

# INFORMATION BULLETIN

(UG, PG and Ph.D. Courses)

2023-24



**The Graduate School**

**ICAR-Indian Agricultural Research Institute**

**(Deemed to be University)**

**New Delhi - 110012**

**The Graduate School**  
**ICAR-Indian Agricultural Research Institute**  
**New Delhi 110012**

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ICAR-IARI was granted the status of a Deemed to be University in 1958 (Under UGC Act 1956). The academic activities of the Institute are regulated by the Academic Council with the Director, ICAR-IARI, New Delhi as its Chairperson and the Joint Director (Edu.) & Dean, ICAR-IARI, New Delhi as its Vice-Chairperson, *henceforth referred to as Dean in the document*. The Academic Council is the competent authority to amend the rules and procedures governing all aspects of the academic programmes (UG, PG and Ph.D; certificate and diploma courses etc.) of the institute. All correspondence regarding admissions should be addressed to the Sr. Registrar, The Graduate School, ICAR-Indian Agricultural Research Institute, New Delhi- 110 012.

**This Information Bulletin should not be treated as a legal document.**

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# 1. INTRODUCTION

ICAR - Indian Agricultural Research Institute is India's largest and foremost Institute in the field of research, higher education and training in agricultural sciences. It has served the cause of science and society with distinction through cutting edge research, generation of appropriate technologies and development of human resources. In fact, the Green Revolution was born in the fields of ICAR- IARI and our students constitute the core of the quality human resource in India's agricultural research and education. The Institute has all along been adjusting and improving its policies, plans and programmes to effectively respond to the needs and opportunities of the nation. During the fifties, the advancement of scientific disciplines constituted the core programme and provided the base for its fast expansion in the 1960's and 1970's in all its three interactive areas namely, research, education and extension. Besides basic research, applied and commodity research gained great importance resulting in the development of several popular high yielding varieties of almost all major crops and their associated management technologies, which brought about an unprecedented increase in the national food and agricultural production. The main functions of the Institute cover the areas of basic and applied research in the major branches of agricultural sciences; under graduate programs viz. B.Sc. Community Science, B.Sc. Agriculture, B. Tech (Agri-Engineering) and B.Sc. (Biotechnology); as well as post graduate education at the M.Sc., M. Tech. and Ph.D. levels for which the Institute has been accorded the status of a Deemed to be University under the University Grants Commission (UGC) Act of 1956; specialized post graduate training courses; and extension education and transfer of technology in selected areas. The administrative control of the Institute is vested with Indian Council of Agricultural Research (ICAR), which is an autonomous organization established under the Societies Registration Act, 1860.

The Institute was originally established by the Government of India in 1905 at the village Pusa in north Bihar. After a devastating earthquake in 1934, it was shifted to New Delhi in 1936. That is why it is popularly known as the Pusa Institute. The present campus of the Institute is a self-contained complex spread over an area of about 500 hectares.

The Institute has inherited a great tradition of agricultural research. Since its early days at Pusa, the Institute has been doing pioneering work in various fields of agricultural sciences. The Institute has expanded greatly in its activities, research facilities and scientific personnel in the post-independence years. When the Institute came to New Delhi in 1936 it had five Sections. Today, the Institute's research and educational activities are carried out through a network of 26 disciplines, 1 Project Directorate, 2 Regional Centres, 8 Units, 1 KVK and 8 Regional Stations. The Institute has been accredited by the NAEAB of ICAR, NAAC of UGC as A and ranked top position in the agriculture and allied category in the NIRF Rankings 2023.

## Mandate of the **Institute**

- Basic, strategic and anticipatory research in field and horticultural crops for enhanced productivity and quality.
- Research in frontier areas to develop resource use efficient integrated crop management technologies for the sustainable agricultural production system.
- Serve as a centre for academic excellence in the areas of higher education and human resources development in agricultural science and allied fields.

Provide national leadership in agricultural research, education, extension and technology assessment and transfer by developing new concepts and approaches and serving as a national reference point for quality and standards.

The laboratories are equipped on modern lines for conducting research of a high order. Most of the Divisions also have smart classroom facility. The experimental fields which form an integral part of the Institute's campus cover an area of about 296 hectares, of which about 160 hectares are irrigated. The various Divisions of the Institute are manned by a large body of highly trained and experienced scientific staff. The strength of the Graduate Faculty of the Institute at present is about 849 in 26 disciplines.

The Institute's Central Library has built-up a collection of over 6,00,000 documents, receives more than 5000

scientific serials annually from all over the world, and is regarded as the best agro-biological library in South Asia. The library has over 10500 serial files in 40 languages received from more than 90 countries which form 30% of the total scientific serials available in the country. It has spacious reading halls and a documentation center. The main hub providing Email-internet connectivity through the Institute is located in the library, which also offers CD-ROM facility and CeRA through the Local Area Network.

Since its early years, the Institute has flourished as a center for imparting post graduate training to officers of the State Departments of Agriculture in India, as also to other candidates, so as to equip them for manning superior posts in the fields of research, teaching and extension. In 1923, the training programme was placed on an organized basis as a two-year course of specialized post graduate training in different major fields of agricultural sciences, leading to the Associateship of the Institute (Assoc. IARI). This diploma course, recognized in 1946 as equivalent to the M.Sc. degree of Indian Universities, was replaced by M.Sc. degree in 1958 when the Institute was granted the status of a “Deemed University” under the University Grants Commission Act of 1956 and authorized to award post graduate degrees of Master of Science and Doctor of Philosophy in agricultural sciences. With regard to educational standard and quality, it 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 modelled on the choice-based credit system, is that research, teaching and extension are fully integrated and also that the programme of instruction is broad-based so as to give the student a mastery not only in his/ her major field of specialization but also in supporting minor fields. Currently, instruction leading to the under graduate and post graduate degrees of the Institute is organized in twenty-six subjects (disciplines).

So far, 4823 M.Sc., 100 M. Tech. and 5360 Ph.D. awarded degrees including 507 international students. At present, the total number of students is 1,992 comprising of 505 M.Sc./ M. Tech; 319 UG, 1168 Ph.D. and 18 international students.

The amenities available on the campus include a medical dispensary, two primary schools, two government senior secondary schools - one for boys and the other for girls, three Play Schools for pre-school children, one Kendriya Bhandar to cater to the daily needs of the residents, one Mother Dairy and one Amul booth, one Safal store for ensured supply of fresh fruits and vegetables, one Cafeteria, in addition to a post office and banks viz. Canara Bank and SBI Bank. The Institute is easily approachable both from Delhi and New Delhi railway stations, by means of city bus/Metro trains. Adjacent to the Institute’s campus are located, the National Physical Laboratory (NPL), the National Institute of Science Communication (NISCOM) of the Council of Scientific and Industrial Research (CSIR), the Institute of Hotel Management, Catering and Nutrition, a Regional Centre of the National Bureau of Soil Survey and Land Use Planning, the National Seeds Corporation and the State Farms Corporation of India.

The academic programme leading to the award of M.Sc. and Ph.D. degrees in Agricultural Statistics, Bioinformatics, Computer Application, Molecular Biology & Biotechnology, and Plant Genetic Resources are conducted at the sister institutes namely ICAR-Indian Agricultural Statistics Research Institute (IASRI), ICAR - National Institute for Plant Biotechnology (NIPB) and ICAR-National Bureau of Plant Genetic Resources (NBPGR) which are located at this campus. In addition to the sister institutes located at the New Delhi Campus; from the session 2023-24 onwards, 16 Regional Hubs comprising clusters of ICAR research institutes with similar mandates as that of ICAR-IARI will be regional academic collaboration centres of ICAR-IARI. Approved by the Academic Council, ICAR-IARI, New Delhi in its 418<sup>th</sup> meeting. students for UG/PG/PhD programmes will be admitted by The Graduate School, ICAR-IARI into these hubs also. On successful completion of their program, the students in regional hubs will be conferred degrees by The Graduate School, ICAR-IARI in Annual Convocation held in the month of February every year.

## 2. ICAR-IARI & ITS REGIONAL ACADEMIC COLLABORATORS (ICAR REGIONAL HUBS)

ICAR- Indian Agricultural Research Institute, New Delhi recognized by UGC as deemed to be University (1958), under the ambit of its sponsoring body Indian Council of Agricultural Research has initiated formal academic collaboration with 16 clusters of ICAR institutes in different regions across the country as per directive of the DG ICAR and Secretary DARE. These clusters have been referred to as the ICAR-IARI hubs. The students admitted in these hubs through the NTA-CUET examination will be deemed as the students on roll of The Graduate School, ICAR-IARI and will be awarded degrees by ICAR-IARI on successful completion of their programmes.

The financial control of these hubs including that of ICAR-IARI is governed by ICAR, whereas the academic management will be governed through the guidelines of The Graduate School, ICAR-IARI. ICAR-IARI is the constituent institute of ICAR.

S. No.	Name of Hub	Name of Nodal Institute and Hub Coordinator	Contact Details of the Nodal Institute	Satellite institutes in cluster
1.	<b>Hyderabad hub</b>	CRIDA, Director CRIDA	<b>Dr. V.K. Singh</b> Director, CRIDA, Hyderabad 040-24532243 director.crida@icar.gov.in	IIRR, IIOR, IIMR, NAARM. DPR, NRC Meat, NBPGR RS, ATARI <b>Total (8)</b>
2.	<b>Bengaluru hub</b>	IIHR, Director IIHR	<b>Dr. S.K. Singh</b> Director, IIHR, Bengaluru 080-28466471 director.iihr@icar.gov.in; iihrdirector@gmail.com	NBAIR, CPCRI, CTCRI <b>Total (3)</b>
3.	<b>Baramati hub</b>	NIASM, Director NIASM	<b>Dr. K.S. Reddy</b> Director, NIASM, Baramati 02112- 254055/57/58/59 k.sammireddy@icar.gov.in; director.niasm@icar.gov.in	DOGR, DFR, NRCG, NRCP, IARI RS, IVRI RS, ATARI <b>Total (7)</b>
4.	<b>Nagpur hub</b>	CICR, Director CICR	<b>Dr. Y.G. Prasad</b> Director, CICR, Nagpur 0710-3275536 director.cicr@icar.gov.in; cicrnagpur@gmail.com	CIRCOT, CCRI, NBSS&LUP <b>Total (3)</b>
5.	<b>Bhopal hub</b>	CIAE, Director CIAE	<b>Dr. C.R. Mehta</b> Director, CIAE, Bhopal 0755-2737191 director.ciae@icar.gov.in; directorciae@gmail.com	IISS, NIHSAD <b>Total (2)</b>
6.	<b>Ranchi hub</b>	IIAB, Director IIAB	<b>Dr. Sujay Rakshit</b> Director, IIAB, Ranchi 651-2261122 director.iiab@icar.gov.in	NISA, RCER RS, NBPGR RS <b>Total (3)</b>
7.	<b>Cuttack hub</b>	NRRI, Director NRRI	<b>Dr. A.K. Nayak</b> Director, NRRI, Cuttack 0671-2367757/67 director.nrri@icar.gov.in; directorrricuttack@gmail.com	CIFA, IIWM, CIWA, ICFMD, IIHR RS, CTCRI RS, DPR RS, IIPR RS, NBPGR RS <b>Total (9)</b>
8.	<b>Kolkata hub</b>	CRIJAF, Director CRIJAF	<b>Dr Gouranga Kar</b> Director, CRIJAF, Kolkata 033-25356122 director.crijaf@icar.gov.in	NINFET, NBSS&LUP RS, ATARI, CSSRI RS, CIFA RS, KVK North 24 Parganas, <b>KVK</b> Burdhwan, CIFRI, SRSJAF <b>Total (9)</b>

9.	<b>Shillong hub</b>	RCNEH-Shillong, Director RCNEH	<b>Dr. V.K. Mishra</b> Director, RCNEH-Umiam, Shillong 0364-2999450 director.icar-neh@icar.gov.in, icarneh.director@gmail.com, VK.Mishra@icar.gov.in	Nil
10.	<b>Lucknow hub</b>	IISR, Director IISR	<b>Dr. Rasappa Viswanathan</b> , Director, IISR, Lucknow 0522-2480726 r.viswanathan@icar.gov.in, director.sugarcane@icar.gov.in	NBFGR, CSSRI RS, CISH <b>Total (3)</b>
11.	<b>Jodhpur hub</b>	CAZRI, Director CAZRI	<b>Dr. O.P. Yadav</b> Director, CAZRI, Jodhpur 0291-2786584 director.cazri@icar.gov.in	Nil
12.	<b>Karnal hub</b>	IWBR, Director CSSRI	<b>Dr. Gyanendra Singh</b> Director, IWBR, Karnal 0184-2267490 director.iwbr@icar.gov.in	NDRI, IARI RS, SBI RS, NBAGR <b>Total (5)</b>
13.	<b>Raipur hub</b>	NIBSM, Director CRIDA	<b>Dr. P.K. Ghosh</b> Director, NIBSM, Raipur 0771-2277333 director.nibsm.cg@gov.in, director.nibsm@icar.gov.in	Nil
14.	<b>Patna hub</b>	RCER-Patna, Director, RCER-Patna	<b>Dr. Anup Das</b> Director, RCER-Patna 0612-2223962 director.icar-rcer@icar.gov.in, <a href="mailto:director.icarrcer@gmail.com">director.icarrcer@gmail.com</a>	CPRI RS, ATARI <b>Total (2)</b>
15.	<b>Assam hub</b>	IARI-Assam, Director IARI	<b>Dr. A.K. Singh</b> Director, ICAR-IARI, New Delhi 011-25841481 director@iari.res.in	Nil
16.	<b>Jharkhand hub</b>	IARI-Jharkhand, Director IARI	<b>Dr. A.K. Singh</b> Director, ICAR-IARI, New Delhi 011-25841481 director@iari.res.in	Nil

### 3. ADMISSION TO UG PROGRAM AT ICAR-IARI, NEW DELHI CUET (ICAR-UG)

Applicants are advised to go through the details available in **Information Bulletin for CUET (ICAR-UG) – 2023 by National Testing Agency for the academic session 2023-24; few excerpts are reproduced below:**

#### 3.1 General Information

All India Entrance Examination for Admission, CUET (ICAR-UG) is conducted for admission to Bachelor Degree programmes for admission to the institute. The CUET (ICAR-UG) - 2023 Examination for the Academic Session 2023-24 has been conducted at centers/cities identified and finalized by NTA, all over the country, enabling participation of a large number of candidates seeking admission in the Bachelor degree programmes offered by the institute. Candidates declared eligible for registration and choice filling for counselling by ICAR will only be considered for allocation of program/subject. There is no provision of direct nomination for admission through ICAR in any Bachelor degree programme without qualifying in CUET (ICAR-UG). For details related to the number of seats available for various programmes [B.Sc. (Hons) Agriculture; B.Tech. (Agricultural Engineering); B.Tech. Biotechnology and B.Sc. (Hons) Community Science] offered at ICAR-IARI, New Delhi and its hubs; UG seat matrix (*Section 8 of this document*) maybe referred to.

##### 3.1.1 Schedule of CUET (ICAR-UG)

Candidates are requested to keep themselves updated about the schedule through NTA and ICAR websites [www.nta.ac.in](http://www.nta.ac.in), <https://icar.nta.ac.in> and [www.icar.org.in](http://www.icar.org.in). (*For details, please refer to Section 2.3 of Information Bulletin for CUET (ICAR-UG) – 2023 by National Testing Agency*)

##### 3.1.2 Scheme of Examination

The Test of CUET (ICAR-UG) is conducted as per the details and schedule defined by the NTA and notified on its website for registration (<https://cuet.samarth.ac.in>). (*For details, please refer to Section 2.4 of Information Bulletin for CUET (ICAR-UG) – 2023 by National Testing Agency*)

##### 3.1.3 Syllabus for the Test

The Questions in the test are based on the syllabus prescribed by the NTA for CUET (ICAR-UG) - 2023 and available on (<https://cuet.samarth.ac.in>) (*Also, refer to Annexure 1 of this document*) (*For details, please refer to Section 2.5 of Information Bulletin for CUET (ICAR-UG) – 2023 by National Testing Agency*)

##### 3.1.4 General Eligibility Criteria to appear in CUET (ICAR-UG)

For details related to qualification, *Sections 3.1 and 3.2 of Information Bulletin for CUET (ICAR-UG) – 2023* by National Testing Agency maybe referred to.

##### 3.1.5 Age Limit

Indian Nationals of at least 16 years of age as on 31.08.2023 are eligible to apply for the examination. No relaxation is admissible regarding the minimum age limit (*For details, please refer to section 3.3 of Information Bulletin for CUET (ICAR-UG) – 2023*) by NTA).

#### 3.2 REGISTRATION AND APPLICATION PROCESS

NTA is the examination conducting body and its scope is limited to conducting the examination and declaration of the Result /Merit List as per the criteria prescribed. Candidates must note that they shall be bound by the conditions as laid down in the NTA's Information Bulletin as well as the Statutes, Ordinances, Notifications, Rules, Regulations and Guidelines of ICAR-IARI, New Delhi, issued from time to time. It is the sole responsibility of the candidate to ensure that he/she fulfills the specified eligibility in toto before filling up the online application form and appearing in the examination.

