydrate, protein and fats in seeds and biosynthesis.

UNIT III
Seed germination, factors influencing, breakdown and mobilization of stored products, carbohydrate, fat, protein, respiration and pathways of interconversion, control process in the mobilization of food reserve, hormonal control of germination. Seed dormancy, different types, environmental influences, mechanism and control including phytochrome, methods of breaking seed dormancy.

UNIT IV
Factors influencing loss of seed viability during storage, physiological and biochemical changes associated with seed ageing, theories of seed ageing, seed viability and its evaluation, seed storage, protection from water, temperature and contaminants, desiccation tolerance and sensitivity in relation to seed longevity.

UNIT V
Seed vigour, concept, importance, measurement; seed invigoration, methods, physiological and molecular basis of seed invigoration, effect of vigour on field emergence and yield, seed hardening.

Practicals
Chemical composition of seed, testing seed vigour and viability, breaking of seed dormancy, germination, seed invigoration and priming treatments, accelerated ageing treatments, seed imbition and leakage, enzyme activities during germination, sink ability of ovules, seed respiration.

Suggested Readings


## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR 004</td>
<td>SOILS AND ENVIRONMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 501</td>
<td>QUANTITATIVE INORGANIC ANALYSIS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 503/ AP 503</td>
<td>FUNDAMENTALS OF SOIL PHYSICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 504</td>
<td>SOIL CHEMISTRY</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 509</td>
<td>RADIO TRACER TECHNIQUES IN SOIL AND PLANT STUDIES</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 510/ AG 510/ WST 510</td>
<td>MANAGEMENT OF PROBLEM SOILS AND WATERS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 603</td>
<td>NUTRIENTS IN SOILS AND PLANTS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>SSAC 605</td>
<td>SOIL RESOURCE MANAGEMENT</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>SSAC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSAC 505/ AP 505</td>
<td>SOIL GENESIS, CLASSIFICATION AND SURVEY</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 506</td>
<td>SOIL BIOLOGY AND BIOCHEMISTRY</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 508</td>
<td>MANURES, FERTILIZERS AND BIOFERTILIZERS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 601</td>
<td>SOIL CLAYS AND CLAY MINERALOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 602</td>
<td>SOIL CHEMICAL ENVIRONMENT AND PLANT GROWTH</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 604/ ES 604</td>
<td>SOIL ORGANIC MATTER</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>SSAC 606/ ES 606</td>
<td>SOIL AND WATER POLLUTION</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSAC 502/ AG 502/ AP 502</td>
<td>SOIL FERTILITY AND NUTRIENT MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Course</td>
<td>Title</td>
<td>Credits</td>
<td>Elective Credits</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------------------</td>
<td>---------</td>
<td>------------------</td>
</tr>
<tr>
<td>SSAC 507</td>
<td>SOIL TESTING, WATER QUALITY AND FERTILIZER RECOMMENDATIONS</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SSAC 607</td>
<td>MODELING SOIL PLANT SYSTEM</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>SSAC 611/</td>
<td>SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSAC 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.**: SSAC 501, SSAC 502, SSAC 503, SSAC 504, SSAC 505, SSAC 506

**Ph.D.**: SSAC 601, SSAC 602, SSAC 603, SSAC 605
SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Major Fields:
- Soil Science
- Agricultural Chemistry
(For M.Sc. students: Soil Science and Agricultural Chemistry)

Minor Field:
- Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
- M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 004 SOILS AND ENVIRONMENT (2L + 1P) I

Objective
To impart fundamental knowledge on soil as a natural entity and its management for crop production

Theory
UNIT I
Soil as a natural body and medium for plant growth; nature and origin of soil, soil formation, classification and survey.

UNIT II
Composition of rocks, minerals and soils; soil properties – physical, chemical and biological; soil-water-plant relations.

UNIT III
Essential plant nutrients, their functions and symptoms of deficiencies; soil fertility and productivity; techniques of soil fertility evaluation; soil testing and fertilizer recommendations; manures, fertilizers and amendments.

UNIT IV
Soil organic matter; enhancing potential of agricultural soils for carbon sequestration; role of soils in carbon cycling; soil nutrient mining and land degradation; soil management and climate change.

UNIT V
Soil erosion, and soil and water conservation; problem soils - nature and management of acidic, salt-affected and waterlogged soils; soils of India.

Practicals
Soil sampling and processing; determination of water holding capacity of soil, pH, electrical conductivity, soil organic carbon, mineralizable N in soil; determination of available P, K and micronutrients in soil; lime requirement of acid soils and gypsum requirement of sodic soils; soil-test based fertilizer recommendations
Suggested Readings


**SSAC 501 QUANTITATIVE INORGANIC ANALYSIS (3L+2P)**

**Objective**

To impart the basic knowledge to the students on principles of inorganic analysis including use of instruments in soil, plant and water research and develop their skills as the quality analysts through sustained practical exercises

**Theory**

UNIT I
Introduction and scope of the course; principles of chemical analyses; ionic equilibria, ionic product, hydrolysis, solubility product.

UNIT II
Fusion and digestion of soil and plant samples including wet digestion and dry-ashing.

UNIT III
Volumetric analysis: Principles of volumetric analysis; neutralization reactions, complex formation reactions, precipitation reactions and oxidation-reduction reactions; indicators and theory of indicators.

UNIT IV
Gravimetric analysis: Formation and properties of precipitates; washing of precipitates; co-precipitation and post-precipitation; conditions of precipitation.

UNIT V
Principles of potentiometry; Beer-Lambert's law; colorimetry, turbidimetry and spectrophotometry.

UNIT VI
Emission and absorption spectroscopy: Principles of flame photometry, atomic absorption spectroscopy and inductively coupled plasma atomic emission spectroscopy.

UNIT VII
Errors in quantitative inorganic analysis.
Practicals
Preparation of primary and secondary standard solutions; wet digestion/ fusion of soil for elemental analysis; tri-acid/di-acid digestion of plant samples; estimation of chloride by Mohr and Volhard’s titration; organic carbon by Walkley and Black method; nitrogen in soil: total, ammoniacal, nitrate and available N, plant-N content by Kjeldahl method; volumetric and colorimetric estimation of P in soil, plant and water; estimation of zinc, iron, copper and manganese in soils and plants by colorimetry and atomic absorption spectrometry; potassium estimation by flame photometry; $\text{CO}_3^{2-}$, $\text{HCO}_3^-$ and RSC in irrigation water; Ca by Ca-oxalate titration; S in soils and plants by turbidimetric and BaCrO$_4$ precipitation–yellow colour methods; Ca and Mg by versenate titration method; boron by azomethine-H method

Suggested Readings

SSAC 502/ AG 502/ AP 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT  (3L+1P) III

Objective
To teach basics of soil fertility evaluation, techniques of soil fertility evaluation, plant nutrients, integrated approach of plant nutrition, and environmental quality.

Theory
UNIT I
Historical aspects of soil fertility, essential plant nutrients: criteria of essentiality, classification, functions, deficiency and toxicity symptoms, beneficial elements.

UNIT II
Carbon cycle in nature, carbon stocks, sequestration, greenhouse effects, different carbon pools in soil and their role in maintaining soil quality and productivity; soil organisms and their role in soil fertility.

UNIT III
Transformations and dynamics of major- and micro-nutrients in soils and their availability to plants.
UNIT IV
Nutrient interactions in soils and plants: concept, different types of interaction, interaction among essential plant nutrients, law of minimum and maximum.

UNIT V
Commercial fertilizers, new fertilizer materials and principles of their evaluation, crop response to fertilizer application and use efficiency, economics of fertilizer use, nutrient requirements of crops and cropping systems in sustainable agriculture and quality of the produce, foliar nutrition of crop plants.

UNIT VI
Soil fertility evaluation: different approaches, soil and plant tests, biological tests, hidden hunger, critical nutrient concentration - concept and determination (graphical and statistical procedures), critical nutrient range, diagnosis recommendation and integrated system (DRIS)

UNIT VII
Integrated nutrient management (INM): concept, objectives and components; organic farming: principles, practices and its impact on soil processes; precision farming: concept and practices; organic manures including compost, farmyard manure, green manure and crop residues.

UNIT VIII
Fertilizer x water interactions, crop production under fertilizer / water constraints; site-specific nutrient management: concept and practices; summary of long-term fertilizer experiments.

Practicals
Soil and plant sampling and processing for chemical analysis; determination of soil pH, total and organic carbon in soil; chemical analysis of soil for total and available nutrients (major and micronutrients); analysis of plants for essential elements (major and micronutrients)

Suggested Readings


**SSAC 503/ AP 503 FUNDAMENTALS OF SOIL PHYSICS**

**(3L+1P) I**

**Objective**

To impart knowledge about physics and physical properties of soil and their role in its management

**Theory**

**UNIT I**

Basic principles of physics applied to soils *viz.* viscosity, surface tension, capillarity, stress-strain relations, gaseous diffusion, heat transport, thermodynamic principles; properties of water in relation to porous media.

**UNIT II**

Physical characterization of soil; soil as a polyphase system; mass-volume relationships.

**UNIT III**

Particle size distribution; soil texture; mechanical analysis; specific surface; clay - a colloidal surface; hydration of clays.

**UNIT IV**

Soil structure and aggregation: genesis, classification and evaluation; soil structural stability and indices; soil tilth; soil conditioners.

**UNIT V**

Geometry of pore space and pore size distribution; inter- and intra-aggregate pores; soil consistency and its limits; consistency and deformation of cohesive soils; compaction and crusting in soils; soil strength and its measurement.

**UNIT VI**

Geometry of water phase; energy state of soil water; water content and potential and their measurement; different components of soil water potential; soil water characteristics, hysteresis and available water.

**UNIT VII**

Flow of water in soil; Darcy’s law, hydraulic conductivity and water diffusivity; saturated and unsaturated flow and equations; methods for saturated and unsaturated hydraulic conductivity measurement - both *in situ* and in laboratory; capillary movement of water, contact angle.
UNIT VIII
Entry of water into soil and its redistribution; permeability; evaporation from bare soil; modification of soil surface affecting infiltration and evaporation; field water balance.

UNIT IX
Gaseous phase in soil, content and composition; renewal of soil air and gaseous diffusion; measurement of soil aeration; factors affecting soil aeration.

UNIT X
Energy balance in bare soil; soil heat flux, heat capacity, specific heat and thermal diffusivity; soil temperature and its measurement, factors affecting; thermal regime in soil profile.

Practicals
Particle size analysis of soil; determination of bulk density, particle density and mass-volume relationships of soil; soil aggregate analysis; measurement of soil moisture content and soil moisture potential; determination of soil-moisture characteristic curve, saturated and unsaturated hydraulic conductivity, and infiltration characteristics of soil; determination of Atterberg constants; measurement of soil strength and soil temperature.

Suggested Readings

SSAC 504 SOIL CHEMISTRY (4L+1P) I

Objective
To impart basic knowledge on fundamentals of soil chemistry and chemistry of the soil, clay mineralogy, ionic equilibria, chemical processes and mechanisms of the soil constituents in relation to basic soil functions

Theory
UNIT I
Chemical composition of earth crust, soils, rocks and minerals.

UNIT II
Chemical bonding, chemical equilibria, chemical kinetics and thermodynamics.
UNIT III
Pauling’s rule, silicate structure, crystalline oxides and amorphous materials; XRD analysis, stability and weathering of minerals; clay mineral transformation and synthesis.

UNIT IV
Soil colloids: Inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-change soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids.

UNIT V
Ion exchange processes in soil; cation exchange - theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny’s concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement; anion and ligand exchange - inner-sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; soil solution; potassium dynamics, quantity-intensity relationships.

UNIT VI
Soil acidity - formation and properties of acid and acid sulphate soils; salt-affected soils - formation and properties.

UNIT VII
Organic matter – extraction, fractionation and characterization; interaction of organic matter with clay minerals and metals ions.

UNIT VIII
Phosphate chemistry in soil; geochemistry of micronutrients; chemical speciation; chemistry of waterlogged soils; environmental soil chemistry.

Practicals
Preparation of saturation extract; measurement of EC, pH, CO₃, HCO₃, Ca, Mg, K and Na concentration in saturation extract; calculation of minimum radius ratio of polyhedra and making models of silicate structure; quantity-intensity relationships of potassium in soil; extraction of humic substances; determination of lime potential and phosphate potential, zero-point charge of soil and redox-potential of submerged soils; calcium–potassium exchange equilibria in soil.

Suggested Readings
SSAC 505/ AP 505 SOIL GENESIS, CLASSIFICATION AND SURVEY (2L+2P) II

Objective
To teach the students concept of pedon, Pedology as a core discipline of Soil Science, factors and processes of soil formation, soil classifications systems, survey and cartography. Main emphasis is on enabling the students to conduct soil survey and interpret soil survey reports for sustainable land use and planning.

Theory
UNIT I
Historical developments in Pedology; characterization and classification of rocks and minerals; weathering of rocks and minerals, weathering sequences of minerals with special reference to Indian soils; soil forming processes and factors of soil formation.

UNIT II
Concept of soil as an individual entity; soil classification – principles and historical development; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy.

UNIT III
Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps; landform – soil relationships; application of remote sensing and GIS in soil survey and mapping; major soil groups of India.

UNIT IV
Land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystems.

Practicals
Morphological properties of soil profile in different landforms; classification of soils using soil taxonomy; calculation of weathering indices and its application in soil formation; grouping soils using available data base in terms of soil quality; aerial photo and satellite data interpretation for soil and land use; cartographic techniques for preparation of base maps and thematic maps; processing of field sheets, compilation and abstraction of maps in different scales.