### **3.2.1 Examination Cities for CUET (ICAR-UG)-2023**

The Examination Cities where the CUET (ICAR-UG)-2023 is decided and finalized by the NTA. The NTA will make efforts to allot city of examination to the candidates in order of the choice opted by them in their application form. However, due to administrative reasons, a different city of nearby area could be allotted. NTA reserves the right to allot a candidate to a nearby exam city, other than the one opted by him/her, if need be, depending on administrative exigencies. NTA reserves the right to cancel/ merge any exam city/centre if need be, depending on administrative exigencies. The Examination City Centre, once opted, shall not be changed. The decision of the NTA regarding allotment of Centre, Date and Shift shall be final. *(For details, please refer to Section 4.1 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.2.2 Applying Online and Submission of Application Form**

The online submission of Application Form for CUET (ICAR-UG)-2023, uploading of scanned photograph and signatures may be made at website <https://cuet.samarth.ac.in>. The candidates should complete all the required details while filling up the online form. On submission of details and required fee, a Confirmation Page with Application Number shall be generated. Candidates are required to take printout of Confirmation Page and keep it for future reference. In order to appear in CUET (ICAR-UG)-2023, the candidates are required to apply online as per procedure detailed at website <https://cuet.samarth.ac.in>. Before filling and submitting the online form, candidates should download the Information Bulletin by NTA and Replica of Application Form; and read them carefully. Candidates must follow the instructions strictly as given in the Information Bulletin and on NTA website. Application Forms not complying with the instructions are liable to be rejected. *(For details, please refer to Section 4.2 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.2.3 Replica and Steps of the Application Form**

The Replica of the CUET (ICAR-UG)-2023 Application Form or Format and steps to be completed sequentially are available at <https://cuet.samarth.ac.in>. *(For details, please refer to Section 4.3 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.2.4 Method of Fee Payment**

The payment methods as instructed by the NTA at <https://cuet.samarth.ac.in> should only be followed to avoid misplacement or non-payment of fee. Generation of Confirmation Page confirms the final submission of Application Form. If Confirmation Page has not been generated, this means that Application Form has not been submitted successfully. *(For details, please refer to Sections 4.4a, 4.4b and 4.4c of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.2.5 Admit Card for CUET (ICAR-UG)**

The e-Admit Card would be issued provisionally to the candidates through the NTA website: <https://cuet.samarth.ac.in/>, subject to the fulfillment of the eligibility conditions and receipt of the prescribed application fee by NTA. The Admit Card is issued provisionally to the candidates, subject to their satisfying the eligibility conditions. The candidate has to download the Admit Card from the NTA website and appear for the Examination at the given Centre strictly as per the Date and Shift (Timing) indicated on the Admit Card. allotted to them in their Admit card. The candidates are advised to read the instructions on the Admit Card carefully and follow them during the conduct of the examination. *(For details, please refer to Section 5.1 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

## **3.3 CONDUCT OF THE EXAMINATION**

### **3.3.1 Important Instructions for the Candidates**

Candidates must read the NTA Information Bulletin CUET (UG)-2023 available at <https://cuet.samarth.ac.in/> for important instructions related to the Examination. *(For details, please refer to Section 6.1 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.3.2 Prohibited Materials and Unfair Means**

Candidates are advised to read the NTA Information Bulletin CUET (UG) -2023 available at <https://cuet.samarth.ac.in/> for the topic. *(For details, please refer to Section 6.2 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

## **3.4 RESULT AND COUNSELLING**

### **3.4.1 Procedure of Declaration of Result**

Candidates are advised to read the Chapter 11 of NTA Information Bulletin: CUET (UG) – 2023 available at <https://cuet.samarth.ac.in/> *(For details, please refer to Section 7.1 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

### **3.4.2 Procedure of Online Counseling**

Candidates declared eligible for registration and choice filling for online counseling by the ICAR will only be considered for allocation of subject/seat at the institute. The schedule for counseling will be notified separately on the ICAR website ([www.icar.org.in](http://www.icar.org.in)) after declaration of result. The admission would be granted only when the candidate seeks admission through counseling conducted by the ICAR. *(For details, please refer to Section 7.2 of Information Bulletin for CUET (ICAR-UG) – 2023 by NTA).*

## 4. ADMISSION TO PG PROGRAM AT ICAR-IARI, NEW DELHI – AIEEA (PG)-2023

Applicants are advised to go through the details available in **Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency for the academic session 2023-24**; few excerpts are reproduced below:

### 4.1 General Information

All (100%) seats of ICAR-IARI, New Delhi are filled up through **AIEEA (PG)-2023**. ICAR AIEEA (PG)- 2023 examination for the academic session 2023-24 has been conducted at 89 cities all over the country enabling participation of a large number of candidates seeking admission in Master degree programmes in 26 disciplines of the institute.

#### 4.1.1 Schedule of AIEEA (PG)

Candidates are requested to keep themselves updated about the schedule through NTA and ICAR websites [www.nta.ac.in](http://www.nta.ac.in), <https://icar.nta.nic.in/> and [www.icar.org.in](http://www.icar.org.in) (For details, please refer to Section 2.3 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)

#### 4.1.2 Scheme of Examination

The test of AIEEA (PG)-2023 has a single paper of 2 hours duration. (For details, please refer to Section 2.4 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)

#### 4.1.3 Syllabus for the Test

The Question Papers for the test is based on the syllabus prescribed by the ICAR, which is available at the website: <https://icar.org.in/content/icar%E2%80%99s-aice-jrfsrf-pgs-2020-examination> (Also, refer to Annexure II of this document) (For details, please refer to Section 2.5 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)

#### 4.1.4 General Eligibility Criteria to appear in AIEEA (PG)-2023

In order to appear in ICAR-AIEEA (PG)-2023, an Indian national candidate must ensure that he/she fulfills the eligibility requirements for the examination as well as admission as detailed in the Information Bulletin. (For details, please refer to Section 3.1 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)

#### 4.1.5 Instructions for in-service candidates

(For details, please refer to Section 3.2 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)

#### 4.1.6 Eligibility Qualifications for Admission to different Subjects

Candidates must ensure their subject or discipline specific criteria before selecting subject or discipline for admission; as detailed in Section 3.3 of Information Bulletin of ICAR-AIEEA (PG) Master Degree Programs 2023 by National Testing Agency. Also refer to the below table for eligibility requirements for PG programs at the institute.

## Eligibility Qualifications for Admission to different Subjects

S. No.	Subject/Discipline	Eligibility Qualifications for SAUs/CAUs etc. (4/5/6 years Bachelors' degree in)	Alternate Eligibility Qualifications for IARI
1	AGRICULTURAL CHEMICALS	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry	B.Sc.(10+ 2+3 system)
2	AGRICULTURAL ECONOMICS	B.Sc.Ag./ Horticulture / Agril. Marketing and Co-operation / Forestry or B.Sc. (Hons.) Agriculture/Horticulture / Agril. Marketing and Co-operation/ Forestry	B.Sc. Dairying/ B.Sc. Dairying (DT)/ B. Tech.(DT)/ B.V.Sc. & AH/ B.Sc. (Animal Sciences) / B.F.Sc.
3	AGRICULTURAL ENGINEERING		
	Farm Machinery and Power Engineering	B. Tech. Agril.Engg./Mechanical / Civil/ Elect./ Electronics/ Production Engg	-
	Soil and Water Conservation Engineering	B.Tech. Agril.Engg./ Mechanical/ Civil/ Elect./ Electronics	-
	Processing and Food Engineering	B.Tech. Agril.Engg./ Agric. & FoodEngg./ Mechanical/ Civil/ Elect./ Electronics/ Food Engg./ Process and Food Engg./ Chemical Engg.	-
4	AGRICULTURAL EXTENSION EDUCATION	B.Sc. Agriculture / Horticulture / Forestry / Sericulture/ B.Sc. (Hons.) Agriculture/ Horticulture / Forestry / Sericulture/ B.Sc. Agril. Marketing & Co- operation/ B.Sc. (Hons.) Agril. Marketing & Co-operation	B.Sc. Dairying / B.Sc. Dairying (DT)/ B. Tech.(DT)/ B.V.Sc. & AH/ B.Sc. (Animal Sciences) /B.F.Sc./ B.Sc. Agril. Marketing & Co- operation/ B.Sc.(Hons.) Agril. Marketing & Co-operation
5	AGRICULTURAL PHYSICS	B.Sc. Ag./Horti. or B.Sc. (Hons.) Agriculture / Horticulture	B.Sc.(10+ 2+3 system)
6	AGRICULTURAL STATISTICS	B.Sc. Agriculture/ Horti./Forestry/ Sericulture/ Agricultural Marketing & Coop./B.F.Sc./ Veterinary Sciences / B.Tech. in Agril. Engg. or B.Sc. (Hons.) Agriculture/ Horti./Forestry/ Sericulture / Agricultural Marketing & Coop./ B.F.Sc./ Veterinary Sciences/ B.Tech. in Agril. Engg	B.Sc.(10+2+3system)
7	AGRONOMY	B.Sc. Ag. or B.Sc. (Hons.) Agriculture	-
8	BIOCHEMISTRY	B.Sc. Ag./Horti. or B.Sc. (Hons.) Agriculture/ Horticulture	B.Sc.(10+ 2+3 system)
9	BIOINFORMATICS	B.Sc. Agriculture/ Horticulture/ Forestry /B.F.Sc. /B.Sc. (Hons.) Agric./Horticulture/ Forestry /B.F.Sc./B.Sc. Agril. Engg / B. Tech. Agril. Engg/B. Tech. (Biotechnology)	B.Sc.(10+ 2+3 system)
10	COMPUTER APPLICATION	B.Sc. Agriculture/ Horti./Forestry/ Sericulture/ Agricultural Marketing & Coop./Veterinary Sciences/ B.Tech. in Agril.Engg. or B.Sc. (Hons.) in Agriculture/ Horti./ Forestry/Seri./ Agril. Mktg. & Coop./Veterinary Sciences/ B.Tech. in Agril. Engg	B.Sc.(10+ 2+3 system)
11	ENTOMOLOGY	B.Sc. (Ag.)/Horti./ Forestry/ Sericulture or B.Sc. (Hons.) Agriculture/ Horti./ Forestry / Sericulture	B.Sc.(10+ 2+3 system)
12	ENVIRONMENTAL SCIENCES	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry	B.Sc.(10+ 2+3 system)
13	FLORICULTURE AND LANDSCAPING	B.Sc. Agriculture/ Horticulture or B.Sc. (Hons.) Agriculture/ Horticulture	-

14	FRUIT SCIENCE	B.Sc. Agriculture/ Horticulture or B.Sc. (Hons.) Agriculture/ Horticulture	-
15	GENETICS AND PLANT BREEDING	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry/ B. Tech. (Biotechnology)	B.Sc.(10+ 2+3 system)
16	MICROBIOLOGY	B.Sc. Ag./Horti. or B.Sc. (Hons.) Agriculture / Horticulture/B. Tech. (Biotechnology)	B.Sc.(10+ 2+3 system)
17	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	B.Sc. Ag. / B.Sc. (Hons.) in Agriculture / Horticulture / Forestry / Sericulture / Biotechnology / B. Tech. (Biotechnology-)	B.Sc.(10+ 2+3 system)
18	NEMATOLOGY	B.Sc. (Ag.)/ Horticulture / Forestry or B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry	B.Sc.(10+ 2+3 system)
19	PLANT GENETIC RESOURCES	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons.) Agriculture/ Horticulture / Forestry / B. Tech. (Biotechnology)	B.Sc.(10+ 2+3 system)
20	PLANT PATHOLOGY	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry	B.Sc.(10+ 2+3 system)
21	PLANT PHYSIOLOGY	B.Sc. Ag./Horti. or B.Sc. (Hons.) Agriculture / Horticulture	B.Sc.(10+ 2+3 system)
22	POST HARVEST MANAGEMENT	B.Sc. Agriculture/ Horticulture or B.Sc. (Hons.) Agriculture/ Horticulture	-
23	SEED SCIENCE AND TECHNOLOGY	B.Sc. Ag./Horti./Forestry or B.Sc. (Hons) Agriculture/ Horticulture / Forestry	B.Sc.(10+ 2+3 system)
24	SOIL SCIENCE	B.Sc. Ag./Horti. or B.Sc. (Hons.) Agriculture/ Horticulture	B.Sc.(10+ 2+3 system)
25	VEGETABLE SCIENCE	B.Sc. Agriculture/ Horticulture or B.Sc. (Hons.) Agriculture/ Horticulture	-
26	WATER SCIENCE AND TECHNOLOGY	B.Sc. Ag. / B.Sc. (Hons.) in Agriculture / Horticulture / B. Tech. Agril. Engineering	-

#### 4.1.7 Age Limit

Indian Nationals not below 19 years as on 31.08.2023 are eligible to appear in the examination. *(Please refer to Section 3.4 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)*

## 4.2 REGISTRATION AND APPLICATION PROCESS

NTA is the examination conducting body and its scope is limited to conducting the examination and declaration of the Result /Merit List as per the criteria prescribed. Candidates must note that they shall be bound by the conditions as laid down in the NTA's Information Bulletin as well as the Statutes, Ordinances, Notifications, Rules, Regulations and Guidelines of ICAR-IARI, New Delhi, issued from time to time. It is the sole responsibility of the candidate to ensure that he/she fulfills the specified eligibility in toto before filling up the online application form and appearing in the examination.

#### 4.2.1 Examination Cities for AIEEA (PG)-2023

The Examination Cities where the AIEEA (PG)-2023 will be conducted are given in Annexure- I of NTA's Information Bulletin. While applying, candidates have to select any four cities of their choice for AIEEA (PG)-2023. *(For details, please refer to Section 4.1 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)*

#### 4.2.2 Applying Online and Submission of Application Form

The online submission of Application Form for AIEEA (PG)-2023, uploading of scanned photograph and signatures may be made at website [www.nta.ac.in](http://www.nta.ac.in), <https://icar.nta.nic.in/>. The candidates should complete all the required

details while filling up the online form. On submission of details and required fee, a Confirmation Page with Application Number shall be generated. Candidates are required to take print out of Confirmation Page and keep it for reference. *(For details, please refer to Section 4.2 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)*

#### **4.2.3 Application Fee Payable by the Candidates of Various Categories**

*(For details, please refer to Section 4.5 of Information Bulletin ICAR AIEEA (PG) – 2023 by (NTA)*

#### **4.2.4 Method of Fee Payment**

*(For details, please refer to Section 4.6 of Information Bulletin ICAR AIEEA (PG) – 2023 by (NTA)*

#### **4.2.5 Admit Card for AIEEA (PG)-2023**

The Admit Card is issued provisionally to the candidates, subject to their satisfying the eligibility conditions. The candidate has to download the Admit Card from the NTA website as specified in Schedule of AIEEA (PG)-2023 and appear for the Examination at the given Centre strictly as per the Date and Shift (Timing) indicated on the Admit Card. *(For details, please refer to Section 5.1 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)*

### **4.3 CONDUCT OF THE EXAMINATION**

#### **4.3.1 Important Instructions for the Candidates**

*(For details, please refer to Section 6.1 of Information Bulletin ICAR AIEEA (PG) – 2023 by (NTA)*

#### **4.3.2 Prohibited Materials**

*(For details, please refer to Section 6.2 of Information Bulletin ICAR AIEEA (PG) – 2023 by (NTA)*

#### **4.3.3 Unfair Means**

Unfair Means practice is an activity that allows a candidate to gain an unfair advantage over other candidates. *(For details, please refer to Section 6.3 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency)*

### **4.4 RESULT AND COUNSELLING**

#### **4.4.1 Procedure of declaration of result**

The Result of the AIEEA (PG)-2023 will be displayed to the candidates on NTA website: <https://icar.nta.nic.in/>, [www.nta.ac.in](http://www.nta.ac.in). *[For details, please refer to Chapter 7 (Sections 7.1 to 7.5) of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency]*

#### **4.4.2 Procedure for online counselling**

The schedule for online counseling will be notified separately on ICAR website ([www.icar.org.in](http://www.icar.org.in)) after declaration of result. *For details, please refer to Section 7.6 of Information Bulletin ICAR AIEEA (PG) – 2023 by National Testing Agency.*

## 5. ADMISSION TO Ph.D PROGRAM AT ICAR-IARI, NEW DELHI – ICAR AICE-JRF/SRF (Ph.D.)-2023

Applicants are advised to go through the details available in **Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency** for the academic session 2023- 24; few excerpts are reproduced below:

### 5.1 General Information

All (100%) seats of ICAR-IARI, New Delhi are filled up through **ICAR AICE-JRF/SRF (Ph.D.)-2023**. The examination for the academic session 2023-24 has been conducted at 89 cities all over the country enabling participation of a large number of candidates seeking admission in Ph.D. degree programmes in 26 disciplines of the institute.

#### 5.1.1 Subject-wise Number of Seats Available for Admission and mode of examination

The number of ICAR seats and JRF/SRF (Ph.D.) in different Subjects for the Academic Session 2023– 24 is displayed on ICAR website [www.icar.org.in](http://www.icar.org.in) at the time of counseling. *(For details, please refer to Section 2.2 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

#### 5.1.2 Schedule of AICE-JRF/SRF (Ph.D.)-2023

Schedule for important examination related activities is updated at NTA website ([www.nta.ac.in](http://www.nta.ac.in), <https://icar.nta.nic.in/>). *(For details, please refer to Section 2.3 of Information Bulletin for ICAR AICE- JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

#### 5.1.3 Scheme of Examination

The Test of AICE-JRF/SRF (PhD) has a single Paper of 2hrs duration. *(For details, please refer to Section 2.4 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

#### 5.1.4 Syllabus for the Test of AICE-JRF/SRF (Ph.D.)-2023

The Question Paper for the Test shall be based on the Syllabus of Subjects as prescribed by the ICAR, available at website: <https://icar.org.in/content/icar%E2%80%99s-aice-jrfsrf-pgs-2020-examination> *(Also refer to Annexure III of this document)* *(For details, please refer to Section 2.5 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

#### 5.1.5 General Eligibility Criteria

Indian nationals who have passed Master’s Degree programme with a minimum of Overall Grade Point Average (OGPA) as shown in the below table will be eligible. *(For details, please refer to Section 3.1 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

#### 5.1.6 Eligibility Qualifications at Master’s level

In order to appear in AICE-JRF/SRF (Ph.D.)-2023 in the Subject of specialization, candidates must have completed Master’s degree in one of the Subjects given in the following table (for 26 disciplines at ICAR- IARI, New Delhi). *(For details, please refer to Section 3.2 of Information Bulletin for ICAR AICE- JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

### Eligibility Qualifications at Master's level

S. No.	Subject of specialisation	Master's degree in	Additional Eligibility Qualification at Bachelors level
1	AGRICULTURAL CHEMICALS	Agricultural Chemicals/Chemistry	IARI-B.Sc. (10+2+3 system)
2	AGRICULTURAL ECONOMICS	Agricultural Economics/Dairy/Animal Husbandry Economics/ Veterinary Economics / Fisheries Economics.	-
3	AGRICULTURAL ENGINEERING		
3.1	Farm Machinery and Power Engineering	Agricultural Engineering/Mechanical Engineering with specialization in Farm Machinery and Power/Renewable energy	-
3.2	Soil and Conservation Water Engineering	Agricultural Engineering with specialization in Soil and Water/Soil and Water Conservation/Civil Engineering / Irrigation and Drainage Engg./ Water Resources / Water Science and Technology	-
3.3	Processing and Food Engineering	Agricultural Engineering with specialization in Agricultural Processing Engineering/ Processing and Food Engineering/ Food Process Engineering / Dairy Engineering/ Post Harvest Technology ( <i>with specialization in Post Harvest Engineering and Technology</i> )/ Renewal Energy Engineering	-
4	AGRICULTURAL EXTENSION EDUCATION	Agricultural Extension/ Extension Education/Communication/ Veterinary Extension/Dairy Extension/ Fisheries Extension.	-
5	AGRICULTURAL PHYSICS	Agricultural Physics / Physics / Bio physics / Agricultural Meteorology Soil Science / Environmental Science / Remote Sensing / Geo-informatics.	IARI-B.Sc. (10+2+3 system)
6	AGRICULTURAL STATISTICS	Agricultural Statistics / Statistics Biostatistics /Mathematical Statistic Applied Statistics.	IARI-B.Sc. (10+2+3 system)
7	AGRONOMY	Agriculture with specialization in Agronomy/Soil Water Management/ Forage Production/ Water Science and Technology.	-
8	BIOCHEMISTRY	Plant Biochemistry/Biochemistry.	IARI-B.Sc. (10+2+3 system)
9	BIOINFORMATICS	Bioinformatics/Molecular Biology / Biotechnology / Computer Science / Computer Application /Agri- informatics / Agricultural Statistics / Statistics / Mathematical Statistics /Biostatistics with Bioinformatics as a subject.	IARI-B.Sc. (10+2+3 system)
10	COMPUTER APPLICATION	Computer Science / Computer	IARI-B.Sc. (10+2+3 system).
		Application / Information Technology /Post-graduate degree in any specialization of Computer Science.	

11	ENTOMOLOGY	Agricultural Entomology Entomology/ Plant Protection with specialization in Entomology.	IARI-B.Sc. (10+2+3 system)
12	ENVIRONMENTAL SCIENCES	Environmental Science/ Agroforestry /Agriculture/Forestry with specialization in Environmental Science.	-
13	FLORICULTURE AND LAND- SCAPING	Floriculture & Landscaping/ Floricult- ure & Landscape Architecture/Agricul- ture or Horticulture with specialization in Floriculture and Landscape Architec- ture.	-
14	FRUIT SCIENCE	Fruit Science/ Pomology/ Horticulture with specialization in Fruit Science.	-
15	GENETICS AND PLANT BREEDING	Genetics and/or Plant Breeding.	IARI-B.Sc. (10+2+3sys- tem)
16	MICROBIOLOGY	Agricultural Microbiology/ Microbiology.	IARI-B.Sc. (10+2+3 system)
17	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	Agricultural Biotechnology/Biotechnol- ogy/ Molecular Biology & Biotech- nology.	IARI-B.Sc. (10+2+3 system)
18	NEMATOLOGY	Nematology/Plant Protection with spe- cialization in Nematology.	IARI-B.Sc. (10+2+3 system)
19	PLANT GENETIC RESOURCES	Plant Genetic Resources/ Botany/Agri- cultural Botany.	IARI-B.Sc. (10+2+3 system)
20	PLANT PATHOLOGY	Plant Pathology/Plant Protection with specialization in Plant Pathology.	IARI-B.Sc. (10+2+3 system)
21	PLANT PHYSIOLOGY	Plant Physiology/Crop Physiology.	IARI-B.Sc. (10+2+3 system)
22	POST HARVEST MANAGEMENT	Post-harvest Technology with specialization in Horticultural Crops	-
23	SEED SCIENCE AND TECHNOL- OGY	Seed Science & Technology.	IARI-B.Sc. (10+2+3 system)
24	SOIL SCIENCE	Agriculture/Horticulture with special- ization in Soil Sciences/Soil Science & Agricultural Chemistry/ Agricultural Physics with specialization in Soil Physics and Soil and Water Con- servation/Water Science and Technol- ogy.	IARI-B.Sc. (10+2+3 system)
25	VEGETABLE SCIENCE	Vegetable Science / Olericulture / Horti- culture with specialization in Vegetable Science.	-
26	WATER SCIENCE AND TECH- NOLOGY	Agriculture with specialization in Wa- ter science and Technology/ Agronomy / Soil Science /Agricultural Engineering with specialization in Soil and Water Conservation Engineering / Soil and Water Engineering / Irrigation and Drainage Engineering /Water Re- sources Engineering/ Water Resources Management.	-

### **5.1.7 Instructions for in-service candidates**

(For details, please refer to *Section 3.4 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency*)

### **5.1.8 Age limit**

Indian Nationals of at least 20 years of age as on 31.08.2023 are eligible to apply for the examination. *(For details, please refer to Section 3.3 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

## **5.2 REGISTRATION AND APPLICATION PROCESS**

NTA is the examination conducting body and its scope is limited to conducting the examination and declaration of the Result /Merit List as per the criteria prescribed. Candidates must note that they shall be bound by the conditions as laid down in this Information Bulletin as well as the and the Statutes, Ordinances, Notifications, Rules, Regulations and Guidelines of ICAR-IARI, New Delhi, issued from time to time. It is the sole responsibility of the candidate to ensure that he/she fulfills the specified eligibility in toto before filling up the online application form and appearing in the examination.

### **5.2.1 Examination Cities for AICE-JRF/SRF (Ph.D.)-2023**

The Examination Cities where the AICE-JRF/SRF (Ph.D.)-2023 has been conducted is given in (Annexure- I of NTA's Information Bulletin). While applying candidates have to select any four cities of their choice for AICE-JRF/SRF (Ph.D.) 2023. *(For details, please refer to Section 4.1 of Information Bulletin for ICAR AICE- JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

### **5.2.2 Applying Online and Submission of Application Form**

The online submission of Application Form for AICE-JRF/SRF (Ph.D.)-2023, uploading of scanned photograph and signatures is made at website [www.nta.ac.in](http://www.nta.ac.in), <https://icar.nta.nic.in/>. *(For details, please refer to Section 4.2 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

### **5.2.3 Application Fee Payable by the Candidates of Various Categories**

*(For details, please refer to Section 4.5 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

### **5.2.4 Method of Fee Payment**

(For details, please refer to Section 4.6 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) –2023 by National Testing Agency)

### **5.2.5 Admit Card for AICE-JRF/SRF (Ph.D.)-2023**

*(For details, please refer to Section 5.1 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

## **5.3 CONDUCT OF THE EXAMINATION**

### **5.3.1 Important Instructions for the Candidates**

(For details, please refer to Section 6.1 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)

### **5.3.2 Prohibited materials and use of unfair means**

(For details, please refer to Sections 6.2 and 6.3 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)

## **5.4 RESULT AND COUNSELLING**

### **5.4.1 Procedure of Declaration of Result**

(For details, please refer to Sections 7.1 to 7.5 of Information Bulletin for ICAR *AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency*)

### **5.4.2 Procedure for counselling**

Candidates declared eligible for registration and choice filling for counselling by ICAR will only be considered for allocation of subject. The schedule for counseling will be notified separately on ICAR website ([www.icar.org.in](http://www.icar.org.in)) after declaration of result. *(For details, please refer to Section 7.6 of Information Bulletin for ICAR AICE-JRF/SRF (Ph.D.) – 2023 by National Testing Agency)*

## 6. IMPORTANT DATES for UG/PG/Ph.D programmes

### For UG Programme:-

CUET 2023 Notification Release Date	February 9, 2023
CUET 2023 Application Form Last Date	March 30, 2023, to April 11, 2023 (Re-released)
CUET 2023 Application Fee Last Date	March 30, 2023 to April 11, 2023 (Re-released)
CUET 2023 Correction Window	1st April to 3rd April 2023
CUET 2023 Exam City Announcement	April 30, 2023
CUET Admit Card Release Date	2nd week of May 2023
CUET 2023 Exam Date	May 21 to 31 Reserved dates – June 1 to 7, 2023
Release of Provisional CUET Answer Key	June 29, 2023
CUET Result Date	July 15, 2023
Date of counselling	<i>Pl keep checking ICAR and IARI websites</i>

### For PG Programme:

ICAR AIEEA P(G)-2023 Notification Release Date:	May 22, 2023
ICAR AIEEA P(G)-2023 Application Form Last Date:	June 23, 2023 (Extended)
ICAR AIEEA P(G)-2023 Application Fee Last Date:	June 23, 2023
ICAR AIEEA P(G)-2023 Correction Window:	June 25- June 27, 2023
ICAR AIEEA P(G)-2023 Exam City Announcement:	July 2023
ICAR AIEEA P(G)-2023 Admit Card Release Date:	July 6, 2023
ICAR AIEEA P(G)-2023 Exam Date:	July 9, 2023
Release of Provisional ICAR AIEEA P(G)-2023 Answer Key:	Aug 3, 2023
ICAR AIEEA P(G)-2023 Result Date	Aug 21, 2023
Date of counselling	<i>Pl keep checking ICAR and IARI websites</i>

### For Ph.D. Programme:

ICAR AICE- JRF/SRF (Ph.D.) -2023 Notification Release Date:	May 22, 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Application Form Last Date:	June 23, 2023 (Extended)
ICAR AICE- JRF/SRF (Ph.D.) -2023 Application Fee Last Date:	June 23, 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Correction Window:	June 25- June 27, 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Exam City Announcement:	July 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Admit Card Release Date:	July 6, 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Exam Date:	July 9, 2023
Release of Provisional ICAR AICE- JRF/SRF (Ph.D.) -2023 Answer Key:	Aug 3, 2023
ICAR AICE- JRF/SRF (Ph.D.) -2023 Result Date	Aug 21, 2023
Date of counselling	<i>Pl keep checking ICAR and IARI websites</i>

## 7. SCHEMES OF ADMISSION

The discipline wise details of seats for Ph.D. to be filled at IARI, New Delhi, and for regional hubs are given below:

### Faculty Upgradation Scheme (FUS)

Admission of In-service Faculty Members of State Agricultural Universities (SAUs) under Faculty Upgradation Scheme (FUS)

*Number of Seats: 10 for Ph.D. degree programme ONLY*

- i. The Faculty Members applying under this scheme should be regular employees of the State Agricultural Universities (SAUs).
- ii. Not more than three candidates of any one State Agricultural University shall be admitted in any one year under this Scheme.
- iii. Not more than one seat shall be allotted to a particular discipline. However, the number of seats is interchangeable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.
- iv. The words “**Application for admission under Faculty Upgradation Scheme**” should be clearly inscribed on the application and on the forwarding letter. The declaration duly signed by the Vice-Chancellor or his/her nominee should be attached with the hard copy (print out) of online filled application form.

### ICAR- In Service Scheme

*Admission of Scientists working in ICAR Institutes under ICAR - In service Scheme Number of Seats: 10 for Ph.D. degree programme ONLY*

- i. The candidates applying under this scheme should be Scientists working in ICAR Institutes.
- ii. Not more than one seat shall be allotted to a particular discipline. However, the number of seats is interchangeable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.
- iii. The words “Application for admission under ICAR - In Service Scheme” should be clearly inscribed on the application and on the forwarding letter. The declaration duly signed by the Director of the concerned ICAR Institute should be attached with the hard copy (print out) of online filled application form.

### Departmental (Scientific and Technical) Scheme

Admission under this scheme is for Scientific and Technical staff working at IARI, New Delhi and Regional Stations, ICAR-IASRI, New Delhi, ICAR-NBPGR, New Delhi and ICAR-NIPB, New Delhi.

*Number of Seats:*

- |                                      |  |
|--------------------------------------|--|
| <i>i) Departmental (Scientific):</i> | <i>10 seats for Ph.D. degree programme ONLY</i>    |
| <i>ii) Departmental (Technical):</i> | <i>05 seats for Ph.D. degree programme</i>         |
|                                      | <i>05 seats for M.Sc./M.Tech. degree programme</i> |

- i. Not more than one seat shall be allotted to a particular discipline. However, the number of seats is interchangeable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.
- ii. The words “**Application for admission under Departmental (Scientific)/Departmental (Technical) Scheme**” should be clearly inscribed on the application and on the forwarding letter which should be attached with the hard copy (print out) of online filled application form.

## Children/Widows of Security Forces (CWSF) Scheme

Number of Seats: 05 Seats (02 for Ph.D. degree programme and 03 for M.Sc./M.Tech. degree programme)

(The number of seats for admission to Ph.D. and M.Sc./M.Tech. is inter-changeable in case of non-availability of candidates in that particular degree programme).

Seats under this Scheme are to be filled as per the following order of priority:

- Priority I : Widows/Wards of Defence personnel killed in action.
- Priority II : Wards of disabled in action and boarded out from service.
- Priority III : Widows/Wards of Defence personnel who died while in service with death attributable to military service.
- Priority IV : Wards of disabled in service and boarded out with disability attributable to military service.
- Priority V : Wards of Ex-serviceman and serving personnel who are in receipt of Gallantry Awards:  
(i) Param Vir Chakra; (ii) Ashok Chakra; (iii) MahaVir Chakra; (iv) Kirti Chakra; (v) Vir Chakra; (vi) Shaurya Chakra; (vii) Sena, Nau Sena, Vayu Sena Medal; (viii) Mention-in-Despatches
- Priority VI : Wards of Ex-serviceman. Priority VII : Wives of:  
(i) Defence personnel disabled in action and boarded out from service.  
(ii) Defence personnel disabled in service and boarded out with disability attributable to military service.  
(iii) Ex-serviceman and serving personnel who are in receipt of Gallantry Awards.
- Priority VIII : Wards of Serving Personnel.
- Priority IX : Wives of Serving Personnel.

- i. Not more than one seat shall be allotted to a particular discipline. However, the number of seats is interchangeable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.
- ii. The words “**Application for admission under Children/Widows of Security Forces Scheme**” should be clearly inscribed on the application which should be attached with the hard copy (print out) of online filled application form.

## Wards of Kashmiri Migrants and Kashmiri Pandits/Kashmiri Hindu families (Non-Migrants) living in Kashmir Valley

Number of Seats: 05 for Ph.D. degree programme

05 for M.Sc./M.Tech. degree programme

- i. Not more than one seat shall be allotted to a particular discipline. However, the number of seats is interchangeable subject to a maximum of two seats per discipline in case of non-availability of candidates in that particular discipline.
- ii. The words “**Application for admission under Wards of Kashmiri Migrants and Kashmiri Pandits/Kashmiri Hindu families (Non-Migrants) living in Kashmir valley**” should be clearly inscribed on the application which should be attached with the hard copy (print out) of online filled application form.