Suggested Readings
Boul, S.W., Hole, R.D., McCracken, R.J. and Southard, R.J. 1997. Soil Genesis and Classification. Iowa State University Press, Ames, USA.


Objective

To teach the students the basics of Soil Biology and Biochemistry including nutrient transformation and cycling at the soil-root interface, bioremediation of the contaminated and polluted soils and also the microbial interactions in the soil.

Theory

UNIT I
Soil as biological habitat; soil organisms (flora and fauna) – their ecology and diversity; unculturable soil biota.

UNIT II
Rhizosphere biology: Relationships between plant roots and rhizosphere flora.

UNIT III
Energy relationships in organic matter decomposition, energy flow in the plant-microorganisms system; soil enzymes involved in organic matter break down and plant nutrient transformations; microbiology and biochemistry of decomposition of carbonaceous materials: cellulose, hemicellulose, lignin and minor plant constituents.

UNIT IV
Microbiology and biochemistry of decomposition of proteinaceous materials; N-cycle, C:N ratio and its importance; theories of humus formation and microbial processes involved; role of humus in soil.

UNIT V
Symbiotic N fixation: The symbionts, biochemical mechanisms of N fixation, factors affecting, importance in sustainable agriculture; microbiology and biochemistry of non-symbiotic N fixation; nitrification, de-nitrification - organisms involved, mechanisms and importance in agriculture; biology of transformation of phosphate solubilization; sulphur, zinc, iron and manganese transformations in soil.

UNIT VI
Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis - important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

List of Practicals

Isolation and enumeration of soil microorganisms by serial dilution plate technique; estimation of microbial biomass carbon in soil; study of organic matter decomposition in soil as affected by
varying C:N ratio of crop residues (CO₂ evolution method); determination of dehydrogenase activity in soil; study of acid and alkaline phosphomonoesterases in rhizosphere soil samples; determination of arylsulphatase activity in soils; enumeration of nitrifiers by most probable number method; study of potential nitrogen mineralization in soil; determination of free-living N₂ fixation in soil; determination of soil microbial population; soil microbial biomass; soil enzymes.

**Selected Readings**


**SSAC 507 SOIL TESTING, WATER QUALITY AND FERTILIZER RECOMMENDATIONS**

*(3L+2P) III*

**Objectives**

To teach the students the basic elements of soil, water and plant testing for accelerated sustainable crop production and environmental production.

**Theory**

UNIT I

Soil testing – its scope and significance in sustainable agriculture; historical background and development of soil testing in India and future challenges; SWOT analysis of soil testing service; soil, plant and water sampling and processing techniques.
UNIT II
Soil test methods – principles and development; soil testing for primary, secondary and micronutrients; diagnosis and amelioration of problem soils; interpretation of soil test data; soil test summaries and soil fertility maps.

UNIT III
Sources of soluble salts and other impurities in water; quality of different water resources in India; interaction of ionic constituents in water with soil; leaching and salt movement through soil; water quality evaluation; factors affecting use of poor quality irrigation water for crop production; management practices for using saline-sodic waters; sewage and industrial effluents for irrigation.

UNIT IV
Different approaches of fertilizer recommendation; critical nutrient concept; targeted yield and multiple regression techniques in soil test crop response studies; formulation of fertilizer dose for different types of crops and cropping systems including cereals, vegetables, ornamental and horticultural crops on normal and problem soils; fertilizer recommendations for rain-fed conditions, integrated plant nutrient supply systems.

UNIT V
Emerging concepts of fertilizer application; synchronizing nutrient supply with plant demand; site-specific nutrient management.

Practicals
Collection of soil and plant samples from agricultural and horticultural crops; sample processing; handling of laboratory instruments; determination of pH, EC and organic carbon; available nutrients (N, P, K, S, B, Zn, Cu, Fe and Mn); estimation of non-exchangeable K; lime requirement of acid soils and gypsum requirement of sodic soils; assessment of irrigation water quality; use of leaf colour chart in real-time N management; calculation of fertilizer doses.

Suggested Readings
Richards, L.A. (Editor) 1954. Diagnosis and Improvement of Saline–Alkali Soils, Hand Book 60, USDA.
Objective
To provide a holistic knowledge to the students on the potential and sustainable use of renewable and non-renewable organic, biological and chemical sources of nutrients; chemistry, technology and usage of chemical fertilizers; and recent developments in the field including customized and fortified fertilizers and relevance of the Fertilizer Control Order.

Theory

UNIT I
Role of manures, fertilizers and biofertilizers in sustainable agriculture; fertilizer production, consumption and agricultural production in India and future projections.

UNIT II
Bulky organic manures, farmyard manure, rural and urban composts: their preparation, preservation and mechanisms of decomposition with variable C/N ratio materials; green manures; enriched and concentrated manures - their preparation, preservation and usages.

UNIT III
Bio-fertilizers - definition, classification and their nutrient potential, mechanisms, production, usage and constraints; strategies for popularizing biofertilizers in India.

UNIT IV
Agricultural and industrial wastes and effluents as a source of the plant nutrients, problems and constraints; impact on use of sewage and sludge on soil physical, chemical and biological properties.

UNIT V
Manufacture, chemistry, characteristics and use of different nitrogenous, phosphatic and potassic fertilizers; physical and chemical properties of different fertilizers influencing their storage, transport, handling and utilization by crops.

UNIT VI
NP/ NPK complex and customized fertilizers; solid and liquid fertilizers suitable for fertigation, their merits and demerits; recent developments in secondary and micronutrient fertilizers and their usage.

UNIT VII
Approaches for increasing fertilizer use efficiencies - site-specific nutrient management; use of low-grade rock phosphates on different types of soils; long-term effects of manures and fertilizers on soil fertility and productivity.

UNIT VIII
Quality control of fertilizers and Fertiliser (Control) Order Act.

Practicals

Determination of moisture in manures and fertilizers, and determination of biuret in urea; mineralization rates of manures; total, ammoniacal and nitrate nitrogen in manures and fertilizers; total potassium and phosphorus in manures and fertilizers; micronutrients in some micronutrient fertilizers; water soluble, citrate soluble and citrate insoluble P in fertilizers; chloride other than $\text{NH}_4\text{Cl}$ in ammonium chloride fertilizer; urea-N by hydrolytic method; Ca and S in SSP.
**Suggested Readings**


**SSAC 509 RADIO TRACER TECHNIQUES IN SOIL AND PLANT STUDIES**

**(3L+1P) I**

**Objective**

To train the students in the use of radiotracer techniques in soil-plant studies including assessment of soil fertility, nutrient movement in soil and their absorption by plants

**Theory**

UNIT I
Radioactivity - discovery, nature and properties of radiations; atomic structure and units of radioactivity; radioisotopes - properties and decay principles; artificial radioactivity, nature and properties of nuclear reactions.

UNIT II
Interaction of radiations with matter; radiation hazards, dosimetry, safety procedures and waste disposal; statistics of counting.

UNIT III
Principles of tracer methodology; principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters, neutron moisture meter, mass spectrometry and radioassay.

UNIT IV
Use of stable isotopes; application of isotopes in ion transport, nutrient transformations; labeling, synthesis of labeled compounds; radio-activation and radiometric analysis.

**Practicals**

Storage and handling of radioactive materials; familiarization with counting equipments; determination of instrument efficiency of GM counter; determination of half life and decay constant, backscattering, self-absorption and E-max of beta radiations; preparation of soil and plant samples for radioactive measurements, and radioactively-labeled fertilizers; setting up of experiments on fertilizer use efficiency using radioisotopes; determination of A, E and L values of soil using $^{32}$P/$^{65}$Zn; use of neutron probe for moisture estimation; measurement of $^{14}$C and $^{3}$H by
liquid scintillation counting; single channel analyzer for determination of $^{65}$Zn; autoradiographic techniques; identification of radionuclides; statistics of radioactive measurements; de-contamination of surfaces.

**Suggested Readings**


**SSAC 510/AG 510/ WST 510 MANAGEMENT OF PROBLEM SOILS AND WATERS**  
(3L+1P) I

**Objective**

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

**Theory**

**UNIT I**  
Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problem soils, and factors responsible.

**UNIT II**  
Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH, physical, chemical and microbiological properties.

**UNIT III**  
Acid soils - nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement; management of acid soils, biological sickness of soils and its management.

**UNIT IV**  
Management of saline and sodic soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.
UNIT V
Agronomic practices in relation to problem soils; cropping pattern for utilizing poor quality ground waters.

UNIT VI
Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters.

UNIT VII
Salt stress: Meaning of salt stress and its effect on crop growth; salt stress injury and resistance in plants; practical ways to overcome the effect of salt stress through soil and crop manipulations.

Practicals
Characterization of acid, acid sulphate, salt-affected and calcareous soils; cations (Na⁺, K⁺, Ca²⁺ and Mg²⁺) in ground water and soil samples; anions (Cl⁻, SO₄²⁻, CO₃²⁻ and HCO₃⁻) in ground waters and soil samples; electrical conductivity and gypsum requirement of salt-affected soils; soil pH and lime requirements of acid soils; salt stress / injury on plants under laboratory conditions; visit to salt-affected / acid soil areas (CSSRI / CPRI).

Suggested Readings

SSAC 601 SOIL CLAYS AND CLAY MINERALOGY (3L+1P) II

Objective
To impart the fundamentals of crystallography; structure, classification and identification of soil clays and clay minerals; their agricultural, industrial and environmental uses

Theory
UNIT I
Introduction and elements of crystallography; crystal morphology, constancy of interfacial angles, laws of rational indices, crystallographic axes, Miller indices, symmetry elements, point groups and space groups, crystal classes and systems.
UNIT II
Major geological formations of India; structure and identification of primary minerals; weathering of rocks and minerals, stability index.

UNIT III
Advanced structural features of clay minerals – stacking of 1:1 layers, tetrahedral rotation, thinning of octahedra, M1 and M2 sites, polytypes of mica, hydroxy interlayered minerals; transformation and synthesis of clay minerals and stability diagrams.

UNIT IV
Electrochemical properties of clay; infra-red analysis of clays and clay minerals; electron microscopic and XRD analysis of clay minerals; thermal analysis of clays; chemical and other methods of identification; computation of chemical formula.

UNIT V
Interaction of clay with humus, pesticides, heavy metals; characterization of clay-organic complexes; clay-water interaction.

UNIT VI
Non-crystalline clays in soil and their classification – old and modern; crystallinity of clays, paracrystalline and crystalline with defect; amorphous aluminosilicates, allophane, imogolite – synthesis and properties.

UNIT VI
Clay mineralogical composition of the Indian soils; role of clay minerals in plant nutrition.

Practicals
Separation of sand, silt and clay fraction from soil; identification and quantification of minerals in sand, silt and clay fraction; studies on acid clays; determination of specific surface area and CEC of clay; and estimation of smectite and vermiculite by CEC determination method.

Suggested Readings

SSAC 602 SOIL CHEMICAL ENVIRONMENT AND PLANT GROWTH (3L+2P) II

Objective
To impart the students knowledge on the latest developments on soil chemical environment, soil – solid solution equilibria, soil solution, nutrient movement to plant roots and their absorption by plants and modeling soil-plant processes.
Theory

UNIT I
Soil chemical environment – definition and characterization; soil chemical environment - influence of metal toxicity, industrial effluents, sewage, pesticides and fertilizers; radioactive contamination of soil environment; soil factors in relation to greenhouse gases.

UNIT II
Methods of handling solid-solution equilibria in soils; pe+pH – concept and its use for handling the redox systems; solid-solution equilibria of nutrients and pollutant elements – identification of solid phases and influence of pH, redox potential and other soil factors on equilibria operating in the soils.

UNIT III
Concepts of nutrient bioavailability; soil solution – characterization and techniques of extraction, GEOCHEM and related models in chemical speciation; soil solution and plant growth.

UNIT IV
Nutrient ion movement – mechanisms and their relative importance, factors affecting; theory of diffusion and mass flow in root zone.

UNIT V
Root CEC – its role in ion uptake; root ion uptake properties – root morphology, root absorbing power, root demand coefficient; ion uptake theories - mechanisms and kinetics, active and passive absorption.

UNIT VI
Quantitative models on ion uptake – theoretical developments, boundary conditions, validation and sensitivity analysis.

Practicals
Adsorption equilibria of phosphorus and sulphur in soil; cation exchange capacity of plant roots; apparent free space of plant roots; diffusion coefficients and buffer power of nutrients in soil; L and E values in soil; Michaelis-Menten parameters of ion absorption by plants; and prediction of the nutrient uptake by Barber-Cushman Model.

Suggested Readings


**SSAC 603 NUTRIENTS IN SOILS AND PLANTS**

*(3L+0P) 1*

**Objective**

To teach latest developments in soil-plant interactions/relationships with respect to nutrient management

**Theory**

**UNIT I**

Essential nutrients – historical perspective; nutrient status of the world and Indian soils; nutrient content in relation to stages of crop growth and their uptake by crops and cropping systems.

**UNIT II**

Carbon - a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration *vis-à-vis* sustenance of soil quality and crop productivity.

**UNIT III**

Recent advances in bioavailability, transformation and dynamics of major- and micro-nutrients in soils.

**UNIT IV**

Growth and the factors affecting it; current approaches in soil fertility evaluation: critical nutrient concentration - concept and determination (graphical and statistical procedures); diagnosis and recommendation integrated system (DRIS).