## Self finance, NRI seats

Will be announced as per ICAR Policy. Please check IARI website [www.iari.res.in](http://www.iari.res.in) for details

## 8. SEAT MATRIX for academic year 2023-24

### 8.1 UG Seat Matrix for Academic Year 2023-24 (ICAR-IARI, New Delhi)

S.N.	UG	UR	SC	ST	OBC	Total	EWS	Grand Total (Total+EWS)	PH
1	B.Sc. (Hons.) Agriculture	17	5	2	8	32	2	34	1
2	B.Sc. (Hons.) Community Science	7	2	1	4	14	2	16	1
3	B. Tech. Agricultural Engineering	7	2	1	4	14	2	16	1
4	B. Tech. Biotechnology	7	2	1	4	14	2	16	1
		38	11	5	20	74	8	82	4

### 8.2 PG Seat Matrix for Academic Year 2023-24 (ICAR-IARI, New Delhi)

S. No.	Discipline	UR	SC	ST	OBC	Total	EWS	Grand Total (Total+EWS)	PH
1.	AGRICULTURAL CHEMICALS	1	0	1	1	3	0	3	0
2.	AGRICULTURAL ECONOMICS	1	0	1	1	3	0	3	0
3.	AGRICULTURAL ENGINEERING (Farm Machinery & Power Engineering)	1	0	1	1	3	0	3	0
4.	AGRICULTURAL ENGINEERING (Process & Food Engineering)	2	0	0	0	2	0	2	0
5.	AGRICULTURAL ENGINEERING (Soil & Water Conservation Engineering)	1	0	0	1	2	0	2	0
6.	AGRICULTURAL EXTENSION	1	1	1	1	4	1	5	0
7.	AGRICULTURAL PHYSICS	2	0	0	0	2	0	2	0
8.	AGRICULTURAL STATISTICS	2	1	0	1	4	1	5	0
9.	AGRONOMY	3	1	0	1	5	1	6	1
10.	BIOCHEMISTRY	2	0	0	0	2	0	2	0
11.	BIOINFORMATICS	2	0	0	0	2	0	2	0
12.	COMPUTER APPLICATION	1	1	0	1	3	0	3	0
13.	ENTOMOLOGY	2	1	0	2	5	1	6	1
14.	ENVIRONMENTAL SCIENCE	2	0	0	2	4	1	5	0
15.	FLORICULTURE AND LANDSCAPING	2	0	0	2	4	1	5	0
16.	FRUIT SCIENCE	2	0	0	1	3	0	3	0
17.	GENETICS AND PLANT BREEDING	2	1	0	1	4	1	5	0
18.	MICROBIOLOGY	1	1	0	1	3	0	3	0
19.	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	2	1	1	2	6	1	7	1
20.	NEMATOLOGY	1	1	0	0	2	0	2	0
21.	PLANT GENETIC RESOURCES	1	1	0	1	3	0	3	0
22.	PLANT PATHOLOGY	3	1	1	2	7	1	8	1
23.	PLANT PHYSIOLOGY	2	1	0	0	3	0	3	0
24.	POST HARVEST MANAGEMENT	1	0	0	1	2	0	2	0
25.	SEED SCIENCE AND TECHNOLOGY	2	1	0	1	4	1	5	0
26.	SOIL SCIENCE	2	0	0	1	3	0	3	0
27.	VEGETABLE SCIENCE	4	1	1	2	8	1	9	1
28.	WATER SCIENCE AND TECHNOLOGY	2	1	0	0	3	0	3	0
	<b>TOTAL</b>	<b>50</b>	<b>15</b>	<b>07</b>	<b>27</b>	<b>99</b>	<b>11</b>	<b>110</b>	<b>5</b>

### 8.3 Ph.D. Seat Matrix for Academic Year 2023-24 (ICAR-IARI, New Delhi)

S. No.	Discipline	UR	SC	ST	OBC	Total	EWS	GrandTotal (Total+EWS)	PH
1.	AGRICULTURAL CHEMICALS	5	1	1	3	10	1	11	1
2.	AGRICULTURAL ECONOMICS	5	1	0	2	8	2	10	1
3.	AGRICULTURAL ENGINEERING (Farm Machinery & Power Engineering)	4	1	0	2	7	1	8	0
4.	AGRICULTURAL ENGINEERING (Process & Food Engineering)	3	1	0	1	5	1	6	0
5.	AGRICULTURAL ENGINEERING (Soil & Water Conservation Engineering)	3	1	0	1	5	1	6	0
6.	AGRICULTURAL EXTENSION	5	2	1	3	11	1	12	1
7.	AGRICULTURAL PHYSICS	4	1	0	2	7	1	8	0
8.	AGRICULTURAL STATISTICS	5	1	1	3	10	1	11	1
9.	AGRONOMY	7	2	1	4	14	1	15	1
10.	BIOCHEMISTRY	4	2	1	3	10	1	11	1
11.	BIOINFORMATICS	5	1	0	2	8	1	9	1
12.	COMPUTER APPLICATION	4	2	1	3	10	1	11	0
13.	ENTOMOLOGY	5	2	1	3	11	1	12	1
14.	ENVIRONMENTAL SCIENCES	4	1	1	3	9	1	10	0
15.	FLORICULTURE AND LANDSCAPING	4	1	1	2	8	1	9	0
16.	FRUIT SCIENCE	4	2	1	3	10	1	11	1
17.	GENETICS AND PLANT BREEDING	9	2	1	4	16	1	17	1
18.	MICROBIOLOGY	5	2	1	3	11	1	12	0
19.	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	7	2	1	4	14	1	15	1
20.	NEMATOLOGY	4	1	1	2	8	1	9	0
21.	PLANT GENETIC RESOURCES	5	1	1	2	9	1	10	0
22.	PLANT PATHOLOGY	8	2	1	4	15	1	16	1
23.	PLANT PHYSIOLOGY	4	1	1	2	8	1	9	0
24.	POST HARVEST MANAGEMENT	4	1	0	2	7	1	8	0
25.	SEED SCIENCE AND TECHNOLOGY	6	2	1	3	12	1	13	1
26.	SOIL SCIENCE	6	2	1	4	13	2	15	1
27.	VEGETABLE SCIENCE	6	2	1	3	12	1	13	1
28.	WATER SCIENCE AND TECHNOLOGY	3	1	0	1	5	1	6	0
	<b>TOTAL</b>	<b>138</b>	<b>41</b>	<b>20</b>	<b>74</b>	<b>273</b>	<b>30</b>	<b>303</b>	<b>15</b>

## 8.4 UG/PG/Ph.D. Seat Matrix for ICAR Regional Hubs

IARI-ASSAM HUB									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IARI, ASSAM	M.Sc. (Agri.)	AGRICULTURAL ECONOMICS	2	1	0	0	3	1	1
IARI, ASSAM	M.Sc. (Agri.)	AGRICULTURAL EXTENSION EDUCATION	1	1	1	1	4	0	0
IARI, ASSAM	M.Sc. (Agri.)	AGRONOMY	2	1	0	1	4	0	0
IARI, ASSAM	M.Sc. (Agri.)	ENTOMOLOGY	2	1	1	0	4	0	0
IARI, ASSAM	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	2	1	1	0	4	0	0
IARI, ASSAM	M.Sc. (Agri.)	PLANT PATHOLOGY	2	1	1	0	4	0	0
IARI, ASSAM	M.Sc. (Agri.)	SOIL SCIENCE	2	1	0	0	3	1	0
IARI, ASSAM	M.Sc. (Agri.)	VEGETABLE SCIENCE	2	1	0	0	3	1	0
<b>TOTAL</b>			15	08	04	02	29	03	01
IARI, ASSAM	UG	B.Sc. (Hons.) AGRICULTURE	28	14	8	4	54	6	2

IARI-BENGALURU HUB									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IIHR, BENGALURU	M.Sc. (Agri.)	ENTOMOLOGY	2	0	0	0	2	1	0
IIHR, BENGALURU	M.Sc. (Agri.)	FLORICULTURE AND LANDSCAPING	1	0	0	0	1	1	0
IIHR, BENGALURU	M.Sc. (Agri.)	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	1	0	1	1	3	0	0
IIHR, BENGALURU	M.Sc. (Agri.)	PLANT PATHOLOGY	2	1	0	0	3	0	0
IIHR, BENGALURU	M.Sc. (Agri.)	PLANT PHYSIOLOGY	1	1	1	0	3	0	1
IIHR, BENGALURU	M.Sc. (Agri.)	VEGETABLE SCIENCE	1	1	0	0	2	0	0
IIHR, BENGALURU	M.Sc. (Hort.)	FRUIT SCIENCE	1	1	0	0	2	0	0
IIHR, BENGALURU	M.Sc. (Hort.)	POST HARVEST MANAGEMENT	1	1	0	0	2	0	0
IIHR, BENGALURU	Ph.D.	ENTOMOLOGY	1	1	0	0	2	0	0
IIHR, BENGALURU	Ph.D.	FLORICULTURE AND LANDSCAPING	1	1	0	0	2	1	0
IIHR, BENGALURU	Ph.D.	FRUIT SCIENCE	2	1	1	0	4	0	0
IIHR, BENGALURU	Ph.D.	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	1	1	0	0	2	0	0
IIHR, BENGALURU	Ph.D.	PLANT PATHOLOGY	1	1	0	0	2	0	0
IIHR, BENGALURU	Ph.D.	PLANT PHYSIOLOGY	1	0	1	0	2	0	0
IIHR, BENGALURU	Ph.D.	POST HARVEST MANAGEMENT	2	0	0	0	2	0	0
IIHR, BENGALURU	Ph.D.	VEGETABLE SCIENCE	1	1	1	1	4	1	1
NBAIR BENGALURU	Ph.D.	ENTOMOLOGY	4	1	1	1	7	1	0
NBAIR BENGALURU	Ph.D.	PLANT PATHOLOGY	1	1	0	0	2	0	0
CPCRI, KASARAGOD	M.Sc. (Hort.)	FRUIT SCIENCE	2	2	0	0	4	0	0
CTCRI, THIRUVANANTHAPURAM	M.Sc. (Agri.)	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	1	0	1	0	2	0	0
CTCRI, THIRUVANANTHAPURAM	Ph.D.	PLANT PATHOLOGY	1	0	1	0	2	0	0
<b>TOTAL PG</b>			13	07	03	02	25	02	01
<b>TOTAL Ph.D.</b>			16	08	05	03	31	03	01

IARI-BHOPAL HUB									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
CIAE, Bhopal	M.Tech.	AGRICULTURAL ENGINEERING (FMPE)	2	0	1	1	4	1	0
CIAE, Bhopal	M.Tech.	AGRICULTURAL ENGINEERING (PFE)	2	2	1	0	5	0	0
CIAE, Bhopal	M.Tech.	AGRICULTURAL ENGINEERING (SWCE)	3	2	0	0	5	0	1
CIAE, Bhopal	Ph.D.	AGRICULTURAL ENGINEERING (FMPE)	2	1	1	0	4	0	0
CIAE, Bhopal	Ph.D.	AGRICULTURAL ENGINEERING (PFE)	2	1	0	0	3	1	0
CIAE, Bhopal	Ph.D.	AGRICULTURAL ENGINEERING (SWCE)	2	1	1	0	4	0	0
IISS, BHOPAL	M.Sc. (Agri.)	SOIL SCIENCE	2	1	1	0	4	1	1

IISS, BHOPAL	Ph.D.	SOIL SCIENCE	2	1	1	0	4	1	0
<b>TOTAL PG</b>			09	05	03	01	18	02	02
<b>TOTAL Ph.D.</b>			08	04	03	00	15	02	00

### IARI-CUTTACK HUB

Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
NRRI, CUTTACK	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	1	1	0	0	2	0	0
NRRI, CUTTACK	M.Sc. (Agri.)	PLANT PATHOLOGY	0	0	1	1	2	0	0
NRRI, CUTTACK	M.Sc. (Agri.)	SOIL SCIENCE	1	0	0	0	1	1	0
<b>TOTAL</b>			02	01	01	01	05	01	00
NRRI, CUTTACK	Ph.D.	GENETICS AND PLANT BREEDING	1	1	0	0	2	0	0
NRRI, CUTTACK	Ph.D.	PLANT PATHOLOGY	1	1	0	0	2	0	0
NRRI, CUTTACK	Ph.D.	SOIL SCIENCE	1	0	0	0	1	1	0
<b>TOTAL</b>			03	02	0	0	05	00	00
NRRI, CUTTACK	UG	B.Sc. (Hons.) AGRICULTURE	14	7	4	2	27	3	1

### IARI-HYDARABAD HUB

Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
CRIDA, HYDARABAD	M.Sc. (Agri.)	AGRONOMY	3	1	0	0	4	1	0
CRIDA, HYDARABAD	M.Sc. (Agri.)	ENTOMOLOGY	2	1	1	0	4	1	0
CRIDA, HYDARABAD	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	2	2	1	0	5	0	0
CRIDA, HYDARABAD	M.Sc. (Agri.)	SOIL SCIENCE	2	1	1	1	5	0	1
<b>TOTAL</b>			09	05	03	01	18	02	01
CRIDA, HYDARABAD	Ph.D.	AGRONOMY	2	1	1	0	4	1	1
CRIDA, HYDARABAD	Ph.D.	ENTOMOLOGY	2	1	1	0	4	1	0
CRIDA, HYDARABAD	Ph.D.	GENETICS AND PLANT BREEDING	2	2	1	0	5	0	0
CRIDA, HYDARABAD	Ph.D.	SOIL SCIENCE	2	1	1	1	5	0	0
<b>TOTAL</b>			08	05	04	01	18	02	01
CRIDA, HYDARABAD	UG	B.Sc. (Hons.) AGRICULTURE	9	5	3	1	18	2	1

### IARI-JHARKHAND HUB

Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IARI, JHARKHAND	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	3	1	1	0	5	1	1
IARI, JHARKHAND	M.Sc. (Agri.)	SOIL SCIENCE	2	2	1	0	5	0	0
IARI, JHARKHAND	M.Sc. (Agri.)	VEGETABLE SCIENCE	2	1	1	1	5	0	0
IARI, JHARKHAND	M.Sc. (Hort.)	FRUIT SCIENCE	2	1	0	0	3	1	0
<b>TOTAL</b>			09	05	03	01	18	02	01
IARI, JHARKHAND	UG	B.Sc. (Hons.) AGRICULTURE	31	16	9	4	60	6	2

### IARI-JODHPUR HUB

Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
CAZRI, JODHPUR	M.Sc. (Agri.)	AGRONOMY	1	1	0	0	2	0	0
CAZRI, JODHPUR	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	1	0	1	0	2	0	0

<b>TOTAL</b>			02	01	01	00	04	0	0
CAZRI, JODHPUR	Ph.D.	AGRONOMY	1	1	0	0	02	0	0
CAZRI, JODHPUR	Ph.D.	GENETICS AND PLANT BREEDING	1	0	1	0	02	0	0
<b>TOTAL</b>			02	01	01	00	04	00	00
<b>IARI-KARNAL HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IWBR, KARNAL	M.Sc. (Agri.)	AGRONOMY	3	1	0	0	4	1	0
IWBR, KARNAL	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	2	2	1	0	5	0	0
IWBR, KARNAL	M.Sc. (Agri.)	PLANT PATHOLOGY	2	1	1	1	5	01	0
<b>TOTAL</b>			07	04	02	01	14	01	00
IWBR, KARNAL	Ph.D.	AGRONOMY	1	1	1	0	3	0	0
IWBR, KARNAL	Ph.D.	GENETICS AND PLANT BREEDING	1	1	0	0	2	1	0
IWBR, KARNAL	Ph.D.	PLANT PATHOLOGY	1	0	0	0	1	0	0
IWBR, KARNAL	Ph.D.	SOIL SCIENCE	1	0	0	0	1	0	0
<b>TOTAL</b>			04	02	01	00	07	01	00
IWBR, KARNAL	UG	B.Sc. (Hons.) AGRICULTURE	12	6	3	2	23	2	1
<b>IARI-KOLKATA HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
CRIJAF, KOLKATA	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	1	0	0	0	1	1	0
CRIJAF, KOLKATA	M.Sc. (Agri.)	SOIL SCIENCE	3	1	0	0	4	0	0
<b>TOTAL</b>			04	01	0	0	05	01	00
CRIJAF, KOLKATA	Ph.D.	GENETICS AND PLANT BREEDING	1	0	0	0	1	0	0
CRIJAF, KOLKATA	Ph.D.	SOIL SCIENCE	2	1	0	0	3	0	0
<b>TOTAL</b>			03	01	00	00	04	0	00
CIJAF, BARACKPORE	UG	B.Sc. (Hons.) AGRICULTURE	9	5	3	1	18	2	1
<b>LUCKNOW HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
ICAR-IISR, LUCKNOW	M.Sc. (Agri.)	GENETICS AND PLANT BREEDING	1	1	1	0	3	0	0
ICAR-CISH, LUCKNOW	M.Sc. (Agri.)	FRUIT SCIENCE	2	1	0	0	3	1	0
ICAR-CISH, LUCKNOW	M.Sc. (Agri.)	PLANT PATHOLOGY	1	1	0	0	2	0	0
<b>Total</b>			06	02	01	0	09	01	0
ICAR-CISH, LUCKNOW	Ph.D.	FRUIT SCIENCE	1	1	0	0	2	0	0
ICAR-IISR, LUCKNOW	Ph.D.	GENETICS AND PLANT BREEDING	02	0	0	0	2	0	0
ICAR-IISR, LUCKNOW	Ph.D.	PLANT PATHOLOGY	1	1	0	0	2	0	0
<b>Total</b>			03	0	0	0	04	01	0
IISR, LUCKNOW	UG	B.Sc. (Hons.) AGRICULTURE	12	6	3	2	23	2	1
<b>NAGPUR HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
CICR, NAGPUR	M.Sc. (Agri.)	ENTOMOLOGY	1	1	1	1	4	1	0
CICR, NAGPUR	M.Sc. (Agri.)	PLANT PATHOLOGY	1	1	1	0	3	0	0