**UNIT V**

Nutrient interactions – concepts, chemical and biochemical basis, and models for study; nutrient interactions in soil-plant continuum for maximization of the productivity of crops and cropping systems; water – nutrient interactions under excess and scarce water supply situations; fertigation – an example of water-nutrient synergy.

**UNIT VI**

Nutrient management in water-logged soils and under organic farming and precision farming.

**UNIT VII**

Nutrients and crop quality; micronutrients and human health - essential micronutrients list and their critical levels for human health; biofortification – concept, approaches and implications.
Suggested Readings


**SSAC 604/ ES 604 SOIL ORGANIC MATTER**

(3L+0P) II

**Objective**

To teach basic biochemistry of soil organic matter, its composition, fractionation and reactions in soil and its significance in sustenance of soil fertility and environmental quality

**Theory**

**UNIT I**
Carbon cycle in nature; carbon stocks of the world and Indian soils; pools, composition, and distribution of organic matter in soil.

**UNIT II**
Biochemistry of the humus formation - theories and pathways for humus synthesis in soil; biochemistry of transformation of N, P and S; organo-metallic interactions and role of chelation in bioavailability of nutrients and pollutant elements.

**UNIT III**
Characterization of humic substances: Extraction, fractionation and purification; elemental analysis, reactive functional groups of humic substances, ion exchange properties, other colloidal properties; adsorption of organic compounds by clays and role of organic substances in pedogenesis and soil aggregation.

**UNIT IV**
Soil organic matter (SOM) management in tropics; role of crop residues, tillage, land use and crops and cropping systems in SOM management; carbon sequestration - concept, practices and potential of the world and Indian crop lands; soil carbon stocks – issues and priorities for mitigation and sequestration of organic and inorganic carbon in soils.
UNIT V
Environmental issues related to SOM - greenhouse effect and global warming related to emissions of CO₂, CH₄ and N₂O; organic matter turnover and stabilization in soil - concepts and implications for soil fertility, environmental loads and climate change; soil organic matter dynamics in relation to soil biodiversity in terms of both flora and fauna; carbon transfer model; clean development mechanism – carbon trading; changes in organic carbon turnover in soils - simulation models - Rothamsted Carbon, Century Carbon, Infocrop and DNDC models.

Suggested Readings

SSAC 605 SOIL RESOURCE MANAGEMENT (3L+0P) I

Objective
To impart the students basic holistic knowledge on soil resource and latest developments in its sustainable use.

Theory
UNIT I
Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

UNIT II
Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

UNIT III
Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation;
history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion - on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semi-arid, coastal and diara lands.

UNIT IV
Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands; land restoration and conservation techniques - erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

UNIT V
Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

UNIT VI
Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

Suggested Readings

SSAC 606 /ES 606 SOIL AND WATER POLLUTION (2L+1P) II

Objective
To teach the students on extent, causes and mitigation of soil and water pollution on global scale and in India.

Theory
UNIT I
Soil and water resources of India; introduction to soil and water pollution; major soil and water problems; status of pollution in India.
UNIT II
Sources, cause and type of soil pollution; major soil problems – soil erosion, salinity, sodicity, pesticide pollution, and metal pollution.

UNIT III
Physical, chemical and biological characteristics of water; sources and cause of water pollution, point source and non point source pollution, types of pollution in subsurface and surface water, land fill sites and ground water pollution; nitrate, arsenic and fluoride pollution and their control.

UNIT IV
Microbial pollution in water - their sources; common water-borne diseases; transmission and control of water-borne diseases.

UNIT V
Impact of modern trends of agriculture on pollution; effect of soil and water pollution on agriculture and health; characteristics of domestic, municipal and industrial effluents; merits and demerits of their utilization in agriculture.

UNIT VI
Laws and legislation for soil and water pollution, permissible limits of pollutants in soil and water.

UNIT VII
Physical, chemical and biological remediation of soil and water pollution, waste water treatment, integrated nutrient management.

Practicals
Introduction to limnological studies; determination of nitrate and phosphate in soil and waters; determination of EC, pH and alkalinity; free CO₂; dissolved oxygen and residual chlorine in water; fluoride, calcium, magnesium in and hardness of water; trace metallic elements in soil and water; measurement of Coliform/ MPN; and BOD measurement in natural and waste waters.

Suggested Readings


SSAC 607 MODELLING SOIL PLANT SYSTEM (3L+1P) III

Objective
To train the students in concepts, methodology, technology and use of systems simulation in soil and crop studies
Theory

UNIT I
Introduction, terms and definitions; classification of models; steps of modelling; Taylor series; numerical methods of differentiation and integration; convergence and stability of models.

UNIT II
High level computer language - FORTRAN its commands and usage; testing and evaluation of model.

UNIT III
Description of spatially homogeneous models; K transformation model; model on carbon, nitrogen and phosphorus dynamics in soil.

UNIT IV
Spatially heterogeneous models; equation of continuity; simulation of water flow through soil; explicit and explicit-implicit method; simulation of solute movement through soil by explicit method and with variable moisture flux by explicit-implicit method.

UNIT V
Nutrient uptake models; water uptake models; sensitivity analysis, parameter ranking and model simplification.

Practicals
Testing and usage of FORTRAN commands; writing, compiling, linking and execution of FORTRAN modules on i) K transformation and equilibria in soils, ii) C, N and P transformation in soils, iii) water and salt movement in soils, and iv) nutrient uptake by plants.

Suggested Readings

Web sites
SSAC 611/ AP 611 SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH (3L+1P) III

Objective
To impart knowledge on characterization and management of soil physical environment in relation to plant growth and yield.

Theory

UNIT I
Introduction: Effect of soil physical properties on plant growth - soil water, soil air, soil temperature, mechanical impedance and tillage practices.

UNIT II
Soil water: Soil moisture – plant water relations, available water, newer concepts of water availability, least limiting water range, soil-plant-atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum.

UNIT III
Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.

UNIT IV
Soil temperature – effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching, Radiation – heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere.

UNIT V
Aeration – critical oxygen concentration and factors affecting.

UNIT VI
Field water balance: Field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture.

UNIT VII
Nutrients: Nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, integrated nutrient management in relation to soil physical condition.

UNIT VIII
Resource conservation technologies: Bed planting and zero-tillage - types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term) on soil health.
UNIT IX
Modelling: Interactions of soil, management and climatic factors on plant growth, and development of sustainability indices.

List of Practicals
Measurement of penetration resistance and LLWR; plant water potential; field saturated hydraulic conductivity; transpiration using porometer; root length density, root diameter, root weight using root scanner; germination percentage as affected by temperature; estimation of evapo-transpiration losses under different management options; measurement/estimation of consumptive water use, production functions, field water balance components, and water uptake by plants.

Suggested Readings
# Water Science and Technology

## TRIMESTER WISE DISTRIBUTION OF COURSES

### I TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>WST 501</td>
<td>FUNDAMENTALS OF FLUID MECHANICS AND HYDRAULICS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>WST 502</td>
<td>ENVIRONMENTAL POLLUTION</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>ES 502</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WST 503</td>
<td>SOIL- WATER-PLANT- ENVIRONMENT SYSTEM</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WST 505</td>
<td>SOIL &amp; WATER CONSERVATION AND SEDIMENT TRANSPORT</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>WST 509</td>
<td>ECONOMIC, SOCIAL AND INSTITUTIONAL ISSUES IN WATER RESOURCE MANAGEMENT</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>WST 510</td>
<td>MANAGEMENT OF PROBLEM SOILS AND WATERS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 510 / SSAC 510</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WST 530</td>
<td>FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AP 530</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WST 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### II TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>WST 500</td>
<td>WATER RESOURCE MANAGEMENT - I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>WST 603</td>
<td>ECONOMIC ANALYSIS OF WATER USE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>WST 511</td>
<td>SOIL AND WATER QUALITY AND IRRIGATION MANAGEMENT</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WST 608</td>
<td>DIAGNOSTIC ANALYSIS AND PERFORMANCE EVALUATION OF IRRIGATION PROJECTS</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>WST 611</td>
<td>PRESSURIZED IRRIGATION SYSTEM DESIGN</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WST 504</td>
<td>PRINCIPLES AND PRACTICES OF WATER MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AG 504</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WST 691</td>
<td>SEMINAR</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### III TRIMESTER

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>WST 600</td>
<td>WATER RESOURCE MANAGEMENT-II</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WST 601</td>
<td>CROP WATER REQUIREMENT AND IRRIGATION PLANNING</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WST 506</td>
<td>HYDROLOGY AND WATERSHED MANAGEMENT</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>WST 607</td>
<td>ENVIRONMENTAL IMPACT ASSESSMENT OF IRRIGATION PROJECTS</td>
<td>3 0</td>
<td></td>
</tr>
<tr>
<td>WST 614</td>
<td>IRRIGATION HYDRAULICS</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>WST 615</td>
<td>WATER MANAGEMENT TECHNOLOGIES IN RAINFED AGRICULTURE</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>WST 691</td>
<td>SEMINAR</td>
<td>1 0</td>
<td></td>
</tr>
</tbody>
</table>

**Core Courses**

**M.Sc.:** WST 500, WST 501, WST 503, WST 504/AG 504, WST 601 and WST 608.

**Ph. D.:** WST- 607, WST 611 and WST 615
WATER SCIENCE AND TECHNOLOGY

Major Field : Water Science and Technology
Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.
M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

WST 500 WATER RESOURCE MANAGEMENT – I (3L+0P) II

Objective
To prepare the students with the rationale utilization of land & water resources for optimum production with minimum land and water resources

Theory
UNIT I
Hydrologic Cycle, hydrologic process, Analysis of rainfall data, runoff estimation.
UNIT II
Rain Water Harvesting and Its Management, Development of Surface Water Resource, Basic equations of ground flow, Ground Water Recharge, assessment of ground water recharge, Development of ground water resources
UNIT III
Physical, chemical and biological properties of water, water quality standards for different purposes, Sources of pollution of surface and ground water resources.
UNIT IV
India’s water resources and their development, impact of climate change on water resources, water resources data. Water needs for future in different sectors.

Suggested Readings

WST 501 FUNDAMENTALS OF FLUID MECHANICS AND HYDRAULICS (3L+1P) I

Objective
To impart the basic knowledge of the fluid mechanics and hydraulics to the students of various background. Such a basic knowledge is a mandatory requirement for those who deal with water transport on to the fields.
Theory

UNIT I
Fluids- definitions, properties, fluid pressure and its measurements, hydrostatic force on surface, buoyancy and floatation.

UNIT II
Hydro kinematics- kinematics of fluid flow, methods of describing fluid in motion, lines of flow: path line, stream line, stream tube and potential line.

UNIT III
General types of fluid flow- steady and unsteady flow, uniform and non uniform flows, laminar and turbulent flows, compressible and incompressible flows, one, two and three dimensional flows.

UNIT IV
Rate of flow/discharge, system, control volume, cross section of flow, concept of mean velocity of flow, Equation of continuity, Stream function, velocity function and flow net.

UNIT V
Dynamics of fluid flow, basic energy and momentum equation, Bernoulli’s theorem for liquid and its proof, Hydraulic and energy grade lines, head and power: horse power, application of Bernoulli’s equation.

UNIT VI
Flow through pipes, definition of pipe and pipeline, pipe line problems, siphon, loss of head in pipe, pump in pipe line, most economical diameter of pipe, water hammer, gradual closure of valve, and instantaneous closure of valve.

Practicals
Design problems, Exposure to various hydraulic structures, solutions to class exercises and design exercises of pipe flows.

Suggested Readings
Hydraulics and Fluid Mechanics; Jagdish Lal, Metropolitan Book Co. Pvt. Ltd.
THEORY and Problems of Fluid Mechanics and Hydraulics: Schaum’s Outline Series

WST 502/ES 502 ENVIRONMENTAL POLLUTION (3L+0P) I

Objective
To provide the related information on the Environmental Pollutants and their impacts on agriculture and environments

Theory
UNIT I
Introduction to environmental pollution; water borne diseases and their control; biological and chemical indicators of environmental pollution

UNIT II
Sources and type of water pollution; heavy metals in surface and sub-surface waters; pesticide residues in surface and sub-surface waters; phosphates in surface and sub surface waters; uptake of
pollutants by plants; radio-active wastes and their safe disposal; sampling and analysis techniques; aquatic plants and their role in pollution control-phytoremediation

UNIT III
Particulate and heavy metal pollution of air; atmospheric pollution from fossil fuels used in vehicles and industry; biofuels for air pollution control; ozone layer and its importance; mechanism of ozone layer depletion and diffusion of CFCs; renewable sources of energy.

UNIT IV
Sources and sinks of SOx & NOx in atmosphere; sources and sinks of CO and CO₂ in atmosphere; sources and sinks of CH₄ and nitrous oxide in atmosphere

UNIT V
Solid wastes (crop residues, sludges, food processing industries wasters) and their disposal; sources & nature of soil pollution and their harmful effects; soil and groundwater pollution by nitrates, fluorides and heavy metals.

UNIT VI
Anthropogenic influences on terrestrial and aquatic environments and their copying strategies for greater environmental sustainability.

UNIT VII
Environmental impact assessment and industrial effluent treatment and their disposal; pollution control in agro-based industries by agri-cycling of their effluent; environmental standards; laws for control of water and air pollution.

Suggested Readings

P.A. Vesilind. Environmental Pollution and Control.
Dictionary of the Environment, Hutchinson Pocket Book Series
Peter O. Warmer. Analysis of Air Pollutants.
M. Radojesic and V.N. Bashkin. Practical Environmental Analysis.
Werner Strans. Air Pollution Control (I-IIii).
J.O. Nariagu. Elements in the Environmental Series (Cu, Zn, Hg, Pb).
Nebel. Environmental Sciences.
Ian L. Pepper Charles P. Environmental and Pollution Science.

WST 503 SOIL WATER PLANT ENVIRONMENT SYSTEM (2L+1P) I

Objective
To enable the students to study the interactive relationship among soil, water, plant and the environment in relation to the movement of water into soil, its intake by the plants and its release in the environment.

UNIT I
Introduction to Soil-Water-Plant-Environment System, Soil characteristics in relation to profile and soil horizon, soil system and basic properties of soil water potential, its various components and method of their measurements.
UNIT II
Movement of water in soils and its measurement, soil characteristics and properties in relation to irrigation, Plant water relations and role of water in plants, water loss through transpiration and factors affecting it.

UNIT III
Plant water relations and role of water in crop evapo-transpiration, its measurement and the factors influencing it, Water stress in plants and its effect on growth, quality and yield.

UNIT IV
Water relationship of cell and whole plant, Water and ion uptake by plants and its movement mechanism, Solute content and its movement.

UNIT V
Weather parameters influencing soil-water-plant relations and its measurements, climate characterization/Agroclimatic zoning and indices, introduction to microclimate/macroclimate in crops.

Practicals
- Determination of soil texture and bulk density;
- Determination of field capacity;
- Determination of soil moisture characteristics curve;
- Determination of hydraulic conductivity;
- Determination of infiltration rate;
- Measurement/monitoring of soil temperatures, RH, wind velocity, rain, evaporation, sunshine, dew, solar radiation etc.;
- Determination of matric potential;
- Determination of RWC, LAI, LWP, SDI etc.

Suggested Readings

WST 504 / AG 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT (3L+1P) II

Objective
To teach the basic principles of water management and practices to enhance water productivity.

Theory
UNIT I
Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

UNIT II
Soil-plant-atmosphere continuum, soil water movement in soil and plants, transpiration, soil-water-plant relationships, water absorption by plants, plant response to water stress, crop plant adaptation to moisture stress condition.

UNIT III
Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; micro-irrigation system; fertigation; management of water in controlled environments and polyhouses.
UNIT IV
Water management of crops and cropping systems, management of soil moisture stress and plant growth, strategies of using limited water supply, quality of irrigation water and management of saline water for irrigation, water-use efficiency.

UNIT V
Water stress – deficit and excess, its effect on growth and development, water stress injury and resistance, management of water stress through soil and crop manipulations, excess of soil water and plant growth; water management in problem soils.

UNIT VI
Drainage – concept and classification. Field drainage systems with special emphasis on crop production and soil salinity. Inter-relationship of drainage with cropping patterns and types of farming. Drainage requirement of crops and methods of field drainage, their layout and spacing.

UNIT VII
Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer’s participation in command areas; irrigation legislation.

Practicals

Suggested Readings

WST 505 SOIL AND WATER CONSERVATION AND SEDIMENT TRANSPORT (3L +0P) I

Objective
To acquaint and equip the students with the process of land degradation due to soil erosion and its conservation, including design of structures and sediment transport in river beds and its accumulation in reservoirs.
Theory

UNIT I
Concept of soil and water conservation, relevance of soil and water conservation in agriculture. Problems caused by soil erosion, factors affecting soil erosion.

UNIT II
Types of soil erosion, mechanics of water erosion, factors affecting water erosion, moisture stress and excess, effect of land preparation and cultivation practices on soil erosion. Layout and planning soil erosion control measures. Erosivity and erodibility, Measurement of soil erosion. Hydraulic jump and energy dissipater for erosion central structures;

UNIT III
Design of soil conservation structures, farm ponds and temporary storage reservoirs, drop structures, chute spillways. Aforestation and associated agronomic practices, role of soil and water conservation work-river valley projects, Soil Conservation Department, CADA, etc. Flood control and stream bank protection measures

UNIT IV
Sediment yield and transport, estimation of transported sediment, effective life of dams and water detention structures, multipurpose storage zones, reservoir yield and capacity, determination life of multipurpose reservoirs, erosion of water conveyance systems, designs of channels for erosion control, tractive or face theory, maximum permissible velocity.

Suggested Readings


WST 506 HYDROLOGY AND WATERSHED MANAGEMENT (3L + 1P) III

Objective

To equip the students with the hydrologic processes, analysis hydrologic data for designing various structures, management of water resources through community participation and other aspects pertaining to the holistic development of the area.

Theory

UNIT I
Hydrologic process and systems; hydrologic problems of small watersheds precipitation and runoff and ground water flow, data generation analysis and reduction, estimation and interpretation, gauging and instrumentations. Hydrologic problems of small watershed, hydrologic characteristics of watersheds measurement and analysis of hydrologic parameters, rainfall-runoff, stream flow measurement and analysis of data, hydrograph theory, hydrograph, separation and use, unit hydrograph flood routing.

UNIT II
Concept of watershed, characterization, priority watershed, need for integrated approach, Integrated watershed management - importance and relevance for holistic development, problem identification,
deterioration and priority concept. Land and water degradation, land capability and suitability classification. Database generation and management, Impact evaluation and assessment. Watershed resources appraisal, watershed survey, data requirement,

UNIT III
Community participation, rationale, potential need, constraints, mobilization process, empowerment of panchayats, people's organization, management of common property resources, etc. Role of NGOs and political will and support; Water harvesting technique small storage and traditional methods.

UNIT IV
Watershed management programme in the country-overview, planning and guidelines success and failures, economic evaluation and environmental assessment, watershed policy formulation for planning and management.

Practicals
Delineation of watersheds, watershed yield and estimation of runoff from watershed, analysis of hydrological data, design of soil and water conservation structures, watershed survey watershed management planning

Suggested Readings

WST 509 ECONOMIC SOCIAL AND INSTITUTIONAL ISSUES IN WATER RESOURCES MANAGEMENT (3L+0P) I

Objective
To equip the students with the various principles of economics and use in water resources management for determining the optimal level of crop production at minimal cost, economic and financial function of irrigation water charges and market price determination of irrigation water

Theory
UNIT I
Principles of economics and their applications in water resources management. Factors of production - Determination of optimal level of production and factor application – Optimal factor combination and least cost combination of production – THEORY of product choice; selection of optimal product combination.

UNIT II
Water resources pricing: Economic and financial functions of irrigation water charges – Market price determination of irrigation water – Price elasticity – Charging vehicle

UNIT III
Economic appraisal of irrigation programmes – Feasibility criteria – Assessment of costs and benefits and discounting techniques – Internal rate of discount.
UNIT IV
Policy approaches for efficient on-farm water utilization: Equity and efficiency in water distribution.
– Institutional framework in canal command area and watershed areas – Organizations, their roles
and functions – Water user’s associations in canal command areas and Common Guidelines for
watershed management – Banking and financing mechanism in water resources management.

UNIT V
Interstate water disputes – Constitutional provisions – Water laws, water rights and managing
conflicts.

Suggested Readings
Company. 1971.
The Economics of irrigation Ian Carruthers and Colin Clark Liverpool University Pres, 1981.

WST 510/ SSAC 510/AG 510 MANAGEMENT OF PROBLEM SOILS AND WATERS (3L+1P) I

Objective
To educate students about basic concepts of problem soils and brackish water, and their management.
Attention will be on management of problem soils and safe use of brackish water in relation to
crop production.

Theory
UNIT I
Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin
and basic concept of problematic soils, and factors responsible

UNIT II
Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils
– soluble salts, ESP pH, physical, chemical and microbiological properties.

UNIT III
Acid soils – nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement.
Management of acid soils, biological sickness of soils and its management.

UNIT IV
Management of saline and sodic soils; salt tolerance of crops – mechanism and rating; monitoring
of soil salinity in the field; management principles of sandy, clayey, red lateritic and dry land soils.

UNIT V
Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality
ground waters.

UNIT VI
Quality of irrigation water; management of brackish water for irrigation, salt balance under irrigation
characterization of brackish waters.

UNIT VII
Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in
plants, ways to overcome the effect of salt stress through soil and crop manipulations.
Practicals

Characterization of acid, acid sulfate, salt-affected and calcareous soils. Determination of Cations (Na, K, Ca and Mg) in ground water and soil samples. Determination of anions(Cl, SO₄, CO₃ and HCO) in ground waters and soil samples. Determination electrical conductivity and gypsum requirement of salt-affected soils. Determination of soil pH and lime requirements of acid soils. Determination of salt stress/injury on plants under laboratory conditions. Visit to salt-affected/acid soil area (CSSRI/CPRI)

Suggested Readings


**WST 511 SOIL AND WATER QUALITY AND IRRIGATION MANAGEMENT**  
(2L+IP) II

Objective

To get the student acquainted with the various soil and water quality problems and their extent in India, their impact on crop production and their treatment through monitoring and analyzing.

Theory

UNIT I
Nature of problems, soils-type and extent in India; physical, chemical, topographical and hydrological assessment of magnitude of the problems.

UNIT II
Impact on crop production. Identification and adoption of appropriate water management technologies. Case studies of water-logging and soil salinity problem areas. Water quality classification; sources of water pollution; water quality monitoring; sampling strategies and techniques;

UNIT III
Water quality impacts on crop performance; irrigation with poor quality water. Interaction between water and soil constituents. Salute transport. Treatment of effluents for irrigation

714
List of Practicals

The nature and the extent of soil and water quality problems in India, analysis of water and soil samples to determining their suitability for agriculture, identification for adoption for various water management technologies in relation to this problem, determining the salutary transport mechanism.

Suggested Readings


WST 530/AP 530 FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY (3L+1P) I

Objective

To impart theoretical and practical knowledge about basic physical processes in the atmosphere with an aim to apply in agriculture.

Theory

UNIT I
Atmosphere and its constituents, weather and climate; meteorology and climatology, meteorological elements, instruments for measurement of meteorological elements, meteorological observatory, weather satellites, websites of meteorological organizations – IMD, NCMRWF, IITM, WMO.

UNIT II
Sun and earth; seasons, solstices and equinoxes, solar radiation and laws of radiation, solar constant; radiation receipt on earth surface, heat balance of the earth and atmosphere.

UNIT III
Variation of pressure and temperatures with height; hydrostatic equation, atmospheric moisture; vapour pressure; saturation deficit; psychrometric equations, lapse rates, atmospheric stability, tephigram, potential temperature.

UNIT IV
Climatic controls, seasonal distribution of climatologically elements (radiation, temperature, pressure and precipitation) over latitudes.

UNIT V
Clouds and their classification, precipitation processes; artificial rain making, thunderstorms and dust storms; haze, mist, fog and dew, introduction to evapotranspiration,

UNIT VI
Pressure gradient; coriolis force; cyclones and anti-cyclones, local wind systems; land and sea breeze circulation, mountain and valley winds, air masses and fronts,

UNIT VII
Weather charts, forecasting methods – short, medium and long range forecasting techniques, numerical weather prediction.

UNIT VIII
Climatic classification: Koppen and Thornthwaite systems, agroclimatic indices, agroclimatic zones; different agro ecological zones for India.
UNIT IX
Climatology of India; monsoons, rainfall variability; El Nino, La Nina and ENSO, disastrous weather events in different regions, drought climatology and drought indices, climate change and global warming, impacts of climate change on agro-ecosystems.

Practicals
Meteorological observatory, meteorological instruments, recording of weather parameters, daily, weekly and monthly means, meteorological websites, standard meteorological weeks and Julian days, classification of clouds, climatic normal, climatic chart, low and high pressure systems.

Suggested Readings

Journals
Journal of Climate
International Journal of Climatology
Mausam
Vayumandal
Weather

WST 600 WATER RESOURCE MANAGEMENT-II

(2L+1P) III
Objective
To expose the students to the irrigation development in India, irrigation water distribution practices for water resource utilization analysis in water resource management planning including benefit costs etc.

Theory
UNIT I
Water Resources of India (Sources, current state of development, Potential, State wise distribution),
Natural Resource base for Irrigation (Rainfall, Soil & Land, Crop water requirement)
UNIT II
Irrigation development in India, surface/ground water, Irrigation water distribution practices in India, Warabandi system
UNIT III
Introduction to systems analysis in water resources planning and management, OBJECTIVE functions, benefits, cost, decision variables, constraints etc., Techniques used for systems analysis/
Optimization: Linear programming (LP)/Dynamic Programming/Simulation and their application in water resources management

UNIT IV

UNIT V
Conjunctive use of canal and ground water: Case studies, Water logging and salinity management and modelling, Poor quality water management for agriculture

Practicals
Data collection on water statistics, Irrigation Water distribution practices in India, Formulations of Systems Analysis Problems, Formulation and solutions of LP problems using softwares, Development of simulation models, expert systems, DSS for water resources management (methodology), Estimation of water quality parameters.

Suggested Readings

WST 601 CROP WATER REQUIREMENT & IRRIGATION PLANNING (2L+1P) III

Objective
This course is imperatively needed for effective planning of water utilization in crop production.

Theory
UNIT I
Introduction to the course, land use capability and soil and land irrigability assessment, concepts of crop water requirements, irrigation planning and irrigation scheduling, irrigation planning factors, factors affecting irrigation water requirement

UNIT II
Introduction to Methods of estimation of reference evapo-transpiration, crop response function

UNIT III
Estimation procedure of ET (both reference and actual), water availability and its significance in irrigation management, various methods of estimation of reference evapo-transportation and crop consumptive use.

UNIT IV
Concept of field water balance, various components of field water balance their estimation, both by analytical and empirical methods.