			2	2	2	1	7	1	0
CICR, NAGPUR	Ph.D.	ENTOMOLOGY	1	1	0	1	3	0	0
CICR, NAGPUR	Ph.D.	PLANT PATHOLOGY	1	0	0	0	1	0	0
			2	1	0	1	4	0	0
CICR, NAGPUR	UG	B.Sc. (Hons.) AGRICULTURE	0	0	0	0	0	0	0
<b>TOTAL PG</b>			07	03	02	01	13	01	00
<b>TOTAL Ph.D.</b>			04	02	01	01	08	00	00
<b>PATNA HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IARI, PATNA	M.Sc.	SWCE/LWME	1	0	1	0	2	0	0
<b>TOTAL</b>			01	0	01	0	2	0	00
IARI, PATNA	Ph.D.	SWCE/LWME	2	0	0	0	2	0	0
<b>TOTAL</b>			2	0	0	0	2	00	00
RCER, PATNA	UG	B.Sc. (Hons.) AGRICULTURE	12	6	3	2	23	2	1
<b>RAIPUR HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
NIBSM, RAIPUR	M.Sc. (Agri.)	AGRICULTURAL EXTENSION ED- UCATION	1	0	0	0	1	0	0
NIBSM, RAIPUR	M.Sc. (Agri.)	AGRONOMY	1	0	0	0	1	0	0
NIBSM, RAIPUR	M.Sc. (Agri.)	ENTOMOLOGY	1	1	0	1	3	1	0
NIBSM, RAIPUR	M.Sc. (Agri.)	MICROBIOLOGY	0	0	1	0	1	0	0
NIBSM, RAIPUR	M.Sc. (Agri.)	MOLECULAR BIOLOGY AND BIO- TECHNOLOGY	1	1	0	0	2	0	0
NIBSM, RAIPUR	M.Sc. (Agri.)	PLANT PATHOLOGY	1	0	0	0	1	0	0
<b>TOTAL</b>			05	02	01	01	09	01	00
NIBSM, RAIPUR	Ph.D.	AGRONOMY	1	0	0	0	1	0	0
NIBSM, RAIPUR	Ph.D.	ENTOMOLOGY	0	0	1	0	1	0	0
NIBSM, RAIPUR	Ph.D.	MICROBIOLOGY	1	0	0	0	1	0	0
NIBSM, RAIPUR	Ph.D.	MOLECULAR BIOLOGY AND BIO- TECHNOLOGY	0	1	0	0	1	1	0
<b>TOTAL</b>			02	01	01	00	04	01	00
NIASM, RAIPUR	UG	B.Sc. (Hons.) AGRICULTURE	16	9	5	2	32	3	1
<b>RANCHI HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
IIAB, RANCHI	M.Sc. (Agri.)	BIOCHEMISTRY	1	0	0	0	1	0	0
IIAB, RANCHI	M.Sc. (Agri.)	GENETICS AND PLANT BREED- ING	3	1	1	0	5	1	0
IIAB, RANCHI	M.Sc. (Agri.)	MOLECULAR BIOLOGY AND BIO- TECHNOLOGY	1	1	0	0	2	1	0
IIAB, RANCHI	Ph.D.	BIOCHEMISTRY	1	0	0	0	1	0	0
IIAB, RANCHI	Ph.D.	GENETICS AND PLANT BREED- ING	1	1	0	0	2	0	0
IIAB, RANCHI	Ph.D.	MOLECULAR BIOLOGY AND BIO- TECHNOLOGY	1	0	1	0	2	0	0
NISA, RANCHI	M.Sc. (Agri.)	AGRICULTURAL CHEMICALS	2	1	1	1	5	0	0
NISA, RANCHI	M.Sc. (Agri.)	MOLECULAR BIOLOGY AND BIO- TECHNOLOGY	1	0	0	0	1	0	0
NISA, RANCHI	M.Tech.	AGRICULTURAL ENGINEERING (PFE)	2	1	0	0	3	0	0
IIAB, RANCHI	UG	B.Tech. BIOTECHNOLOGY	14	6	2	1	23	2	1
<b>TOTAL PG</b>			10	04	02	01	17	02	00
<b>TOTAL Ph.D.</b>			03	01	01	00	05	00	00

<b>UMIAM HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
NEH REGION, UMIAM	UG	B.Sc. (Hons.) AGRICULTURE	12	6	3	2	23	2	1
<b>BARAMATI HUB</b>									
Hub	Course	Discipline	GEN	OBC	SC	ST	Total	EWS	PH
NIASM, BARA- MATI	M.Sc. (Agri.)	Environmental Science	1	0	0	1	2	0	0
NIASM, BARA- MATI	M.Sc. (Agri.)	Plant Physiology	1	0	1	0	2	0	0
NIASM, BARA- MATI	M.Tech.	AGRICULTURAL ENGINEERING (SWCE)	1	1	0	0	2	0	0
NIASM, BARA- MATI	M.Tech.	AGRICULTURAL ENGINEER- ING(PFE)	1	1	0	0	2	0	0
<b>TOTAL</b>			04	02	01	01	08	00	00
NIASM, BARA- MATI	Ph.D.	AGRICULTURAL ENGINEER- ING(PFE)	1	0	0	0	1	0	0
NIASM, BARA- MATI	Ph.D.	ENVIRONMENTAL SCIENCE	1	0	0	0	1	0	0
<b>TOTAL</b>			02	00	00	00	02	0	00
NIBSM, BARA- MATI	UG	B.Sc. (Hons.) AGRICULTURE	12	6	3	2	23	2	1

## 9. ACADEMIC CALENDER

The academic calendar will be uploaded on the ICAR-IARI website after receiving communication of completion of counselling process from the Education Division of ICAR. Please keep checking the institute website [www.iari.res.in](http://www.iari.res.in) for the same.

## 10. RESERVATION POLICY

**For details refer to** Section 2.6 of *Information Bulletin for CUET (ICAR-UG) – 2023*; Section 2.8 of *Information Bulletin ICAR AIEEA (PG) – 2023* and Section 2.7 of *Information Bulletin for ICAR AICE- JRF/ SRF (Ph.D.) – 2023*.

## 11. CHOICE-BASED CREDIT SYSTEM

### UG Programme

As per the Fifth Deans' Committee (*constituted vide ICAR office order F. No. Edn. 5.1.2013-EQR dated: 10 July 2013 under the chairmanship of Prof. R.B. Singh*); all degrees in the disciplines of Agricultural Sciences will be declared **as professional degrees**, which include undergraduates in all four programmes viz. B.Sc. (Hons) Agriculture; B.Tech. (Agricultural Engineering); B.Tech. Biotechnology and B.Sc. (Hons) Community Science) initiated by the institute from the current academic year.

### Student READY (Rural and Entrepreneurship Awareness Development Yojana)

Considering the variation in different streams of agricultural education and feasibility, the following five components, are conceptualized for building skills in project development and execution, decision-making, individual and team coordination, approach to problem solving, accounting, quality control, marketing and resolving conflicts, etc. with end to end approach in Student READY program.

1. Experiential Learning/Hands on Training
2. Skill Development Training
3. Rural Agriculture Work Experience
4. In Plant Training/ Industrial attachment
5. Students Projects

The students will be required to have any three of the five components listed above depending on the requirement of their graduate education.

### Examination system

1. External theory (50%)
2. Internal Theory + Practical (50%)
  - o *Courses with Theory and Practical: Mid-term Exam (30%) + Assignment (5%) in practical oriented courses + Practical (15%)*
  - o *Courses with only Theory: Mid-term Exam (40%) + Assignment (10%)*
  - o *Courses with only Practical: (100%) Internal*
3. Paper to be set by external: HOD ensures the coverage of syllabus. If needed moderation is done.
4. Evaluation to be done internally by the faculty other than the Course Instructor. Syllabus of the concerned course is sent to the external examiner, who prepares the question papers. For practical, examination is conducted by course instructor(s) and one teacher nominated by HOD.

## Common courses

In view of the increasing importance of climate change, market competitiveness, information technology, entrepreneurship, and graduates employability, the following **common courses** will be taught to the students of all disciplines:

1. Environmental Studies and Disaster Management
2. Communication Skills and Personality Development
3. Information and Communication Technology
4. Entrepreneurship Development and Business Management
5. Agricultural Informatics
6. Economics and Marketing

## Elective Courses:

### B.Sc Agriculture (Hons.)

	Courses	Credit Hours
1	Agribusiness Management	3(2+1)
2	Agrochemicals	3(2+1)
3	Commercial Plant Breeding	3(1+2)
4	Landscaping	3(2+1)
5	Food Safety and Standards	3(2+1)
6	Biopesticides & Biofertilizers	3(2+1)
7	Protected Cultivation	3(2+1)
8	Micro propagation Technologies	3(1+2)
9	Hi-tech. Horticulture	3(2+1)
10	Weed Management	3(2+1)
11	System Simulation and Agro- advisory	3(2+1)
12	Agricultural Journalism	3(2+1)

### B. Tech. (Agricultural Engineering)

	Courses	Credit Hours
1	Floods and Control Measures	3(2+1)
2	Wasteland Development	3(2+1)
3	Information Technology for Land and Water Management	3(2+1)
4	Remote Sensing and GIS Applications	3(2+1)
5	Management of Canal Irrigation System	3(2+1)
6	Minor Irrigation and Command Area Development	3(2+1)
7	Precision Farming Techniques for Protected Cultivation	3(2+1)
8	Water Quality and Management Measures	3(2+1)
9	Landscape Irrigation Design and Management	3(2+1)
10	Plastic Applications in Agriculture	3(2+1)
11	Mechanics of Tillage and Traction	3(2+1)
12	Farm Machinery Design and Production	3(2+1)
13	Human Engineering and Safety	3(2+1)
14	Tractor Design and Testing	3(2+1)
15	Hydraulic Drives and Controls	3(2+1)

16	Precision Agriculture and System Management	3(2+1)
17	Food Quality and Control	3(2+1)
18	Food Plant Design and Management 19 20 21	3(2+1)
19	Food Packaging Technology	3(2+1)
20	Development of Processed Products	3(2+1)
21	Process Equipment Design	3(2+1)
22	Photovoltaic Technology and Systems	3(2+1)
23	Waste and By-products Utilization	3(2+1)
24	Artificial Intelligence	3(3+0)
25	Mechatronics	3(2+1)

## B.Tech.Biotechnology

Any one Elective given in the below table to be chosen; for each elective; Total Credit Hours=18

CourseNo.	CourseTitle	Credit hours
<b>Elective I. Plant Biotechnology</b>		
Biotech.411	Plant Tissue Culture and its Applications	2+1
Biotech.412	Principles and Applications of Plant Genetic Transformation	2+1
Biotech.413	Applications of Genomics and Proteomics	2+1
Biotech.414	Molecular Breeding in Field Crops	2+1
Biotech.415	Molecular Breeding of Horticultural Crops and Forest Trees	2+1
Biotech.416	Epigenetics and Gene Regulation	2+1
<b>Elective II. Animal Biotechnology</b>		
Biotech.421	Principles and Procedures of Animal Cell Culture	2+1
Biotech.422	Animal Genomics	2+1
Biotech.423	Embryo Transfer Technologies	2+1
Biotech.424	Transgenic Animal Production	3+0
Biotech.425	Molecular Diagnostics	2+1
Biotech.426	Molecular Virology and Vaccine Production	2+1
<b>Elective III. Microbial and Environmental Biotechnology</b>		
Biotech.431	Microbial Biotechnology	2+1
Biotech.432	Bio-prospecting of Molecules and Genes	3+0
Biotech.433	Molecular Ecology and Evolution	3+0
Biotech.434	Fundamentals of Molecular Pharming and Biopharmaceuticals	2+1
Biotech.435	Food Biotechnology	2+1
Biotech.436	Green Biotechnology	2+1
<b>Elective IV. Bioinformatics</b>		
Biotech.441	Programming for Bioinformatics	2+2
Biotech.442	Bioinformatics Tools and Biological Databases	2+1
Biotech.443	Structural Bioinformatics	2+1
Biotech.444	Pharmacogenomics	2+1
Biotech.445	Metabolomics and System Biology	2+1
Biotech.446	Computational Methods for Data Analysis	1+1

## B.Sc. (Hons) Community Science

For B Sc Community Science, there are no elective courses as of now. They have been merged in Module I and Module II of Student ready programmes. Out of 37 credits of Module I, students are required to choose 20 credits; and from 36 credits of Module II, students are required to choose 20 credits.

## PG and Ph.D programme

As per the BSMA guidelines duly approved by the 417th Academic Council of the institute dated 6<sup>th</sup> October, 2023 and subsequently vide notification No. ICAR/IARI/Dte-PGS-I/1-2/2022-AC (417), the details are as under:

### Credit requirements Framework of the courses

The following nomenclature and Credit hours need to be followed while providing the syllabus for all the disciplines

	Masters' Programme	Doctoral Programme
<b>i) Course work</b>		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	-
Seminar	01	02
<b>ii) Thesis Research</b>	30	75
<b>TOTAL</b>	70	100

**Major courses:** From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken are given \*mark

**Minor courses:** From the subjects closely related to a student's major subject

**Supporting courses:** The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments etc.) or necessary for building his/her overall competence.

**Common Courses:** The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/MOOCs. The students may be allowed to register these courses/similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/she may be permitted to register for other related courses with the prior approval of the HoD/BoS.

### Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS.

CODE	COURSE TITLE	CREDITS
STAT 501	Mathematics For Applied Sciences	2+0
STAT 502	Statistical Methods For Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals And Programming	2+1
MCA 502	Computer Organization And Architecture	2+0
MCA 511	Introduction To Communication Technologies, Computer Networking And Internet	1+1
MCA 512	Information Technology In Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques In Biochemistry	2+2

- Evaluation of course work and comprehensive examination
- For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc students.
- For PhD, the approach should be research oriented rather than exam oriented. In order to provide the student adequate time to concentrate on the research work and complete the degree in stipulated time, the examination may have to be only semester final. However, the course teacher may be given freedom to evaluate in terms of assignment/seminar/first test.

For Ph.D., the comprehensive examination (Pre-qualifying examination) is required. As the students are already tested in course examinations, the comprehensive examination should be based on oral examination by an external expert and the evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic. The successful completion of comprehensive examination is to obtain the “Satisfactory” remark by the external expert.

The details of the course credits, course numbers, course titles, residential requirements and other rules and regulations are included in the Graduate School Calendar. The student’s attainment in the courses taken by him/her is judged from the grade obtained in each course and the progress is measured in terms of the overall grade point average (OGPA). The maximum attainable OGPA is 10.00 and the minimum passing point is 6.00.

## 12. FEES AND EXPENSES

The students are liable to pay fees, funds and other charges as may be laid down from time to time. SC / ST students are entitled to the reimbursement of the tuition fees as per GOI rules.

### Fee Structure for Student of M.Sc./M.Tech. & Ph.D. to be admitted in the academic session/ year 2023-24

#### AT THE TIME OF ADMISSION/ REGISTRATION FOR 1<sup>st</sup> SEMESTER

i)	Registration Fee	Rs. 500/-
ii)	Caution Money ( <b>Refundable</b> )	Rs. 10000/-
iii)	Tuition Fee for 1 <sup>st</sup> Semester	Rs. 6000/- (Rs. 5000 for M.Sc./M.Tech.)
iv)	Examination fee	Rs. 1000/-
vii)	Comprehensive Exam (once in degree programme)	Rs. 2000/- (Rs.1000/- for M.Sc./M.Tech)
viii)	Thesis Evaluation Fee	Rs. 2000/- (Rs.1000/- for M.Sc./M.Tech)
ix)	PGS Journal Subscription Fee (Annual)	Rs. 200/-
x)	P.G. School Calendar Charges (One Time)	Rs. 200/-
xi)	PGSS Union Fee (Annual)	Rs. 300/-

xii)	PGSSU Magazine Fee (Annual)	Rs. 100/-
xiii)	Students' Sports Fund (Annual)	Rs. 200/-
xiv)	PGSSU Cultural and Literary Activities Fee (Annual)	Rs. 600/-
xv)	Student Welfare Fund (Annual)	Rs. 200/-
xvi)	Identity Card Fee (Annual)	Rs. 100/-
xvii)	IARI Alumni Life Membership Fee (One Time)	Rs. 250/- (Once either in M.Sc./M.Tech. or in Ph.D.)