UNIT V
Application of concepts of cropping pattern and cropping intensity, crop planning in relation to changing scenario of input availability, crop response function to irrigation, irrigation scheduling to crops and irrigation methods.
UNIT VI
Estimation of seasonal and annual water requirement of various field crops, progressive peak and seasonal consumptive water use and their significance in operation of irrigation projects, application of simulation model for irrigation planning and scheduling.

Practicals

Suggested Readings

WST 603 ECONOMIC ANALYSIS OF WATER USE (3L+0P) II

Objective
To make the students aware of the econometric research in the field of water utilization and developing various econometric models and their validation.

Theory
UNIT I
Econometric models. Introduction and stages in econometric research, properties of an econometric model.

UNIT II
Basic two variable regression, the Ordinary Least Square Method, assumptions, estimation and interpretation – extension to multivariable models, multiple regression estimation and interpretation.

UNIT III
Violation of assumptions – identification, consequences and remedies for multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

UNIT IV
WST 607 ENVIRONMENTAL IMPACT ASSESSMENT OF IRRIGATION PROJECTS
(3L+0P) III

Objective

To get the students acquainted with the environmental impact of water resource storage facilities and their assessment, regulation, operation and maintenance through various tools, models and techniques.

Theory

UNIT I
Introduction to the concept of EIA; Environmental impact of dams and reservoirs for irrigation water supply. Environment Impact Assessment (EIA) protocols, guidelines, regulation and policies for construction of dams and reservoirs in India. Case studies of use of EIA in addressing the impact of irrigated agricultural environment and rural development activities in India.

UNIT II
Agricultural nonpoint sources of pollution, process of salinization and desalinization, land reclamation measures, land remediation through subsurface drainage technology, leaching of nitrate and phosphorous beyond crop root zone, Indicators of biological health of the soil, final assessment of the irrigable class of the land for sustainable use.

UNIT III

UNIT IV

Suggested Readings

Dunne, T. and Leopold, LB. Water in Environmental Planning
Environmentally Sound Water Management (Ed.) Tharh, NC and Biswas, AK. Oxford Uni. Press.
Important Aspects of River Valley Project No. 4.
Water and the Environment. FAO Paper No. 8

Suggested Readings

Economics of Irrigation; Ian Carruthers and Colin clark Liverpool University Press, 1981.
WST 608 DIAGNOSTIC ANALYSIS AND PERFORMANCE EVALUATION OF IRRIGATION PROJECTS (1L +3P) II

Objective

To expose the students to the basic problems in irrigation projects and equip them with the analysis of data to diagnostic approach in farmer’s field to design manage and operate irrigation systems both at farm level and command levels.

Theory

UNIT I
Definition, objectives, activities and basic aspects of diagnostic analysis. Fundamentals of conceptual framework for performance evaluation of irrigation project.

UNIT II
Study and measurement of performance parameters under different fertility levels. Efficient utilization of irrigation water. Hydraulics of water advance and recession. Design of surface irrigation methods, evaluation of irrigation methods.

UNIT III

UNIT IV
Socio-economic, political and organizational implications in the management of irrigation systems. Pricing of irrigation water Case studies.

List of Practicals

Volume and mass relationship of soil constituents, soil texture and structure, movement of water into soil, determination of soil moisture coefficients, water and irrigation requirements, irrigation efficiencies, operational management of irrigation projects and socio-economic survey of framers, design and evaluation of irrigation methods, evaluation of irrigation project, diagnostic analysis in farmers fields and remedial measures for improving irrigation management at the farms.

Suggested Readings


WST 611 PRESSURIZED IRRIGATION SYSTEM DESIGN (2L+1P) II

Objective

To introduce design and planning procedures for sprinkle and trickle irrigation system; Special attention is given to modern irrigation equipment, system and automation and to energy saving measures.
Theory
UNIT I
Sprinkler irrigation: an overview, types of systems, system components, design objective, uniformity, adequacy and efficiency of application.

UNIT II
Design of different types of sprinklers; Design of pipelines, laterals, manifold, submain and mains; Design of traveler sprinkler system, layout, hose selection, gun sprinklers

UNIT III
An introduction of trickle or drip irrigation, overview of types of system, various components of trickle systems, clogging and filtration, system flushing and maintenance.

UNIT IV
Trickle / drip irrigation planning factors, emitter selection and design criteria,
Trickle system design strategy and trickle lateral design.

UNIT V
Trickle manifold design, trickle system design synthesis and pressurized irrigation system selection.

Practicals
Design of pipelines, laterals, manifold, submain and mains of drip and sprinkler irrigation systems. Determination of uniformity coefficients, developing criteria for evaluating pressurized irrigation system.

Suggested Readings


WST 614 IRRIGATION HYDRAULICS (2L+1P) III

Objective
To equip the students with the development of various models in surface irrigation hydraulics, using basic infiltration equations movement and disappearance of water from the surface through infiltration and finding numerical solution to various problems in irrigation hydraulics.

Theory
UNIT I
Evolution of surface irrigation methods, selection of a particular irrigation method, Fundamentals of surface irrigation hydraulics,
UNIT II
Infiltration equations and key parameters, irrigation performance parameters

UNIT III
Flow processes in basin, border and furrow irrigation and flow governing equations, The hydrodynamic models and numerical solution, The zero-inertia models and numerical solution

UNIT IV
The kinematic-wave models and numerical solution, The volume balance models and numerical solution, One and two-dimensional surface irrigation models

UNIT V
Surface irrigation design and operation software, Pipe hydraulics in pressurized irrigation network, Total head, friction head loss estimation in pressurized irrigation.

Practicals
Development of various criteria for selecting a particular method, study of the various processes in basin, border and furrow irrigation through governing equations, developing irrigation designs and operation software, estimation of head loss due to friction in pressurized irrigation pipes.

Suggested Readings

WST 615 WATER MANAGEMENT TECHNOLOGIES IN RAINFED AGRICULTURE
(2L+1P) III

Objective
To expose the student with the various problems of water management and their solution for increasing agriculture production in rainfed areas, agriculture production as climatic change and the characterization and rainfed areas, development and use of techniques and mathematical models.

Theory
UNIT I
Prospects of rainfed agriculture, climate change and its impact, characterization and delineation of rainfed areas, moisture stress and low productivity, concepts of blue, green, gray, black, fossil water, rainfall analysis, dry and wet spells, drought, Huff curves.

UNIT II
Techniques and mathematical models for quantification of runoff, use of GIS, RS, DSS, GPS tools and hydrological models in assessment of surface & ground water resources, uncertainty analysis, up scaling/down-scaling approaches, modified Mitscherlich equation, modern tools and crop models in water management.
UNIT III
Resource conservation techniques, improving water use efficiency, conservation tillage, water harvesting, irrigation techniques, mulches and evaporation suppressants, integrated nutrient management.

UNIT IV
Watershed development and integrated watershed management, case studies, crop diversification, farming system approach, alternate land use systems.

UNIT V
Extension strategy, RRA, PRA and PAR, economic issues, institutions and water users associations, PIM and rotational water supply schemes, research and developmental needs, policy issues, National Rainfed Area Authority.

Practicals
Characterization and delineation of rainfed areas, rainfall analysis, dry and wet spells, drought, Huff curves, techniques and mathematical models for quantification of runoff, use of GIS, RS, DSS, GPS tools and hydrological models in assessment of surface & ground water resources, uncertainty analysis.

Suggested Readings
## 25 Other Compulsory Courses

### A. Other Compulsory Courses for all M.Sc./M.Tech. & Ph.D. Students

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Course</th>
<th>Code No.</th>
<th>Name of the Discipline</th>
<th>Compulsory course for the students of</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Library and information services</td>
<td>PGS 501</td>
<td>Library Services</td>
<td>M.Sc./M.Tech.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0L+1P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Technical writing and communication skills</td>
<td>PGS 502</td>
<td>Agricultural Extension</td>
<td>M.Sc./M.Tech.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1L+1P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Basic statistical methods in agriculture</td>
<td>PGS 504</td>
<td>Agricultural Statistics</td>
<td>M.Sc./M.Tech. and Ph.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2L+1P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Intellectual property and its management in agriculture</td>
<td>PGS 503</td>
<td>Plant Genetic Resources</td>
<td>Ph.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1L+0P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Agricultural research, research ethics and rural</td>
<td>PGS 505</td>
<td>Agricultural Extension</td>
<td>Ph.D.</td>
</tr>
<tr>
<td></td>
<td>development programmes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1L+0P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>History of agriculture</td>
<td>PGS 506</td>
<td>Genetics</td>
<td>M.Sc./Ph.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1L+0P)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PGS 501 LIBRARY AND INFORMATION SERVICES**  
(0L+1P) I, II, III

**Objective**

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

**Practical**

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.
PGS 502 TECHNICAL WRITING AND COMMUNICATION SKILLS (1L + 1P) I, II, III

Objective

This course is intended to expose the students about the basics skills needed for writing, reporting scientific data in the form of reports, research papers, manuals etc., and develop skill in preparing appropriate graphics to be used in such documents and presentations.

UNIT I
Basics of writing, writing style, art of clear writing: Readability and comprehension testing procedures, Principles of technical writing, purpose of technical reports, Preparing a documentation plan, Understanding information types, Gathering the data, Analyzing and sorting the results, Outlining the report

UNIT II
Use of charts, graphs, tables, diagrams and photographs, scientific photography, Graphic formats, typology, Presentation of scientific data, general and exact data, Editing, Proof reading, Bibliography

UNIT III
Role of visuals in Communication; Characteristics of visuals, functions of visuals and graphics; Theories of visual perception; Classification of visuals, visual formats, Selection of visuals, Preparing lecture slides – content, limitation and layout; its utility in preparing presentations for research papers and other publications, Public speaking.

Practical
Writing technical reports, research papers, preparing graphics, preparing computer based presentations.

Suggested Reading

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1L+0P) I, II, III

Scope and Objectives
Generation of intellectual property (IP) and Protection of intellectual property rights (IPRs) play vital role in enhancing the inventive and hence developmental activities of the nation. IPRs provide structured mechanisms of rewarding and nurturing inventive activities. Advanced nations and globally competitive corporations strategically protect their IPs in all potential markets/countries through various IPR arrangements.
Indian agriculture requires earnest inventive activities, committed translation of research into technologies and enthusiastic efforts for transfer of technology. Propitiously, agriculture and agricultural research present themselves as immense opportunities for Indian research and development endeavors (both public and private) to compete globally. However, comprehension and implementation of IP management practices are fundamental.

India, as state, is well equipped with government investments in R&D to generate IPs as well as with legislative instruments and institutions to implement IPRs. It is, therefore, imperative for today’s research scholars in the field of agriculture to not only have some basic understanding of the IPRs but also their potential strategic relevance and the management issues. Provision of such an understanding in a nut-shell is the objective of this course.

**Pedagogy**

Interactive lecture sessions will be the main medium of learning in this course. Each session will be of one hour duration and the course will be covered in 10 sessions at the maximum. Practicing experts may also be invited and there may be some pre-arranged visits.

**UNIT I. BASICS**

- Concept of IP, need for IPRs, various legal instruments to protect IPRs
- Types of agricultural technologies that may be protected
- Interface between IPR regime, public good, biodiversity and environment

**UNIT II. LEGISLATIONS AND INSTITUTIONS**

- International Treaties and Conventions affecting agriculture innovation system
- Institutional mechanism of the IPR regime in India: Legislation and authorities
- Protection of Plant Variety and Farmers’ Right, Authority, implementation, implications

**UNIT III. IP MANAGEMENT**

- Management of IPs: (i) Internal assessment of technology and IP audit; (ii) Licencing strategies, technology transfer and commercialization; (iii) Alliances and partnerships
- IP management structure in publicly funded agricultural research systems: a case study of ICAR
- Prior art search, filing of application, examination, grant: Generic procedure
- Case studies

**Suggested Readings**

Following websites provide excellent information (concepts, national and international legislations and institutions, statistics, procedures, FAQs etc.)

World Intellectual Property Organization (http://www.wipo.int/portal/index.html.en)
World Trade Organization (http://www.wto.org/)
International Union for the Protection of New Varieties of Plants (http://www.upov.int/)
Convention on Biological Diversity (www.cbd.int)
Indian Patent Office (http://www.patentoffice.nic.in/)
National Institute for Intellectual Property Management (http://ipindia.nic.in/Niipm/index.htm)
PPV and FR Authority (http://plantauthority.gov.in/)
National Innovation Foundation (www.nif.org.in)
PGS 504 BASIC STATISTICAL METHODS IN AGRICULTURE (2L+1P) I, II, III

Objective

This basic course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of statistical methods that would help them in understanding the importance and need of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, correlation and regression, tests of significance and multivariate analytical techniques. The students would also be exposed to basic design of experiments and sample surveys.

Theory

UNIT I

UNIT II
Correlation and regression: Correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, simple and multiple linear regression model. Estimation of parameters. Coefficient of determination. Introduction to multivariate analytical tools: Principal component analysis and cluster analysis.

UNIT III
Planning of an experiment and basic principles of design of experiments. Analysis of variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin square design (LSD). Randomization procedure, analysis and interpretation of results. Concept of factorial experiments.

UNIT IV
Planning of sample surveys. Sampling vs complete enumeration, Simple random sampling, Stratified sampling.

Practical

Descriptive statistics. Exercises on probability distributions. Correlation and regression analysis. Large sample tests, testing of hypothesis based on $\chi^2$, t and F. Exercises on non-parametric tests. Principal component analysis and cluster analysis. Analysis of data obtained from CRD, RBD, LSD. Analysis of data of factorial experiments. Selection of a random sample, estimation using simple random sampling. Exercises on stratified sampling.
Suggested Readings


PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1L+0P) I, II, III

Objective

The course intends to sensitize the scholars about the basic issues related with agricultural research, ethics in research as well as rural development. The scholars will be also educated about principles and philosophy of rural development and motivated towards practising and promoting ethics in research and developmental endeavours.

UNIT I

Agricultural Research System - NARS and CGIAR; Agricultural Revolutions; Food and Livelihood Security; Climate Change - Mitigation and Adaptation; Overview of ethics and research; Principles and foundations of research ethics; Publishing and Authorship, Plagiarism, Intellectual property Rights and Policy, Researchers’ responsibilities, Research participants’ rights- consent, Privacy and confidentiality; Interviewing ethics; Agricultural research and bioethics; Incentives, Regulation and Activism for ethics;

UNIT II

Ethics and development; Process and outcome of development; Decentralized decision making; Vulnerable groups; Beneficence; Social justice and Equity; Gender sensitivity; Ethics in agriculture - social contract, socio-economic issues, environment, etc; Indigenous knowledge and benefit sharing; Values and attitude for Conservation, improvement and sustainable utilization of natural resources; Overview of rural development programmes in India; Panchayati Raj Institution;
Suggested Readings


Minakshi Bhardwaj, Fumi Maekawa, Yuki Niimura, Darryl RJ Macer. 1999. Ethics in Food and Agriculture: Views from FAO.

Rivera, Roberto and David Borasky 2009. Research Ethics Training Curriculum, Family Health International. P.O. Box 13950 Research Triangle Park, NC 27709. USA.


PGS 506 HISTORY OF AGRICULTURE (1L+0P) III

Objective

To learn about the evolution and achievements of agricultural science in India, lessons learnt and vision for future

UNIT I
Agriculture in ancient India: archaeological findings and literature.

UNIT II
Ancient literature on: farm implements, forecast of weather and rains, types of lands, manure, irrigation, seed and sowing, pests and their management, horticulture and arboriculture, cattle management etc.

UNIT III
Agricultural research, education and extension in pre-and post-independent India. Green revolution, success, associated problems, lessons learnt.

UNIT IV
Challenges to Indian agriculture: future needs and capabilities, environmental problems, international agriculture and partnership. Emerging scenario and expectations.

Suggested Readings


Annexure-I

RECOGNITION OF THE ASSOCIATESHIP OF THE INDIAN AGRICULTURAL RESEARCH INSTITUTE AS EQUIVALENT TO M.Sc. DEGREE OF THE INDIAN UNIVERSITIES

Copy of office memorandum No. F. 17-13/49-T. dated the 8th October, 1949, from the Ministry of Education, Government of India (received under the Ministry of Agriculture, letter No. 1147 Institute/49, dated the 14th November, 1949).

The undersigned is directed to say that the Government of India have, in consultation with the Federal Public Service Commission, decided to recognise the Associationship of Indian Agricultural Research Institute, New Delhi, an alternative qualification to the M.Sc. degree of Indian Universities covered by the Associationship Diploma of the Institute.
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Proforma for Membership of the Post-Graduate Faculty

1. Name:
   (in block letters)

2. Date of birth:

3. Parent discipline:

4. Present place of posting:

5. i) Designation:

   ii) Field of specialisation:

   iii) Specific area of research work:

6. Educational qualifications:

<table>
<thead>
<tr>
<th>Name of the Degree</th>
<th>Name of the University</th>
<th>Whether by course work alone or course work + thesis</th>
<th>Year</th>
<th>Class/Division/Equivalent Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>*B.Sc./B.Sc. (Ag.)/B.Tech.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*M.Sc./M.Sc. (Ag.)/M.Tech.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Strike out words not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Professional record:

<table>
<thead>
<tr>
<th>Designation and grade</th>
<th>Period From</th>
<th>To</th>
<th>Institution and place of posting</th>
</tr>
</thead>
</table>

**Note:** Please indicate here whether facilities required are available in the same Division or outside e.g., inter-disciplinary units. If available outside, indicate whether the consent of the concerned establishment and the officer has been obtained.

8. Teaching discipline in which faculty membership is sought:
9. (a) Total years of research/teaching experience at P.G. Level/extension experience if any after M.Sc. (for those who do not hold Ph.D. degree)

(b) Courses taught: Code No. of course & years:

Whether attested copies of degree certificate enclosed. (Yes/No.)

Signature of the applicant

A. Recommendation by the Board of Studies for faculty membership in the discipline of ……………………………………………………………….. (full justification with specific recommendation whether applicant’s induction to the faculty add to the efficiency of the teaching programme in the discipline may be given).

B. Certified that the attested copies of the degree certificates are enclosed.

Chairman of the Board of Studies

POST GRADUATE SCHOOL

Recommended by the Standing Committee on Faculty and Discipline for faculty membership on ……………………………………….

Chairman, Standing Committee
on Faculty and Discipline
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Proforma for becoming eligible for Research Guide

1. Name: (in block letters)
2. Date of birth:
3. Parent discipline:
4. Present place of posting:
5. i) Designation:
   II) Field of specialisation:
   III) Specific area of research work:
6. Educational qualifications:

<table>
<thead>
<tr>
<th>Name of the Degree</th>
<th>Name of the University</th>
<th>Whether by course work alone or course work + thesis</th>
<th>Year</th>
<th>Class/Division/Equivalent Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.Sc./B.Sc. (Ag.)/B.Tech.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Sc./M.Sc. (Ag.)/M.Tech.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Strike out words not applicable

7. Professional record:

<table>
<thead>
<tr>
<th>Designation and grade</th>
<th>Period From</th>
<th>To</th>
<th>Institution and place of posting</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. Teaching discipline in which faculty membership is/has been granted (No. and date of Post Graduate School letter may be quoted).

9. Teaching discipline in which faculty membership is sought:

10. (a) Total years of research/teaching experience at P.G. Level/extension experience, if any, after M.Sc. (for those who do not hold Ph.D. degree)
(b) Courses taught: Please provide year-wise details of the courses taught indicating the course code no. & no. of lectures taken.

Whether attested copies of degree certificate enclosed. (Yes/No.)

Signature of the applicant

A. Recommendation by the Board of Studies for recognition of the faculty member as Research Guide in the discipline of ................................................................. (full justification with specific recommendation whether applicant's induction as Research Guide will add to the efficiency of the teaching programme in the discipline may be given).

B. Certified that the attested copies of the degree certificates are enclosed.

Chairman of the Board of Studies

POST GRADUATE SCHOOL

Recommended by the Standing Committee on Faculty and Discipline for recognition as Research Guide in the discipline of ..................................................

Chairman, Standing Committee on Faculty and Discipline
REGISTRATION-CUM-ROSTER FORM

Name ........................................................................................................... Roll. No. ..........................................................

Discipline ..........................................................................................................................

Academic Year ................................................................. Trimester: I/II/III/IV/V/VI/VII/VIII/IX/X/XI/XII.

Whether progress report of the preceding

trimester is submitted to the Chairman Yes/No

Fees Paid:

Amount Rs ........................................... : Syndicate Bank Receipt No. .............................................

(Copy to be attached)

Proposed Title of the Thesis ...................................................................................................

................................................................................................................................................

................................................................................................................................................

................................................................................................................................................

Course No. Title of Course No of Credits

................................................................................................................................................

................................................................................................................................................

Research work to be undertaken

................................................................................................................................................

(..................................................)

Signature of the student

Certified that the student has submitted his progress report of the preceding trimester, as per his programme

of work.

(..................................................)

Signature of Professor

Signature of Chairman Advisory Committee

Registered on ...........................................

(..................................................)

Signature of Registrar
INSTRUCTIONS

1. Submit complete set consisting of five copies of this form.

2. Prior approval of the Dean is necessary for any deviation from the approved PPW.

3. When a student has no course work or research work in a trimester indicate “nil” in the space for courses and research respectively.

4. In case any student desires to take more than 15 credits in a trimester, he/she should obtain prior approval of the Dean, Post Graduate School for relaxation of the prescribed limit.
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Progress Report for Trimester Ending : ________________

1. Academic Year 200 -200 Trimester________ M.Sc./Ph.D. ____________

2. Discipline ___________________________________________ Roll No. ____________

3. Name of student __________________________________________________________________

4. Date of Admission __________________________________________________________________

5. Name of Chairman, Advisory Committee ____________________________________________

6. Total No. of credits included in PPW ________________________________________________

7. Total No. of credits completed so far trimester-wise Trimester Credits OGPA

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

8. Whether Thesis Problem identified:

9. Date of submission of ORW:

10. Date of Passing Qualifying Examination:

11. Has research work started ? If so, give a resume of the work done so far bringing out the salient points including difficulties, if any:

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

Signature of the student

12. (a) Is the statement in column 11 correct ? If not, indicate factual position

________________________________________________________________________________
(b) Is the student regularly attending to his approved research work? ________________________

13. Date of meeting of the Advisory Committee of the student during the trimester under report ________________________________

14. Comments of the Advisory Committee ___________________________________________

__________________________________________________________________________________

________________________________________

Date: ______________ Signature of Chairman, Advisory Committee

Date: ______________ Signature of Professor

Note:

1. The student should submit this, in duplicate, to his Chairman, Advisory Committee, 15 days before the end of each trimester.

2. The Chairman, Advisory Committee shall deliver both copies of the Progress Report to Professor of the discipline after recording his comments within 2 days.

3. The Professor shall get the Progress Report reviewed in the Board of Studies well before the start of the next trimester.

4. The Professor shall furnish the duplicate copy of the Progress Report to P.G. School Office along with comments of the Divisional Board of Studies.
PROFORMA FOR THE APPROVAL OF STUDENTS’ ADVISORY COMMITTEE
AND PLAN OF POST GRADUATE WORK FOR M.Sc./Ph.D. STUDENTS

1. Name of the student: ____________________________________________________________
2. Roll No.: ___________________________________________ 3. Date of enrolment: _____________
4. Discipline: _________________________________________________________________
5. Major field: _________________________________________________________________
6. Minor fields: i) ____________________________ ii) __________________________________
7. Other fields: _________________________________________________________________
8. Degrees/Diploma earned elsewhere:

<table>
<thead>
<tr>
<th>Institution/University</th>
<th>Subject</th>
<th>Year</th>
<th>% of marks / OGPA</th>
</tr>
</thead>
</table>

   (Thesis Title)
   (Two page note with objectives, introduction indicating gaps and
   expected outcome to be enclosed) ________________________________________________

10. Whether radioactivity is involved in proposed research work?

11. Composition of the Advisory Committee and its approval for PPW:

<table>
<thead>
<tr>
<th>Name &amp; Designation</th>
<th>Division</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Chairman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Co-Chairman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii) Member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv) Member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v) Member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi) Member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vii) Member</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signature of Chairman

Recommended by:
Signature of Professor Approved
Signature of Head Signature of Dean
12. Details of courses proposed to be taken:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Course code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. No of Credits of course recommended:

<table>
<thead>
<tr>
<th>Major field</th>
<th>Minor field</th>
<th>Others</th>
<th>Remedial</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Copy for:

P.G. School

Professor

Chairman

Signature of the Student

Student
1. Name of discipline in which course is to be listed:

2. Title of the course and course no:

3. Course content:

4. (a) Number of credits:  
   (theory and practical)

   (b) Number of theory lectures  
       per week and duration

   (c) Number of practical lectures  
       per week and duration

5. To be offered: Trimester No.: Yearly/Odd year/Even year

6. Need for new course/revising the course:

7. Relation to other course:
   (a) Pre-requisite(s), if any:
   (b) This course is to be a formal  
       pre-requisite for course no.:
   (c) In your judgement, does this course overlap  
       to a considerable extent, with any other course  
       whether in your discipline or in another discipline?  
       If so, Please name the common topic and the course

       | Topic | Course |
       |-------|--------|
       | (i)   | (i)    |
       | (ii)  | (ii)   |
       | (iii) | (iii)  |

   Please indicate the reason why overlapping is justified.

8. Would the introduction of this course necessitate any addition to the staff strength of the division concerned?
9. (a) Name of the course leader:
   (b) Name of alternate course leader(s):

10. Topical outline of course separately for theory and practicals (give under major and minor heading the principal topics covered in this course together with the approximate number of class hours to be devoted to each topic. Please be specific and inclusive).