#### AT THE TIME OF REGISTRATION FOR II<sup>nd</sup> SEMESTER

i)	Tuition Fee for II <sup>nd</sup> Semester	Rs. 6000/- (Rs.5000 for M.Sc./M.Tech.)
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#### Fee Structure for Student of B.Sc./B.Tech. to be admitted in the academic session/ year 2023-24

#### AT THE TIME OF ADMISSION/ REGISTRATION FOR 1<sup>st</sup> SEMESTER

i)	Registration Fee (One Time)	Rs. 500/-
ii)	Caution Money ( <b>Refundable</b> )	Rs. 10000/-
iii)	Tuition Fee for 1 <sup>st</sup> Semester	Rs. 4000/-
iv)	Examination fee	Rs. 600/-
vii)	PGS Journal Subscription Fee (Annual)	Rs. 200/-
viii)	P.G. School Calendar Charges (One Time)	Rs. 200/-
ix)	PGSS Union Fee (Annual)	Rs. 300/-
x)	PGSSU Magazine Fee (Annual)	Rs. 100/-
xi)	Students' Sports Fund (Annual)	Rs. 200/-
xii)	PGSSU Cultural and Literary Activities Fee (Annual)	Rs. 600/-
xiii)	Identity Card Fee (One Time)	Rs. 100/-
xiv)	Student Welfare Fund (Annual)	Rs. 200/-
xv)	IARI Alumni Life Membership Fee (One Time)	Rs. 250/-

#### AT THE TIME OF REGISTRATION FOR II<sup>nd</sup> SEMESTER

i)	Tuition Fee for II <sup>nd</sup> Semester	Rs. 4000/-
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The Fee Structure for Old and New Hostels is given below:

<b><u>Annual Charges of Old IARI Hostels for students admitted in academic year 2023-24</u></b>	
<b>Old Hostels</b>	<b>Amount (In Rupees)</b>
Single Seater	10000
Double/Triple Sharing Room	6000
Family Hostel/Suite*	100000
Common Electricity + Water Charges	6000
*Common Electricity + Water Charges for family Hostel/Suite	12000

<b><u>Annual Charges of New IARI Hostels for students admitted in academic year 2023-24</u></b>	
<b>Madhumas and New Girls hostel</b>	<b>Amount (In Rupees)</b>
Single Seater – Common Bathroom	30000
Single seater - attached Kitchennet + Bathroom	96000
Family suite *	180000
Common Electricity + Water Charges	6000
*Common Electricity + Water Charges for family suite	12000

1. Hostel Caution Money @Rs. 10,000/- (Refundable) is to be paid by all student availing hostel facility.
2. The student will be given choice to opt for New or Old Hostel.

3. Allocation of hostel will be done as per hostel allotment policy.
4. There will be 10% hike on total amount (Hostel Fee+Electricity & Water Charge) every year, year on year in Hostel fees of all Hostels.

New hostels are equipped with lifts and have 24X7 power backup facility. Students can install AC/Oil Heaters/ Refrigerator or other Electrical Gadgets after due permission from the MOHR. Electricity bill of these gadgets shall be borne by the individual student as per use through pre-paid meter.

A nominal monthly fee from students shall be charged for air-conditioned Gym and newly developed air-conditioned badminton courts.

***Note: The fee structure is liable to change as per the rules/orders of Institute/ICAR/UGC/GOI from time to time with approval of Competent Authority.***

### **13. ACCOMODATION POLICY**

Hostel facility in ICAR-IARI, New Delhi and its hubs is very limited and availability is not guaranteed. Allotment of the available hostel accommodation to the students will be as per the Institute Hostel allotment Policy and subject to availability of rooms. The hostel shall be allotted only for one semester at a time and shall be vacated at the end of each semester by the student. Students taking admission should be prepared to stay in the city if hostel accommodation is not available. Hostel charges shall be revised by the Institute each academic year. It will be obligatory for every hostel allottee to abide by hostel discipline rules which may get revised periodically. Student not complying with hostel or Institute rules and regulations shall be penalized as per Institute discipline policy.

### **14. SCHOLARSHIP, MEDALS and AWARDS**

The Financial assistance to the students will be as per the ICAR policy for its deemed to be universities. For more details, please get updates from the IARI website [www.iari.res.in](http://www.iari.res.in)

### **15. DISCIPLINE**

The Joint Director (Education) and Dean, The Graduate School, ICAR-IARI, New Delhi is in-charge of the general control of students and with the maintenance of discipline. The Dean shall have the discretion to remove any student from the rolls of the Graduate School of ICAR-IARI for any reason qualifying as violation of code of conduct on or off the campus. Few reasons but not limited to are, exemplified as follows:

- (a) Failure to gain from the course of studies
- (b) Misbehavior
- (c) Failure to pay the dues (fees etc.) on time
- (d) Continuous absence from studies for a long period

The detailed student handbook on ICAR-IARI Disciplinary Rules and Code of Conduct will be provided to the admitted students.

The ICAR-IARI disciplinary guidelines and code of conduct, duly approved by the Academic Council in its 419<sup>th</sup> meeting may be referred to for details.

## 16. STUDENTS' SUPPORT SERVICES

- (a) **Prof. M.S. Swaminathan Library:** The IARI library is one of the oldest and the best in South Asia. It is playing the role of National Agricultural Library of India, and is regarded as one of the 10 best agro-biological libraries of the world. The IARI Library has got a well-equipped "Facility Management Unit" and a "Training Cell". Periodic trainings are organized for scientists and students of the Institute for CD-ROM search, Digital Resources, E-Journals, On-line information retrieval *etc.* Library is fully automated with vast collection of highly specialized research publications on agriculture and related sciences. The collection gets enriched continually. CDROM, Online journals, CeRA, OPA Care available in campus through LAN connectivity to nearly 2000 users. Reading halls are having wired internet terminals as well as Wi-Fi connectivity. The library has 10,500 serial files, and 2000 current serials are being procured from 90 countries. Exchange relationship is maintained with 67 Indian and foreign institutions. Library is repository of FAO, CGIAR publications. The IARI Library has been assigned the job of AGRIS database input for National Agricultural Research Database (NARD) in ISO format using AGRIN methodology. This library is contributing in AGRIS database in merging data of 10 core Indian Journals. It has text books section and also Hindi reference books section.
- (b) **Medical Facilities:** A qualified Medical Officer looks after the health of the students, and is in charge of the IARI Dispensary located in the vicinity of the Hostels. The Medical Officer resides inside the campus and is thus available during day and night. The medical service provided free to students at the dispensary.
- (c) **Sports and Recreation:** The Post Graduate School encourages extra-curricular activities that enrich cultural, physical and social life of students. Spacious playgrounds are provided near the student hostels and necessary facilities exist for outdoor games like cricket, football, hockey, volleyball, tennis, badminton and various athletic events. There are facilities also for indoor games in each hostel. There is a Students' Sports Fund to which every student subscribes at the beginning of each academic year.
- (d) **Student Welfare Fund:** With a view to render financial aid to students in distress and to support any other students' activities, a Students' Welfare Fund has been instituted. All students are required to contribute to the fund at the beginning of each academic year. No loan shall ordinarily be given from this fund in the first trimester of admission.
- (e) **Students' Counseling and Placement Cell:** A "Student Career Development and Industry Interface Centre" has been established for career counseling and arranging frequent Institute- Industry interface. It has been organizing campus interviews for career counseling and placement of outgoing students in the jobs of their choice.
- (f) The Graduate School Students' Union (Previously PGSSU): All students admitted to the Graduate School automatically become members of the Graduate School Students' Union and are entitled to participate in the Union election.
- (g) Internet facility: Internet, intranet and Wi-Fi connectivity is available to students free of charge. The course schedules along with contents and suggested readings are also available on IARI intranet system.
- (h) Communication and Language Laboratory: This facility created in 2012 is being used to teach English and Hindi language courses and communication skills to students who need improvement in these aspects.
- (i) Institute Complaint Committee: in compliance to the UGC (Prevention, Prohibition and Redress of Sexual harassment of women workers and students in Higher Education Institutions), Regulation 2015. Institute has functional assistance/mechanism for dispute redressal and to protect the safety of the complainant by not divulging the person's identity as well as to ensure that victims or witnesses are not discriminated against which dealing with complaints of sexual harassment.
- (j) **Anti-Ragging Committee:** The Institute's ARC ensures compliance with the provisions of UGC Regulations as well as provisions of any law for the time being in force concerning ragging and also monitor and oversee the performance of the ARS in prevention of ragging in the ICAR-IARI, New Delhi.

# ANNEXURE 1: SYLLABUS FOR ICAR'S ALL INDIA ENTRANCE EXAMINATION FOR ADMISSION TO BACHELOR DEGREE PROGRAMMES

## PHYSICS

### Unit-1: Physical World and Measurement

Physics scope and excitement; nature of physical laws; Physics, technology and society. Need for measurement: Units of measurement; systems of units; SI units, fundamental and derived units. Length, mass and time measurements; accuracy and precision of measuring instruments; errors in measurement; significant figures. Dimensions of physical quantities, dimensional analysis and its applications.

### Unit-2: Kinematics

Frame of reference. Motion in a straight line: Position-time graph, speed and velocity. Uniform and non-uniform motion, average speed and instantaneous velocity. Uniformly accelerated motion: velocity-time graph, position-time graphs, relations for uniformly accelerated motion (graphical treatment). Elementary concepts of differentiation and integration for describing motion. Scalar and vector quantities: Position and displacement vectors, general vectors and notation, equality of vectors, multiplication of vectors by a real number; addition and subtraction of vectors. Relative velocity. Unit vector; Resolution of a vector in a plane - rectangular components. Motion in a plane. Cases of uniform velocity and uniform acceleration-projectile motion. Uniform circular motion. Motion of objects in three-dimensional space. Motion of objects in three-dimensional space.

### Unit-3: Laws of Motion

Intuitive concept of force. Inertia, Newton's first law of motion; momentum and Newton's second law of motion; impulse; Newton's third law of motion. Law of conservation of linear momentum and its applications. Equilibrium of concurrent forces. Static and kinetic friction, laws of friction, rolling friction. Dynamics of uniform circular motion: Centripetal force, examples of circular motion (vehicle on level circular road, vehicle on banked road).

### Unit-4: Work, Energy and Power

Scalar product of vectors. Work done by a constant force and a variable force; kinetic energy, work-energy theorem, power. Notion of potential energy, potential energy of a spring, conservative forces: conservation of mechanical energy (kinetic and potential energies); non-conservative forces: elastic and inelastic collisions in one and two dimensions.

### Unit-5: Motion of System of Particles and Rigid Body

Centre of mass of a two-particle system, momentum conservation and center of mass motion. Centre of mass of a rigid body; center of mass of uniform rod. Vector product of vectors; moment of a force, torque, angular momentum, conservation of angular momentum with some examples. Equilibrium of rigid bodies, rigid body rotation and equations of rotational motion, comparison of linear and rotational motions; moment of inertia, radius of gyration. Values of moments of inertia for simple geometrical objects. Statement of parallel and perpendicular axes theorems and their applications.

### Unit-6: Gravitation

Kepler's laws of planetary motion. The universal law of gravitation. Acceleration due to gravity and its variation with altitude and depth. Gravitational potential energy; gravitational potential. Escape velocity. Orbital velocity of a satellite. Geo-stationary satellites.

### Unit-7: Properties of Bulk Matter

Elastic behavior, Stress-strain relationship, Hooke's law, Young's modulus, bulk modulus, shear modulus, modulus of rigidity. Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes).

Effect of gravity on fluid pressure. Viscosity, Stokes' law, terminal velocity, Reynold's number, streamline and turbulent flow. Bernoulli's theorem and its applications. Surface energy and surface tension, angle of contact, application of surface tension ideas to drops, bubbles and capillary rise.

Heat, temperature, thermal expansion; specific heat - calorimetry; change of state - latent heat. Heat transfer-conduction, convection and radiation, thermal conductivity, Newton's law of cooling.

### **Unit-8: Thermodynamics**

Thermal equilibrium and definition of temperature (zeroth law of thermodynamics). Heat, work and internal energy. First law of thermodynamics. Second law of thermodynamics: reversible and irreversible processes. Heat engines and refrigerators.

### **Unit-9: Behavior of Perfect Gas and Kinetic Theory**

Equation of state of a perfect gas, work done on compressing a gas. Kinetic theory of gases - assumptions, concept of pressure. Kinetic energy and temperature; rms speed of gas molecules; degrees of freedom, law of equipartition of energy (statement only) and application to specific heats of gases; concept of mean free path, Avogadro's number.

### **Unit-10: Oscillations and Waves**

Periodic motion - period, frequency, displacement as a function of time. Periodic functions. Simple Harmonic Motion (S.H.M) and its equation; phase; oscillations of a spring-restoring force and force constant; energy in S.H.M.- kinetic and potential energies; simple pendulum- derivation of expression for its time period; free, forced and damped oscillations, resonance. Wave motion. Longitudinal and transverse waves, speed of wave motion. Displacement relation for a progressive wave. Principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, fundamental mode and harmonics, Beats, Doppler effect.

### **Unit-11: Electrostatics**

Electric Charges; Conservation of charge, Coulomb's law - force between two-point charges, forces between multiple charges; superposition principle and continuous charge distribution. Electric field, electric field due to a point charge, electric field lines; electric dipole, electric field due to a dipole; torque on a dipole in uniform electric field. Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside). Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field. Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarization, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor. Van de Graaff generator.

### **Unit-12: Current Electricity**

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, electrical resistance, V - I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity. Carbon resistors, colour code for carbon resistors; series and parallel combinations of resistors; temperature dependence of

resistance. Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel. Kirchoff's laws and simple applications. Wheatstone bridge, meter bridge. Potentiometer - principle and its applications to measure potential difference and for comparing emf of two cells; measurement of internal resistance of a cell.

### **Unit-13: Magnetic Effects of Current and Magnetism**

Concept of magnetic field, Oersted's experiment. Biot - Savart law and its application to current carrying circular

loop. Ampere's law and its applications to infinitely long straight wire, straight and toroidal solenoids. Force on a moving charge in uniform magnetic and electric fields. Cyclotron. Force on a current-carrying conductor in a uniform magnetic field. Force between two parallel current-carrying conductors-definition of ampere. Torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Current loop as a magnetic dipole and its magnetic dipole moment. Magnetic dipole moment of a revolving electron. Magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to its axis. Torque on a magnetic dipole (bar magnet) in a uniform magnetic field; bar magnet as an equivalent solenoid, magnetic field lines; Earth's magnetic field and magnetic elements. Para-, dia- and ferro - magnetic substances, with examples. Electromagnets and factors affecting their strengths. Permanent magnets.

#### **Unit-14: Electromagnetic Induction and Alternating Currents**

Electromagnetic induction; Faraday's law, induced emf and current; Lenz's Law, Eddy currents. Self and mutual inductance. Need for displacement current. Alternating currents, peak and rms value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits, wattless current. AC generator and transformer.

#### **Unit-15: Electromagnetic waves**

Displacement current, Electromagnetic waves and their characteristics (qualitative ideas only). Transverse nature of electromagnetic waves. Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

#### **Unit-16: Optics**

Reflection of light, spherical mirrors, mirror formula. Refraction of light, total internal reflection and its applications, optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula. Magnification, power of a lens, combination of thin lenses in contact. Refraction and dispersion of light through a prism. Scattering of light - blue colour of the sky and reddish appearance of the sun at sunrise and sunset. Optical instruments: Human eye, image formation and accommodation, correction of eye defects (myopia, hypermetropia, presbyopia and astigmatism) using lenses. Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers. Wave optics: wave front and Huygens' principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygens' principle. Interference, Young's double slit experiment and expression for fringe width, coherent sources and sustained interference of light. Diffraction due to a single slit, width of central maximum. Resolving power of microscopes and astronomical telescopes. Polarization, plane polarised light; Brewster's law, uses of plane polarised light and Polaroids.

#### **Unit-17: Dual Nature of Matter and Radiation**

Dual nature of radiation. Photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light. Matter waves-wave nature of particles, de Broglie relation. Davisson-Germer experiment.

#### **Unit-18: Atoms & Nuclei**

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum. Composition and size of nucleus, atomic masses, isotopes, isobars; isotones. Radioactivity, alpha, beta and gamma particles/rays and their properties; radioactive decay law. Mass- energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear reactor, nuclear fusion.

#### **Unit-19: Electronic Devices**

Semiconductors; semiconductor diode – I -V characteristics in forward and reverse bias, diode as a rectifier; I -V characteristics of LED, photodiode, solar cell, and Zener diode; Zener diode as a voltage regulator. Junction transistor, transistor action, characteristics of a transistor; transistor as an amplifier (common emitter configuration)

and oscillator. Logic gates (OR, AND, NOT, NAND and NOR). Transistor as a switch.

### **Unit-20: Communication Systems**

Elements of a communication system (block diagram only); bandwidth of signals (speech, TV and digital data); bandwidth of transmission medium. Propagation of electromagnetic waves in the atmosphere, sky and space wave propagation. Need for modulation. Production and detection of an amplitude-modulated wave.

## **CHEMISTRY**

### **Unit-1: Some Basic Concepts of Chemistry**

General Introduction: Importance and scope of chemistry. Historical approach to particulate nature of matter, laws of chemical combination. Dalton's atomic theory: concept of elements, atoms and molecules. Atomic and molecular masses mole concept and molar mass: percentage composition, empirical and molecular formula chemical reactions, stoichiometry and calculations based on stoichiometry.

### **Unit-2: Solid State**

Classification of solids based on different binding forces: molecular, ionic, covalent and metallic solids, amorphous and crystalline solids (elementary idea), unit cell in two dimensional and three- dimensional lattices, calculation of density of unit cell, packing in solids, voids, number of atoms per unit cell in a cubic unit cell, point defects, electrical and magnetic properties.

### **Unit-3: Solutions**

Types of solutions, expression of concentration of solutions of solids in liquids, solubility of gases in liquids, solid solutions, colligative properties – relative lowering of vapor pressure, elevation of Boiling Point, depression of freezing point, osmotic pressure, determination of molecular masses using colligative properties, abnormal molecular mass.

### **Unit-4: Structure of Atom**

Discovery of electron, proton and neutron; atomic number, isotopes and isobars. Thomson's model and its limitations, Rutherford's model and its limitations. Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p, and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals.

### **Unit-5: Classification of Elements and Periodicity in Properties**

Significance of classification, brief history of the development of periodic table, modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii, ionic radii. Ionization enthalpy, electron gain enthalpy, electro negativity, valence.

### **Unit-6: Chemical Bonding and Molecular Structure**

Valence electrons, ionic bond, covalent bond: bond parameters. Lewis's structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR (Valence shell electron pair repulsion) theory, concept of hybridization, involving s, p and d orbitals and shapes of some simple molecules, molecular orbital; theory of homonuclear diatomic molecules (qualitative idea only), hydrogen bond.

### **Unit-7: States of Matter: Gases and Liquids**

Three states of matter. Intermolecular interactions, type of bonding, melting and boiling points. Role of gas laws in elucidating the concept of the molecule, Boyle's law. Charles law, Gay Lussac's law, Avogadro's law. Ideal behavior, empirical derivation of gas equation, Avogadro's number. Ideal gas equation. Derivation from ideal

behavior, liquefaction of gases, critical temperature. Liquid State - Vapor pressure, viscosity and surface tension (qualitative idea only, no mathematical derivations).

### **Unit-8: Thermodynamics**

Concepts of System, types of systems, surroundings. Work, heat, energy, extensive and intensive properties, state functions. First law of thermodynamics - internal energy and enthalpy, heat capacity and specific heat, measurement of  $\Delta U$  and  $\Delta H$ , Hess's law of constant heat summation, enthalpy of: bond dissociation, combustion, formation, atomization, sublimation. Phase transformation, ionization, and solution. Introduction of entropy as a state function, free energy change for spontaneous and non-spontaneous processes, criteria for equilibrium.

### **Unit-9: Equilibrium**

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant, factors affecting equilibrium - Le Chatelier's principle; ionic equilibrium - ionization of acids and bases, strong and weak electrolytes, degree of ionization, concept of  $pH$ . Hydrolysis of salts. Buffer solutions, solubility product, common ion effect.

### **Unit-10: Redox Reactions**

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, applications of redox reactions.

### **Unit-11: Hydrogen**

Position of hydrogen in periodic table, occurrence, isotopes, preparation, properties and uses of hydrogen; hydrides - ionic, covalent and interstitial; physical and chemical properties of water, heavy water; hydrogen peroxide-preparation, properties and structure; hydrogen as a fuel.

### **Unit-12: s-Block Elements (Alkali and Alkaline earth metals) Group 1 and Group 2 elements**

General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens; uses.

### **Unit-13: Preparation and properties of some important compounds**

Sodium carbonate, sodium chloride, sodium hydroxide and sodium hydrogen carbonate, biological importance of sodium and potassium.  $CaO$ ,  $CaCO_3$  and industrial use of lime and limestone, biological importance of  $Mg$  and  $Ca$

### **Unit-14: Some p-Block**

#### **Elements General Introduction to p-Block Elements: Group 13 elements**

General introduction, electronic configuration, occurrence. Variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group; Boron- physical and chemical properties, some important compounds: borax, boric acids, boron hydrides. Aluminum: uses, reactions with acids and alkalis.

### **Unit-15: Group 14 elements**

General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behavior of first element, Carbon - catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of silicon and a few uses: silicon tetrachloride, silicones, silicates and zeolites.

### **Unit-16: Organic Chemistry**

#### **Some Basic Principles and Techniques**

General introduction, methods of qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds, electronic displacements in a covalent bond: inductive effect, electromeric effect, resonance

and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions; electrophiles and nucleophiles, types of organic reactions

### **Unit-17: Hydrocarbons Classification of hydrocarbons**

**Alkanes** - Nomenclature, isomerism, conformations (ethane only), physical properties, chemical reactions including free radical mechanism of halogenation, combustion and pyrolysis.

**Alkenes** - Nomenclature, structure of double bond (ethene) geometrical isomerism, physical properties, methods of preparation; chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markovnikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

**Alkynes** - Nomenclature, structure of triple bond (ethyne), physical properties. Methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water.

Aromatic hydrocarbons: Introduction, IUPAC nomenclature; benzene: resonance, aromaticity; chemical properties: mechanism of electrophilic substitution. – nitration, sulphonation, halogenation, Friedel-Craft's alkylation and acylation: directive influence of functional group in mono-substituted benzene; carcinogenicity and toxicity.

### **Unit-18: Electrochemistry**

Conductance in electrolytic solutions, specific and molar conductivity variations of conductivity with concentration, Kohlrausch's Law, electrolysis and laws of electrolysis (elementary idea), dry cell – electrolytic cells and Galvanic cells; lead accumulator, EMF of a cell, standard electrode potential, Nernst equation and its application to chemical cells, fuel cells; corrosion.

### **Unit-19: Chemical Kinetics**

Rate of a reaction (average and instantaneous), factors affecting rate of reaction; concentration, temperature, catalyst; order and molecularity of a reaction; rate law and specific rate constant, integrated rate equations and half-life (only for zero and first order reactions); concept of collision theory (elementary idea, no mathematical treatment)

### **Unit-20: Surface Chemistry**

Adsorption – physisorption and chemisorption; factors affecting adsorption of gases on solids; catalysis: homogenous and heterogeneous, activity and selectivity: enzyme catalysis; colloidal state: distinction between true solutions, colloids and suspensions; lyophilic, lyophobic, multimolecular and macromolecular colloids; properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulation; emulsion – types of emulsions.

### **Unit-21: General Principles and Processes of Isolation of Elements**

Principles and methods of extraction - concentration, oxidation, reduction electrolytic method and refining; occurrence and principles of extraction of aluminum, copper, zinc and iron.

### **Unit-22: p-Block Elements Group 15 elements**

General introduction, electronic configuration, occurrence, oxidation states, trends in physical and chemical properties; nitrogen - preparation, properties and uses; compounds of nitrogen: preparation and properties of ammonia and nitric acid, oxides of nitrogen (structure only); Phosphorous-allotropic forms; compounds of phosphorous: preparation and properties of phosphine, halides (PCl<sub>3</sub>, PCl<sub>5</sub>) and oxoacids

### **Unit-23: Group 16 elements**

General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; dioxygen: preparation, properties and uses; simple oxides; Ozone. Sulphur - allotropic forms; compounds of Sulphur: preparation, properties and uses of Sulphur dioxide; sulphuric acid: industrial process of manufacture, properties and uses, oxoacids of Sulphur (structures only).

### **Unit-24: Group 17 elements**

General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; compounds of halogens: preparation, properties and uses of chlorine and hydrochloric acid, interhalogen compounds, oxoacids of halogens (structures only).

### **Unit-25: Group 18 elements**

General introduction, electronic configuration. Occurrence, trends in physical and chemical properties, uses.

### **Unit-26: d and f Block Elements**

General introduction, electronic configuration, occurrence and characteristics of transition metals, general trends in properties of the first-row transition metals – metallic character, ionization enthalpy, oxidation states, ionic radii, colour catalytic property, magnetic properties, interstitial compounds, alloy formation preparation and properties of  $K_2Cr_2O_7$  and  $KMnO_4$ .

**Lanthanoids** - electronic configuration, oxidation states, chemical reactivity and lanthanoid contraction.

### **Unit-27: Coordination Compounds**

Coordination compounds - Introduction, ligands, coordination number, colour, magnetic properties and shapes, IUPAC nomenclature of mononuclear coordination compounds. bonding; isomerism, importance of coordination compounds (in qualitative analysis, extraction of metals and biological systems).

### **Unit-28: Haloalkanes and Haloarenes**

**Haloalkanes:** Nomenclature, nature of C-X bond, physical and chemical properties, mechanism of substitution reactions.

**Haloarenes:** Nature of C-X bond, substitution reactions (directive influence of halogen for monosubstituted compounds only) Uses and environmental effects of - dichloromethane, trichloromethane, tetrachloromethane, iodoform, freons, DDT.

### **Unit-29: Alcohols, Phenols and Ethers**

**Alcohols:** Nomenclature, methods of preparation, physical and chemical properties (of primary alcohols only); identification of primary, secondary and tertiary alcohols; mechanism of dehydration, uses of methanol and ethanol. **Phenols:** Nomenclature, methods of preparation, physical and chemical properties, acidic nature of phenol, electrophilic substitution reactions, uses of phenols. **Ethers:** Nomenclature, methods of preparation, physical and chemical properties, uses.

### **Unit-30: Aldehydes, Ketones and Carboxylic Acids**

**Aldehydes and Ketones:** Nomenclature, nature of carbonyl group, methods of preparation, physical and chemical properties mechanism of nucleophilic addition, reactivity of alpha hydrogen in aldehydes; uses.

**Carboxylic Acids:** Nomenclature, acidic nature, methods of preparation, physical and chemical properties; uses.

### **Unit-31: Organic compounds containing Nitrogen**

**Amines:** Nomenclature, classification, structure, methods of preparation, physical and chemical properties, uses, identification of primary, secondary and tertiary amines.

**Cyanides and Isocyanides** - will be mentioned at relevant places in context.

**Diazonium salts:** Preparation, chemical reactions and importance in synthetic organic chemistry.

### **Unit-32: Biomolecules**

**Carbohydrates-** Classification (aldoses and ketoses), monosaccharide (glucose and fructose), oligosaccharides

(sucrose, lactose, maltose), polysaccharides (starch, cellulose, glycogen); importance.

Proteins - Elementary idea of  $\alpha$ -amino acids, peptide bond, polypeptides, proteins, structure of amines-primary, secondary, tertiary structure and quaternary structures (qualitative idea only), denaturation of proteins; enzymes.

**Vitamins** - Classification and functions.

**Nucleic Acids:** DNA and RNA.

### **Unit-33: Polymers**

copolymerization. Some important polymers: natural and synthetic like polythene, nylon, polyesters, Bakelite, rubber.

### **Unit-34: Environmental Chemistry**

Environmental pollution - air, water and soil pollution, chemical reactions in atmosphere, smog, major atmospheric pollutants; acid rain, ozone and its reactions, effects of depletion of ozone layer, greenhouse effect and global warming - pollution due to industrial wastes; green chemistry as an alternative tool for reducing pollution, strategy for control of environmental pollution.

### **Unit-35: Chemistry in Everyday life**

1. **Chemicals in medicines** - analgesics, tranquilizers, antiseptics, disinfectants, antimicrobials, antifertility drugs, antibiotics, antacids, antihistamines.
2. **Chemicals in food** - preservatives, artificial sweetening agents.

**Cleansing agents** - soaps and detergents, cleansing action.

## **BIOLOGY (BOTANY AND ZOOLOGY)**

### **Unit: 1 The Living World**

Nature and scope of Biology. Methods of Biology. Our place in the universe. Laws that govern the universe and life. Level of organization. Cause and effect relationship.

Being alive. What does it mean? Present approaches to understand life processes, molecular approach; life as an expression of energy; steady state and homeostasis; self-duplication and survival; adaptation; death as a positive part of life.

Origin of life and its maintenance. Origin and diversity of life. Physical and chemical principles that maintain life processes. The living crust and interdependence. The positive and negative aspects of progress in biological sciences. The future of the living world, identification of human responsibility in shaping our future.

### **Unit: 2 Unit of Life**

Cell as a unit of life. Small biomolecules; water, minerals, mono and oligosaccharides, lipids, amino acids, nucleotides and their chemistry, cellular location and function. Macromolecules in cells - their chemistry, cellular location and functional significance. Polysaccharides, proteins and nucleic acids. Enzymes; chemical nature, classification, mechanism in action-enzyme complex, allosteric modulation (brief), irreversible activation. Bio membranes; Fluid mosaic model of membrane, role in transport, recognition of external information (brief). Structural organization of the cell; light and electron microscopic views of cell, its organelles and their functions; nucleus mitochondria, chloroplasts, endoplasmic reticulum. Golgi complex, lysosomes, microtubules, cell wall, cilia and flagella, vacuoles, cell inclusions. A general account of cellular respiration. Fermentation, biological oxidation (A cycle outline), mitochondrial electron transport chain, high energy bonds and oxidative phosphorylation, cell reproduction; Process of mitosis and meiosis.

### **Unit: 3 Diversity of Life**

Introduction. The enormous variety of living things, the need for classification to cope with this variety; taxonomy and phylogeny; shortcomings of a two-kingdom classification as plants and animals; the five-kingdom

classification, Monera, Protista, Plantae, Fungi and Animalia; the basic features of five kingdom classification. modes of obtaining nutrition-autotrophs and heterotrophs. Life style producers, consumers and decomposers. Unicellularity and multicellularity, phylogenetic

binomial nomenclature; principles of classification and nomenclature; identification and nature of viruses and bacteriophages; kingdom Monera-archaebacteria - life in extreme environments; Bacteria, Actinomycetes, Cyanobacteria. Examples & illustration of autotrophic and heterotrophic life; mineralizes-nitrogen fixers; Monera in cycling matter; symbiotic forms; disease producers. Kingdom Protista-Eukaryotic unicellular organisms, development of flagella and cilia; beginning of mitosis; syngamy and sex. Various life styles shown in the major phyla. Evolutionary precursors of complex life forms. Diatoms, dinoflagellates, slime moulds, protozoans; symbiotic forms. Plant kingdom- complex autotrophs, red brown and green algae; conquest of land, bryophytes, ferns, gymnosperms and angiosperms. Vascularization; development of flower, fruit and seed. Kingdom fungi-lower fungi (Zygomycetes), higher fungi (Ascomycetes and Basidiomycetes); the importance of fungi. Decomposers; parasitic forms; lichens and mycorrhizae. Animal kingdom-animal body pattern and symmetry. The development of body cavity in invertebrate vertebrate physia. Salient features with reference to habitat and example of phylum porifera, coelenterata, helminthis, annelids, mollusca, arthropoda, echinoderms; chordata - (classes-fishes, amphibians, reptiles, birds and mammals) highlighting major characters.

#### **Unit: 4 Organisms and Environment**

Species: Origin and concept of species population, interaction between environment and population community. Biotic community, interaction between different species, biotic stability. Changes in the community. Succession. Ecosystem; interaction between biotic and abiotic components; major ecosystems, manmade ecosystem-Agro ecosystem. Biosphere; flow of energy, trapping of solar energy, energy pathway, food chain, food web, biogeochemical cycles, calcium and Sulphur, ecological imbalance and its consequences. Conservation of natural resources; renewable and non- renewable (in brief). Water and land management, wasteland development. Wild life and forest conservation; causes for the extinction of some wild life, steps taken to conserve the remaining species, concept of endangered species-Indian examples, conservation of forests; Indian forests, importance of forests, hazards of deforestation, concept of afforestation. Environmental pollution; air and water pollution, sources, major pollutants of big cities of our country, their effects and methods of control, pollution due to nuclear fallout and waste disposal, effect and control, noise pollution; sources and effects.

#### **Unit: 5 Multicellularity : Structure and Function - Plant Life**

Form and function. Tissue system in flowering plants; meristematic and permanent. Mineral nutrition- essential elements, major functions of different elements, passive and active uptake of minerals. Modes of nutrition, transport of solutes and water in plants. Photosynthesis; photochemical and biosynthetic phases, diversity in photosynthetic pathways, photosynthetic electron transport and photophosphorylation, photorespiration. Transpiration and exchange of gases. Stomatal mechanism. Osmoregulation in plants: water relations in plant cells, water potential. Reproduction and development in Angiosperms; asexual and sexual reproduction. Structure and functions of flower: development of male and female gametophytes in angiosperms, pollination, fertilization and development of endosperm, embryo seed and fruit. Differentiation and organ formation. Plant hormones and growth regulation; action of plant hormones in relation to seed dormancy and germination, apical dominance, senescence and abscission. Applications of synthetic growth regulators. A brief account of growth and movement in plants.