11. List of reading and reference material required for the course:

12. Class room, laboratory, equipment and other facilities required and whether they are available:

13. Examination and weightage:

<table>
<thead>
<tr>
<th>Type of Examination</th>
<th>Number</th>
<th>Weightage to be given</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Quizzes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Mid term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Term paper/assignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Practical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Final</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Other type of examination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. Sequence of action:

   Request prepared by: Date:
   Approved by the Board of Studies Date:
   Approved by the Standing Committee on Course, Curricula and Academic Affairs Date:
   Approved by the Academic Council Date:
Annexure-VII

POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Proforma for Outline of Research Work

1. Name of the student :
2. Roll No. :
3. Discipline :
4. M.Sc./Ph.D. :
5. Date of joining the Post Graduate School :
6. Major field :
7. Minor field :
8. Title of the thesis :
9. Objectives :
10. Previous work done :
11. Programme of research work :
12. Methodology :
13. *Facilities required & their availability
   Date: Signature of the Student
   Recommended by:
   1. Advisory Committee: (a) (Chairman)
      (b)
      (c)
      (d)
14. Whether radioactivity is involved in the proposed work: if yes
   (i) Whether Radio-safety badge has been obtained or applied for?
   (ii) Whether the laboratory in which the work has to carried out is approved for radioactivity work?
   Certify that ORW of the student has been formulated and finalised in accordance with the procedure
   prescribed in Para 8.14.2 of the Calendar.
   2. Professor Date:
   3. Head of the Division Date:
   4. Approved by the Dean, Post Graduate School: Date:
I. Performa for Forwarding Final Trimester Examination Result

Annexure-VIII

POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Academic Year :

1. Course Code No. Title
2. Name(s) of instructor(s) :
   (i)
   (ii)
   (iii)

Trimester :

Credits (L+P):

Lectures given
L  P

3. Details of classes
   Lecture (No.) Scheduled :
   Given :
   Practical (No.) Scheduled :
   Given :

4. Details of Examination held
   Quiz :
   Mid-term :
   Final Theory :
   Practical :

5. Invigilation done by :

6. Date of dispatch of result :
   (Result should be sent to the Post Graduate School within 7 days of the examination)

7. Reasons for delay, if any :

8. Analysis of grading (Give details of result overleaf)
   No. of students who took the examination :
   M.Sc.  Ph.D.  Total :
   No. of students for whom result furnished :
   M.Sc.  Ph.D.  Total :

747
No. of students obtained grade between  
9.00 to 10.00  8.00 to 8.99  7.0 to 7.99  6.0 to 6.99  below 6.00

M.Sc.
Ph.D.

*Note: Please enclose one copy each of the Question Papers given for the final examination :*

**Trimester Final Examination Result for Course Code No.**

To check the attendance requirement indicate here the number of Lectures/Practicals equal to 85 or nearest higher percentage of the total Lectures/Practicals given:

<table>
<thead>
<tr>
<th>Roll No.</th>
<th>Name of the student</th>
<th>No. of classes attended</th>
<th>OGPA Awarded</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lectures</td>
<td>Practicals</td>
<td></td>
</tr>
</tbody>
</table>

It is certified that :

a. the type of examinations and the weightage attached to each course including practicals had been announced by me at the commencement of the trimester;

b. the result has been declared to and discussed with the students concerned as per Post Graduate School calendar guidelines; and

c. the course Evaluation Proforma was obtained by me duly filled in by the concerned students.

Forwarded to the Dean, Post Graduate School

Signature of Professor  
(Signature with date)  
Name & designation of  
Course Instructor

Note: Course instructors may themselves declare the result to the students at the end of evaluation and discussion with the students shall be completed within 2 days of such declaration and result communicated to Post Graduate School through Professor within 7 days of date of examination.
II. PROFORMA FOR SENDING RESULT OF MAKE UP EXAMINATION IN RESPECT OF MISSED FINAL THEORY EXAMINATION

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Credit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of the Course:</td>
<td></td>
</tr>
<tr>
<td>Total No. of Classes conducted:</td>
<td>Lectures:</td>
</tr>
<tr>
<td>Roll No.</td>
<td>Name of student</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
</tbody>
</table>

Certified that the student has completed 85% attendance separately in lectures and practicals.

Signature
& Name of Course Leader

Signature of Professor
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Grade Card

Name of the student :

Roll No. :

Academic year : Trimester No. : M.Sc./Ph.D. :

Discipline :

<table>
<thead>
<tr>
<th>Course code no. and title</th>
<th>Credits</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Date :

Signature : Registrar
M.Sc./Ph.D. Transcript

1. Name:
2. Roll number:
3. Father’s name:
4. Permanent address:
5. Date of birth:
6. Institution last studied and degree obtained:
7. Date of admission at IARI:
8. Subject:

   Major:

   Minor(s):

9. Qualifying Examination passed on:
10. Title of thesis:
11. Thesis submitted on:
12. Date of passing the Final thesis *viva-voce* examination:
13. Details of courses credited: (see reverse)
14. Overall grade point average:

New Delhi

Date:
Details of the course work and Overall Grade Point Average obtained

<table>
<thead>
<tr>
<th>Trimester</th>
<th>Course code No.</th>
<th>Descriptive title of course</th>
<th>Credits (L+P)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks

Total :

(1) **OGPA**

**Description of Performance**

- 9.0 to 10.0 (90 to 100%) Ist Class with distinction
- 8.0 to 8.99 (80 to 89%) Ist Class
- 7.0 to 7.99 (70 to 79%) IInd Class
- 6.0 to 6.99 (60 to 69%) Pass
- Below 6.00 (less than 60%) Fail (F)
- Incomplete I

(2) **OGPA = Total points earned divided by total credits taken.**

(3) **One hour lecture or three hours practical per week for 12 weeks carries one credit hour.**

Prepared by

Checked by

Registrar

752
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

PROPOSAL FOR HOLDING M.Sc./Ph.D. QUALIFYING EXAMINATION
(TO BE SUBMITTED IN TRIPlicate TO THE CHAIRMAN)

1. Name of the student: 
   (In block letters)

2. Roll No. :
3. Date of joining

4. Discipline :

5. Major field :
   Minor field :

6. Course work:
   Total No. of courses
   No. of credits completed
   % of credit completed

7. Overall Grade Point Average earned :

8. Date of submission of ORW to the Professor :

9. Advisory Committee :
   1. Chairman
   2.
   3.
   4.
   5.
10. Names to be proposed by the Chairman, Advisory Committee for co-opted member of the Examining Committee:

   For M.Sc.: From amongst the faculty members outside the major discipline at IARI

   For Ph.D.: From amongst the experts in the major discipline out of IARI

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation with complete address</th>
<th>Phone No.</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Signatures of Chairman)

11. Names proposed by Professor/Head of Division:

   1. 

   2. 

Signature:  

Professor  

Head of Division  

Note:

1. Chairman to give two copies to Professor.

2. The qualifying examination must be completed at least three months in advance of the proposed date for completion of M.Sc. and six months for Ph.D. degree programme of the student.
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Report on the M.Sc./Ph.D. Qualifying Examination

Name of the student : Roll No. :

Major field of specialisation :

The Examining Committee hereby certify that in their judgement the above named student has Passed/Failed in the Qualifying Examination Viva which has been held this day the _____________ and Recommended/Do not Recommend that this student be admitted to the Candidacy for the degree of Doctor of Philosophy/Master of Science of the Institute.

Signature

Chairman :
Co-opted Member :
Member :
Member :
Member :
Member :

Findings of the Committee :

1. The student should be encouraged to proceed/discouraged from proceeding.

2. The student should add to the programme of study the following :

3. The student should modify the approved programme of study as follows :

4. Other comments, if any :

5. Certified that, except for the addition of the Co-opted member nominated by the Dean, the Examining Committee given above is the same as the approved Advisory Committee of the student if the change in the Examining Committee from that of the approved Advisory Committee of the student has been duly approved by the Dean, Post-Graduate School.

Chairman, Examining Committee
To

The Dean, Post-Graduate School

Signature of Professor

Note: The oral examination shall be held only after the written examination has been successfully completed. If a student fails in one or more subjects in the written examination, the Examining Committee shall make specific recommendations as to whether the candidate is to be re-examined only in that/those subject. Similarly, if a student fails in the oral examination, the Examining Committee shall specifically recommend as to whether the candidate is to be re-examined in the oral examination alone or in the written portion as well.
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

PROPOSAL FOR SUBMISSION OF M.Sc./Ph.D. THESIS

Part I: To be neatly filled-in or typewritten by the student and submitted in duplicate to the Chairman Advisory Committee, not later than two months before the proposed date for submission of thesis.

1. Name in full: ____________________________ (in block letters)

2. Roll No.: ____________________________

3. Date of joining: ____________________________

4. Discipline: ____________________________ Major: ____________________________
   Minor: ____________________________

5. Proposed date of submission of thesis: ____________________________

6. Approved thesis title:

   ______________________________________
   ______________________________________
   ______________________________________

7. Total course work assigned (including additional course work; if any, assigned at the qualifying examination): ____________________________

8. Trimester in which course work completed: ____________________________

9. Overall Grade Point Average earned: ____________________________

10. Date of Qualifying Examination: ____________________________
11. Advisory Committee: 1. Chairman
   2.
   3.
   4.
   5.

Date: (Signature of the Student)

Part II: To be completed by the Chairman (after checking Part I above and one copy submitted to the Dean through the Professor and Head of the Division.

12. Suggestions about names for appointment as examiner for thesis adjudication by the Chairman of the Advisory Committee:

   S. No.   Name   Designation & Address   Phone/Fax/E-mail
   1.
   2.
   3.

Certified that the student has completed all the course work.

Date: 

Signature of Chairman, Advisory Committee

15. Two additional names: To be proposed by Professor. (In case the Professor himself is the Chairman of Advisory Committee, these names are to be proposed by the Head of Division.)

   1.
   2.

Signature by: Professor     Head of Division

To

The Dean
Post Graduate School
IARI, New Delhi - 110 012
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Report on Thesis and Final *Viva-voce* Examination

1. Name of the student :
2. Roll No. :
3. Venue of the Examination :
4. Date of Examination :
5. Discipline :
6. Degree: *Doctor of Philosophy/Master of Science*
7. Major field of specialisation :
8. Thesis title :

The Examining Committee hereby certify that they have examined the above mentioned thesis presented by the above named candidate and after going through the report(s) of the External Examiner(s) on its adjudication, have finally conducted a *viva-voce*. In the judgement of the Examining Committee the candidate has SATISFACTORILY MET/FAILED TO MEET SATISFACTORILY the requisite standard of performance in these respects for the award of the Ph.D./M.Sc. degree.

Signature

Chairman
Co-opted Member
Member
Member
Member

(a) Certified that the typographical and other errors/omissions pointed out by the External Examiner(s) in their assessment of the thesis as also by the Examining Committee at the final *viva* have been corrected by the candidate, and the thesis approved by the Advisory Committee.

(b) Certified that the required number of copies of thesis duly bound have been deposited in the Central Library and Divisional Library.

(c) Remarks, if any :

Forwarded :

Signature of Professor

(Chairman, Examining Committee)

To the Dean, Post Graduate School, IARI, New Delhi 110 012
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Course Evaluation Proforma

Name of the Course and Code No.

Course Instructors:

Academic Year/Trimester:

(To be filled in by the Students)

A. Course Content

1. Is the objective of the course clear?
   - Yes
   - No

2. (a) Was the detailed course outline given in the first week of the course?
   - Yes
   - No

   (b) If the answer to 2(a) is “No”, was it given at all?
   - Yes
   - No

3. Were the course contents covered as outlined in the beginning?
   - Yes
   - No

4. Was there any overlapping in the course content with any other course?
   - Yes
   - No

5. Was the overlapping avoidable without any deficiency in the course content?
   - Yes
   - No

6. Do you have any suggestion with regard to the course content?
   - Yes
   - No

7. Is the time provided for the course adequate?
   - Yes
   - No
B. Teacher (indicate your opinion about each instructor specially)

1. Did the instructor(s) take interest in teaching?
   Yes  No

2. Did he/they encourage discussion in and outside the class?
   Yes  No

3. Was he able to arouse interest in the subject?
   Yes  No

4. Was he easily approachable?
   Yes  No

5. (a) Did you like the teaching?
   Yes  No
   (b) If the answer to above is “No” indicate whether it was a part or whole of the course.
   (c) If in part, please state which part you did not like.
   (d) You did not like the teaching because of (tick mark the most appropriate one):
       (i) Poor knowledge of the subject matter
       (ii) Poor delivery
       (iii) Unpreparedness

C. Teaching

1. Were the theory classes held regularly?
   Yes  No

2. Were the text books and other reading materials suggested?
   Yes  No

3. (a) Were the library facilities in the Division/Central Library adequate in relation to the course?
   Yes  No
   (b) If “No”, which text books or journals were wanting?
4. (a) Were the suggested reading material adequate to cover the course content?  
   Yes  No  
   (b) Did you read suggested literature?  
   Yes  No

5. Were the practical classes held regularly?  
   Yes  No

6. Were the laboratory facilities for conducting practicals adequate?  
   Yes  No

7. Was the presentation of subject matter by the instructor clear, definite and forceful?  
   Yes  No

8. Were the practicals conducted by the instructors themselves?  
   Yes  No

9. Did you have any specific suggestions for the improvement in the theory/practicals? If so, please state.

10. Organization of this course with respect to the following:  
    (a) Scheduling of classes  
    (b) Number of instructors  
    (c) Distribution of syllabus  
    (d) Punctuality of instructors  
    (e) Timing/duration of classes

D. Evaluation

1. Should there have been a term paper assigned?  
2. If yes,  
   (a) Was the term-paper relevant to the course?  
   Yes  No  
   (b) Were the term-papers presented in the class?  
   Yes  No  
   (c) Were the presentations of the term-papers of any benefit to you?  
   Yes  No
3. (a) Were the quizzes conducted?
   Yes-----------No
(b) Were the quizzes too many?
   Yes-----------No

4. Did the questions in mid-term and final examinations represent the course content fairly well?
   Yes-----------No

5. Were the mode of evaluation and weightage for various examinations for the purpose of grading explained in the first week of the course?
   Yes-----------No

6. Is the evaluation system fair and consistent?
   Yes-----------No

7. What score do you expect in this course?

E. Others

1. Why did you take this course?

2. Is your expectation from the course fulfilled?
   Yes-----------No

3. How would you evaluate the course?
   Excellent   V. Good   Good   Fair   Poor
Proforma for Relief of Students Pending/After Submission of Thesis

1. Name of the student : Roll No.: (M.Sc./Ph.D.)
2. Regular/Departmental:
3. Date of enrolment:
4. Details of scholarship held (ICAR, IARI etc.):
5. Details of work completed:
   (i) Credits taken and completed:
   (ii) Date of qualifying examination:
   (iii) Whether seminars have been completed:
   (iv) Whether research work and analysis of data completed:
6. Expected date of submission of thesis :
7. Reasons for requesting relief before/after the date of submission of thesis (if taking up employment, indicate employer's name):
8. In case of accepting outside employment, whether application was routed through the Dean:
9. Date from which relief sought:
   I. I undertake to pay the tuition fee of Rs. 400/- per month from the date of relief till the date of submission of thesis. (This shall be deposited in the Syndicate Bank up to the 10th of every month)
   II. I undertake that I will submit my thesis within a period of one year from the date of relief, failing which, action may be taken against me as per PG School guidelines.

Date : Signature of the Student

Comments of the Chairman, Advisory Committee

Recommended and Certified:-
(i) That he/she has completed all course work including research work and seminar except writing of thesis.
(ii) That he/she has fulfilled the minimum requirements regarding residence and attendance.
(iii) He/she has given the Thesis Seminar on __________.

Date : Signature of Professor
APPLICATION FOR EXTENSION IN THE TENURE OF THE IARI SCHOLARSHIP

Name of the student :

Roll No. :

Division :

1. Whether awarded Junior or Senior Scholarship:

2. Date of start of the Scholarship:

3. Period for which Scholarship sanctioned:

4. Period for extension of the Scholarship sanctioned earlier, if any:

5. Date of registration with the Institute for M.Sc./Ph.D.:

6. Minimum period after registration prescribed by the Institute for submission of thesis:

7. Grade Point Average up-to-date:
   (where applicable)

8. Date of passing the comprehensive examination:
   (where applicable)

9. Report of the work done so far by the fellow with reference to the time schedule submitted earlier:

10. The work that remains to be done:

11. Specific justification for not completing the work according to the time schedule:

12. Detailed justification in support of the proposal for extension of the tenure of Scholarship:

13. Period of extension requested for:

   Signature of the Student

   Signature of the Chairman, Advisory Committee of the student

15. Recommendations of the Professor:

   Note: (Attach separate sheets if space is insufficient under any item)
A. UNDERTAKING

1. I hereby undertake that if I am selected for the Scholarship applied for by me, I shall not leave the work assigned to me under the Indian Agricultural Research Institute scholarship programme unfinished.

2. I will not leave the course work prior to its completion without approval of the Dean, Post Graduate School. In case, I leave the course prior to its completion without the approval of the Dean, I will refund the entire amount received by me from the Institute as scholarship, contingency and temporary loan etc.

3. I authorise the Bank/Institute to recover from my bank account any sum that may have been drawn in excess or due to the Institute by way to rent, mess fee etc. remaining unpaid by me.

In witness whereof I ........................................................................................................have signed those present on the ................................................................. day of .........................

Signature ..................................................

(Ph.D./M.Sc.) ............................................

Roll No ....................................................

Address....................................................

In the presence of

I. Signature ..........................................

Name in full .................................

Designation .................................

Address .................................

II. Signature .................................

Name in full .................................

Designation .................................

Address .................................
B. UNDERTAKING

As I have been offered a Junior/Senior Scholarship of the Indian Agricultural Research Institute for study and research leading to M.Sc./Ph.D. in the subject of and as I have accepted the said Scholarship and also the terms and conditions governing the Scholarship, I hereby undertake that I shall complete the study and research work assigned to me by the Guide. I also undertake that I shall not leave the course before its completion without prior approval of the Dean, Post Graduate School. I also certify that I am not drawing any other fellowship/scholarship from any source. I shall not accept any other fellowship without the permission of the Dean.

In witness whereof I ........................................................................................................... have signed those present on the ................................................................................. day of .........................

Signature ....................................................

(Ph.D./M.Sc.) ............................................

Roll No ....................................................

Address ....................................................

In the presence of

I. Signature ........................................
   Name in full .................................
   Designation .................................
   Address .................................

II. Signature .................................
   Name in full .................................
   Designation .................................
   Address .................................
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Proforma giving details in respect of Short-term Training Course

1. Name of the Division:
2. Name of the course:
   (Whether regular or ad-hoc)
3. Brief contents of the course:
4. Duration along with proposed dates of the course:
5. Staff member/Faculty member who will be in-charge of the course:
6. Number of trainees to be admitted:
7. Details of qualification and experience prescribed for participants:
8. (a) Number of persons for whom hostel accommodation will be necessary and whether its availability has been ascertained from the concerned Hostel.
   (b) Whether boarding facilities also required:
9. (a) Estimated expenditure on the course:
   (b) Source from which the expenditure will be met:

Signature of the Course Director
POST GRADUATE SCHOOL
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI - 110 012

Memorandum of Understanding

Between POST GRADUATE SCHOOL, INDIAN AGRICULTURAL RESEARCH INSTITUTE and ____________ in the areas of agriculture research and teaching.

1. This memorandum of understanding is executed on ______________ between INDIAN AGRICULTURAL RESEARCH INSTITUTE (P G SCHOOL, IARI, New Delhi) and ______________ for carrying out collaborative agricultural research and teaching in relation to improvement of ______________.

2. Inducted ______________ faculty will be accredited with PG SCHOOL, IARI for guiding Masters/Doctoral research of P G School, IARI students.

3. The students who opt for such research work that may require work at ___________ or support of faculty of ____________ along with sessions required to be completed at ____________ will submit the thesis at P G School, IARI ____________ for respective degrees.

4. The students will be admitted at IARI and will undergo Course work and written and all oral examinations at IARI. The Co-Supervisor of the student at ____________ shall join the Final Viva-Voce Examination of the student.

5. ______________ will provide necessary infra-structural support to students such as hostel, library, farm, laboratory and computer facilities, etc. during the research work undertaken there. P G SCHOOL, IARI and ____________ will share joint credit in publications, reports and awards resulting from information generated under collaborative research and degree projects.

6. The Faculty identified at ____________ and approved by the Academic Council as faculty of P G School, IARI shall be eligible to serve as Co-supervisors of students and may be required to visit IARI for short periods for teaching Theory and/or Practical classes. Such visiting faculty shall be provided guest house accommodation at IARI, New Delhi

7. Identified ____________ faculty will look after the day to day conduct and progress of the student during his/her stay and also supervision of experiments at__________.

8. Any new developed technology will be taken up for commercialization or adoption in farmers fields through frontline demonstrations, Kisan Goshties and Kisan Melas. These activities will be undertaken under the supervision of ______________ , P G SCHOOL and IARI experts.

9. Joint meeting of ____________ and P G SCHOOL, IARI teams will be held at least once a year.

(Signature of H.O.I., ______________) (Signature of H.O.I., IARI)
Instructions to Examiners with regard to Evaluation of M.sc./Ph.d. Thesis

1. The requirements for the degree of Master of Science and Doctor of Philosophy of the Indian Agricultural Research Institute include the taking up by the student of a specified amount of course work in his/her major field as well as in the minor and supporting fields and offering of seminars. On completion of the major portion of the course work the student has to pass the qualifying examination in order to be eligible for submission of thesis.

2. In addition to the above, the student has to submit a thesis embodying the results of a research investigation carried out under the supervision of his/her Advisory Committee. While the thesis for M.Sc. degree is required to be of such nature as to indicate the student’s potentiality for conducting research, the thesis for the Ph.D. degree has to be a definite contribution of an original nature to the subject and the results and conclusions presented therein have to be of sufficient importance of merit for publication.

3. The manuscript based thesis submission has been introduced from 2009-10 academic session. This includes chapters on: (i) Introduction, (ii) Background, (iii) General Materials & Methods, (iv) Research Papers I, II, III ….. or Patent application/Prototype, etc., (v) General Discussion, (vi) Summary & Conclusion, (vii) Abstract, and (viii) Bibliography.

4. Examiners are requested to go through the thesis and give a critical assessment covering the different aspects such as whether:
   a. The thesis addresses a relevant researchable issue;
   b. The thesis has entailed the solution of one or more problems;
   c. The planning and conduct of the experiments are appropriate;
   d. The review of the literature is analytical and up-to-date, the references to literature have been presented in the proper form, and the data are well presented and interpreted in a set of research papers/patent applications/prototype descriptions etc. and discussed in relation to previous literature;
   e. General Materials and Methods do not elaborate methods described in detail in research papers and vice-versa, avoiding repetition as far as possible;
   f. The general discussion is critical and links the different papers/applications/descriptions in totality in relation to the previous literature and thoughts for future. General Discussion is not a repetition of the Discussion in the different research papers etc.;
   g. The illustrations are appropriate and of good quality;
   h. Only unavoidable repetitions exist in the text

4. Typographical and other errors should be pointed out and stated if these are considered serious which detract from the merit of the thesis and which the student may be required to correct before the thesis is accepted for the award of degree. It may also be indicated whether the thesis is considered fit for publication in extenso or in an abridged form.
5. In case of Ph.D. thesis the Examiner should particularly mention whether in his opinion the contributions made by the thesis are of fundamental value or applied standpoint. Whether the thesis contains new ideas, solution of problem, inventions, discoveries, improved measurement and observations.

6. The thesis together with the Examiner's Report in the prescribed format provided and the Remuneration Bill must be returned in a month's time of its receipt by the Examiner. In case the thesis is delayed beyond the aforesaid period without any intimation, the Dean will have the right to cancel the Examinership and make alternate arrangement for evaluation of the thesis. The report must be returned in a sealed cover marked “SECRET” to the sender.

7. Remuneration payable for evaluating the thesis is ₹2,000/- for Ph.D. Thesis and ₹1,000/- for M.Sc. Thesis. The Dean may withhold the honorarium if the Report is not received within two months.

8. The Examiner's final recommendation as to whether or not the thesis should be accepted in the form in which it has been presented for the award of the degree must be clear and unambiguous.
Title of the thesis:
Name of the student:
Roll No.:
Discipline:
Thesis received on:
Evaluation report submitted on:

Chapter-wise comments on the thesis (please give your comments on each point as under):

1. Introduction and Objectives
   (a) Relevance and novelty of researchable issue
   (b) Reasonability of hypothesis
   (c) Relevance of objectives

2. Background
   (a) Proper referencing of past studies in the background chapter, their exhaustiveness and up-to-date
   (b) Synthesis and analysis of available literature relevant to the present research problem

3. Planning and conduct of experiments
   (a) Specific comments on the novelty of research problem
   (b) Appropriateness of objectives and their clear statement
   (c) Academic contribution of the research work
   (d) Practical utility of research work
   (e) Whether the thesis has embodied any new ideas with original thoughts?

4. Materials and Methods chapter
   (a) Methodology technically sound and explained adequately
   (b) Statistical design, analytical or experimental skills utilised
   (c) Methodology common to most or all papers properly described in this chapter while specific methods are given in research papers etc.

5. Results chapter (research papers)
   (a) Research papers justify the thesis title and objectives
   (b) Is there duplication of data/results in different research papers?
   (c) Presentation of data with quality figures/illustrations and tables
   (d) Is there repetition of detail general materials and methods part in research papers?
   (e) Are the research papers fit for publication in peer reviewed journals?
6. **General Discussion**  
(a) Is this a clear analysis and critical discussion of overall results avoiding repetition of data in relation to relevant literature, holistically and logically linking the different research papers?

7. **Summary and Conclusions**  
(a) Findings and advancements summarized in brief without repetition of detailed data  
(b) Conclusions valid and based on research findings described in thesis

8. **Bibliography**  
(a) References properly arranged and presented in uniform pattern  
(b) References quoted in text tally with the bibliography

9. **General comments on overall presentation of the thesis**  
(a) Are there any unavoidable repetitions in the thesis?  
(b) Quality of figures, photographs, illustrations etc.  
(c) Appropriateness of tables  
(d) Sample size, statistical design and analysis of data  
(e) Quality of research papers  
(f) Language and grammar  
(g) Typographical errors of serious nature  
(h) Abstract clear and conveys the work and significant findings in brief  
(i) Is there plagiarism in the thesis to the best of your knowledge; if yes, kindly elaborate.

10. **Critical Comments on the contributions made on fundamental value or applied standpoint**  
(a) Highlights and strong/weak points of the thesis  
(b) Grading of the thesis (circle the mark in the grade columns)

<table>
<thead>
<tr>
<th>Thesis chapter/ parameters</th>
<th>Grading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Background</td>
<td>2</td>
</tr>
<tr>
<td>Methods &amp; Materials</td>
<td>2</td>
</tr>
<tr>
<td>Results</td>
<td>6</td>
</tr>
<tr>
<td>Discussion</td>
<td>2</td>
</tr>
<tr>
<td>Summery</td>
<td>2</td>
</tr>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td>Bibliography</td>
<td>1</td>
</tr>
<tr>
<td>Language/ typographical errors</td>
<td>1</td>
</tr>
<tr>
<td>Overall novelty, Practical utility or scientific technology advancement</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total score**
11. List of questions to be asked during the final *viva-voce* examination of the student.

12. Final Recommendation

   a) **I recommend** that the thesis submitted by ____________________________ be accepted for the award of degree of _____________ of the Indian Agricultural Research Institute, New Delhi, subject to my observations.

   OR

   b) **I do not recommend** the acceptance of the thesis submitted by ____________________________ for the award of the degree of _____________ of the Indian Agricultural Research Institute, New Delhi, in view of my observations.

   (Signature of Examiner)

   Name :

   Date:

   Designation :

   Address :

*(Note: Blank sheets may be added to complete the report under any particular head/s above)*