#### **Unit: 6 Multicellularity: Structure and Function - Animal Life**

Animal tissues, epithelial, connective, muscular, nerve. Animal nutrition, organs of digestion and digestive process, nutritional requirements for carbohydrates, proteins, fats, minerals and vitamins; nutritional imbalances and deficiency diseases. Gas exchange and transport: Pulmonary gas exchange and organs involved, transport of gases in blood, gas exchange in aqueous media circulation: closed and open vascular systems, structure and pumping action of heart, arterial blood pressure, lymph. Excretion and osmoregulation. Ammonotelism, Ureotelism, ureotelism, excretion of water and urea with special reference to man. Role of kidney in regulation of plasma, osmolarity on the basis of nephron structure, skin and lungs in excretion. Hormonal coordination; hormones of mammals, role of hormones as messengers and regulators. Nervous coordination, central autonomic and peripheral

nervous systems, receptors, effectors, reflex action, basic physiology of special senses, integrative control by neuroendocrinal systems. Locomotion: joints, muscle movements, types of skeletal muscles according to types of movement, basic aspects of human skeleton. Reproduction; human reproduction, female reproductive cycles. Embryonic development in mammals (up to three germs layers), growth, repair and ageing.

### **Unit: 7 Continuity of Life**

Heredity and variation: Introduction, Mendel's experiments with peas and concepts of factors. Mendel's laws of inheritance. Genes: Packaging of heredity material in prokaryotes-bacterial chromosome and plasmid; and eukaryote chromosomes. Extranuclear genes, viral genes. Linkage (genetic) maps. Sex determination and sex linkage. Genetic material and its replication, gene manipulation. Gene expression; genetic code, transcription, translation, gene regulation. Molecular basis of differentiation.

### **Unit: 8 Origin and Evolution of Life**

Origin of life: living and non-living, chemical evolution, organic evolution; Oparin ideas, Miller-Urey experiments. Interrelationship among living organisms and evidences of evolution: fossil records including geological scale, Morphological evidence - hematology, vestigial organs, embryological similarities and biogeographical evidence.

Darwin's two major contributions. Common origin of living organisms and recombination as source of variability, selection and variation, adaptation (Lederberg's replica plating experiment for indirect selection of bacterial mutants), reproductive isolation, speciation. Role of selection, change and drift in determining composition of population. Selected examples: industrial melanism; drug resistance, mimicry, malaria in relation to G-6-PD deficiency and sickle cell disease. Human evolution: Palaeontological evidence, man's place among mammals. Brief idea of Dryopithecus, Australopithecus, *Homo erectus*, *H. neanderthlensis*, Cro-Magnon man and *Homo sapiens*. Human chromosomes, similarity in different racial groups. Comparison with chromosomes of non-human primates to indicate common origin; Cultural vs. biological evolution.

Mutation: origin and types of mutation, their role in speciation.

### **Unit: 9 Application of Biology**

Introduction, role of biology, in the amelioration of human problems. Domestication of plant- a historical account, improvement of crop plants; Principles of plant breeding and plant introduction. Use of fertilizers, their economic and ecological aspects.

Use of pesticides: advantages and hazards. Biological methods of pest control. Crops today. Current concerns, gene pools and genetic conservation. Underutilized crops with potential uses of oilseeds, medicines, beverages, spices, fodder, new crops-Leucaena (Subabul), Jojoba, Guayule, winged bean, etc. Biofertilizers - green manure, crop residues and nitrogen fixation (symbiotic, non-symbiotic). Applications of tissue culture and genetic engineering in crops. Domestication and introduction of animals. Livestock, poultry, fisheries (fresh water, marine, aquaculture). Improvement of animals: principles of animal breeding. Major animal diseases and their control. Insects and their products (silk, honey, wax and lac). Bioenergy-biomass, wood (combustion; gasification, ethanol). Cow dung cakes, gobar gas, plants as sources of hydrocarbons for producing petroleum, ethanol from starch and lignocellulose. Biotechnology, application in health and agriculture, genetically modified (GM) organisms, bio-safety issues. A brief historical account-manufacture of cheese, yoghurt, alcohol, yeast, vitamins, organic acids, antibiotics, steroids, dextrans. Scaling up laboratory findings to Industrial production, sewage treatment. Production of insulin, human growth hormones, interferon. Communicable diseases including STD and diseases spread through 'blood transfusion (hepatitis, AIDS, etc.) Immune response, vaccine and antisera. Allergies and Inflammation. Inherited diseases and dysfunctions, sex-linked diseases, genetic incompatibilities, and genetic counseling. Cancer-major types, causes, diagnosis and treatment. Tissue and organ transplantation. Community health services and measures; blood banks; mental health, smoking, alcoholism and drug addiction-physiological symptoms and control measures. Industrial wastes, toxicology, pollution-related diseases. Biomedical engineering - spare parts for man, instruments for diagnosis of diseases and care. Human population related diseases. Human population, growth, problems and control, inequality between sexes, control measures; test-tube babies aminocentesis. Future of Biology.

## MATHEMATICS

### Unit-1: Sets and Functions

- Sets:** Sets and their representations. Empty set. Finite & Infinite sets. Equal sets. Subsets, Subsets of the set of real numbers especially intervals (with notations). Power set. Universal set. Venn diagrams. Union and Intersection of sets. Difference of sets. Complement of a set.
- Relations & Functions:** Ordered pairs, Cartesian product of sets. Number of elements in the cartesian product of two finite sets. Cartesian product of the reals with itself (upto  $\mathbb{R} \times \mathbb{R} \times \mathbb{R}$ ). Definition of relation, Types of relations: reflexive, symmetric, transitive and equivalence relations. One to one and onto functions, composite functions, inverse of a function. Binary operations, Pictorial representation of a function, domain. Co-domain and range of a relation. Function as a special kind of relation from one set to another. Real valued function of the real variable, domain and range of these functions, constant, identity, polynomial, rational, modulus, signum and greatest integer functions with their graphs. Sum, difference, product and quotients of functions.
- Trigonometric Functions:** Positive and negative angles. Measuring angles in radians & in degrees and conversion from one measure to another. Definition of trigonometric functions with the help of unit circle. Truth of the identity  $\sin^2 x + \cos^2 x = 1$ , for all  $x$ . Signs of trigonometric functions and sketch of their graphs. Expressing  $\sin(x+y)$  and  $\cos(x+y)$  in terms of  $\sin x$ ,  $\sin y$ ,  $\cos x$  &  $\cos y$ . Deducing the identities like the following:

$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \pm \tan x \tan y}, \quad \cot(x \pm y) = \frac{\cot x \cot y \pm 1}{\cot y \pm \cot x}$$

$$\cos x + \cos y = 2 \cos \frac{x+y}{2} \cos \frac{x-y}{2}$$

$$\sin x - \sin y = 2 \cos \frac{x+y}{2} \sin \frac{x-y}{2} \quad \cos x - \cos y = -2 \sin \frac{x+y}{2} \sin \frac{x-y}{2}$$

Identities related to  $\sin 2x$ ,  $\cos 2x$ ,  $\tan 2x$ ,  $\sin 3x$ ,  $\cos 3x$  and  $\tan 3x$ . General solution of trigonometric equations of the type  $\sin \theta = \sin \alpha$ ,  $\cos \theta = \cos \alpha$  and  $\tan \theta = \tan \alpha$ .

**Inverse Trigonometric Functions:** Definition, range, domain, principal value branches. Graphs of inverse trigonometric functions. Elementary properties of inverse trigonometric functions.

Properties of triangles, including centroid, incentre, circum-centre and orthocentre, Solution of triangles. Heights and Distances.

### Unit-2: Algebra

- Principle of Mathematical Induction:** Processes of the proof by induction, motivating the application of the method by looking at natural numbers as the least inductive subset of real numbers. The principle of mathematical induction and simple applications.
- Complex Numbers and Quadratic Equations:** Need for complex numbers, especially  $-1$ , to be motivated by inability to solve every quadratic equation. Brief description of algebraic properties of complex numbers. Argand plane and polar representation of complex numbers. Statement of Fundamental Theorem of Algebra, solution of quadratic equations in the complex number system.
- Linear Inequalities:** Linear inequalities. Algebraic solutions of linear inequalities in one variable and their representation on the number line. Graphical solution of linear inequalities in two variables. Solution of system of linear inequalities in two variables- graphically.
- Permutations & Combinations:** Fundamental principle of counting. Factorial  $n$ . ( $n!$ ). Permutations and combinations, derivation of formulae and their connections, simple applications.
- Binomial Theorem:** History, statement and proof of the binomial theorem for positive integral indices. Pascal's triangle, General and middle term in binomial expansion, simple applications.
- Sequence and Series:** Sequence and Series. Arithmetic progression (A.P.). arithmetic mean (A.M.) Geometric progression (G.P.), general term of a G.P., sum of  $n$  terms of a G.P., geometric mean (G.M.), relation between A.M. and G.M. Sum to  $n$  terms of the special series  $\sum n$ ,  $\sum n^2$  and  $\sum n^3$ .

- 7. Matrices:** Concept, notation, order, equality, types of matrices, zero matrix, transpose of a matrix, symmetric and skew symmetric matrices. Addition, multiplication and scalar multiplication of matrices, simple properties of addition, multiplication and scalar multiplication. Non-commutativity of multiplication of matrices and existence of non-zero matrices whose product is the zero matrix (restrict to square matrices of order 2). Concept of elementary row and column operations. Invertible matrices and proof of the uniqueness of inverse, if it exists.

**Determinants:** Determinant of a square matrix (up to 3 x 3 matrices), properties of determinants, minors, cofactors and applications of determinants in finding the area of a triangle. Adjoint and inverse of a square matrix. Consistency, inconsistency and number of solutions of system of linear equations by examples, solving system of linear equations in two or three variables (having unique solution) using inverse of a matrix.

### Unit-3: Coordinate Geometry

- 1. Straight Lines:** Slope of a line and angle between two lines. Various forms of equations of a line: parallel to axes, point-slope form, slope-intercept form, two-point form, intercepts form and normal form. General equation of a line. Distance of a point from a line.
- 2. Conic Sections:** Sections of a cone: circle, ellipse, parabola, hyperbola, a point, a straight line and pair of intersecting lines as a degenerated case of a conic section. Standard equations and simple properties of parabola, ellipse and hyperbola. Standard equation of a circle.

**Introduction to Three-dimensional Geometry:** Coordinate axes and coordinate planes in three dimensions. Coordinates of a point. Distance between two points and section formula.

### Unit-4: Calculus

- 1. Limits and Derivatives:** Derivative introduced as rate of change both as that of distance function and geometrically, intuitive idea of limit. Definition of derivative, relate it to slope of tangent of the curve, derivative of sum, difference, product and quotient of functions. Derivatives of polynomial and trigonometric functions.
- 2. Continuity and Differentiability:** Continuity and differentiability, derivative of composite functions, chain rule, derivatives of inverse trigonometric functions, derivative of implicit function. Concept of exponential and logarithmic functions and their derivative. Logarithmic differentiation. Derivative of functions expressed in parametric forms. Second order derivatives. Rolle's and Lagrange's Mean Value Theorems (without proof) and their geometric interpretations.
- 3. Applications of Derivatives:** Applications of derivatives: rate of change, increasing/decreasing functions, tangents & normal, approximation, maxima and minima (first derivative test motivated geometrically and second derivative test given as a provable tool). Simple problems.
- 4. Integrals:** Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts; only simple integrals of the type to be evaluated. Definite integrals as a limit of a sum, Fundamental Theorem of Calculus (without proof). Basic properties of definite integrals and evaluation of definite integrals.

$$\int \frac{dx}{x^2 \pm a^2} \quad \int \frac{dx}{\sqrt{x^2 \pm a^2}} \quad \int \frac{dx}{\sqrt{a^2 - x^2}} \quad \int \frac{dx}{ax^2 + bx + c} \quad \int \frac{dx}{\sqrt{ax^2 + bx + c}} \quad \int \frac{(px + q)}{ax^2 + bx + c} dx$$

$$\int \frac{(px + q)}{\sqrt{ax^2 + bx + c}} dx \quad \int \sqrt{a^2 \pm x^2} dx \quad \text{and} \quad \int \sqrt{x^2 - a^2} dx$$

- 5. Applications of the Integrals:** Applications in finding the area under simple curves, especially lines, areas of circles/ parabolas/ellipses (in standard form only), area between the two above said curves.
- 6. Differential Equations:** Definition, order and degree, general and particular solutions of a differential equation. Formation of differential equation whose general solution is given. Solution of differential equations by method of separation of variables, homogeneous differential equations of first order and first degree. Solutions of linear differential equation of the type:

$$dy + py = q, \text{ where } p \text{ and } q \text{ are functions of } x.$$

## Unit-5: Vectors and Three-Dimensional Geometry

1. **Vectors:** Vectors and scalars, magnitude and direction of a vector. Direction cosines/ratios of vectors. Types of vectors (equal, unit, zero, parallel and collinear vectors), position vector of a point, negative of a vector, components of a vector, addition of vectors, multiplication of a vector by a scalar, position vector of a point dividing a line segment in a given ratio. Scalar (dot) product of vectors, projection of a vector on a line. Vector (cross) product of vectors.
2. **Three-dimensional Geometry:** Direction cosines/ratios of a line joining two points. Cartesian and vector equation of a line, coplanar and skew lines, shortest distance between two lines. Cartesian and vector equation of a plane. Angle between (i) two lines, (ii) two planes. (iii) a line and a plane. Distance of a point from a plane.

## Unit-6: Linear Programming

**Linear Programming:** Introduction, definition of related terminology such as constraints, objective function, optimization, different types of linear programming (L.P.) problems, mathematical formulation of L.P. problems, graphical method of solution for problems in two variables, feasible and infeasible regions, feasible and infeasible solutions, optimal feasible solutions (up to three non-trivial constraints).

## Unit-7: Mathematical Reasoning

**Mathematical Reasoning:** Mathematically acceptable statements. Connecting words/ phrases - consolidating the understanding of “if and only if (necessary and sufficient) condition”, “implies”, “and/or”, “implied by”, “and”, “or”, “there exists” and their use through variety of examples related to real life and Mathematics. Validating the statements involving the connecting words, difference between contradiction, converse and contrapositive.

## Unit-8: Statistics & Probability

1. **Statistics:** Measures of central tendency, mean, median and mode from ungrouped/grouped data. Measures of dispersion, mean deviation, variance and standard deviation from ungrouped/grouped data. Correlation, regression lines.
2. **Probability:** Random experiments: outcomes, sample spaces (set representation). Events: occurrence of events, ‘not’, ‘and’ and ‘or’ events, exhaustive events, mutually exclusive events Axiomatic (set theoretic) probability, Probability of an event, probability of ‘not’, ‘and’ & ‘or’ events. Multiplication theorem on probability. Conditional probability, independent events, total probability, Bayes’ theorem, Random variable and its probability distribution, mean and variance of stochastic variable. Repeated independent (Bernoulli) trials and Binomial distribution.

## Unit-9: Statics

Introduction, basic concepts and basic laws of mechanics, force, resultant of forces acting at a point, parallelogram law of forces, resolved parts of a force, Equilibrium of a particle under three concurrent forces. Triangle law of forces and its converse, Lami’s theorem and its converse, Two Parallel forces, like and unlike parallel forces, couple and its moment.

## Unit-10: Dynamics

Speed and velocity, average speed, instantaneous speed, acceleration and retardation, resultant of two velocities. Motion of a particle along a line, moving with constant acceleration. Motion under gravity. Laws of motion, Projectile motion.

## AGRICULTURE

### Unit-1: Agrometeorology, Genetics and Plant Breeding, Biochemistry and Microbiology

**Agrometeorology:** Elements of Weather-rainfall, temperature, humidity, wind velocity, Sunshine weather forecasting, climate change in relation to crop production.

**Genetics & Plant Breeding:** (a) Cell and its structure, cell division-mitosis and meiosis and their significance (b) Organization of the genetic materials in chromosomes, DNA and RNA (c) Mendel's laws of inheritance. Reasons for the success of Mendel in his experiments, Absence of linkage in Mendel's experiments. (d) Quantitative inheritance, continuous and discontinuous variation in plants. (e) Monogenic and polygenic inheritance. (f) Role of Genetics in Plant breeding, self and cross-pollinated crops, methods of breeding in field crops-introduction, selection, hybridization, mutation and polyploidy, tissue and cell culture. (g) Plant Biotechnology-definition and scope in crop production.

**Biochemistry:** pH and buffers, Classification and nomenclature of carbohydrates; proteins; lipids; vitamins and enzymes.

**Microbiology:** Microbial cell structure, Micro-organisms- Algae, Bacteria, Fungi, Actinomycetes, Protozoa and Viruses. Role of micro-organisms in respiration, fermentation and organic matter decomposition

## **Unit-2: Livestock Production**

**Scope and importance:** (a) Importance of livestock in agriculture and industry, White revolution in India. (b) Important breeds Indian and exotic, distribution of cows, buffaloes and poultry in India.

**Care and management:** (a) Systems of cattle and poultry housing (b) Principles of feeding, feeding practices.

Balanced ration-definition and ingredients. (d) Management of calves, bullocks, pregnant and milch animals as well as chicks' cockerels and layers, poultry. (e) Signs of sick animals, symptoms of common diseases in cattle and poultry, Rinderpest, black quarter, foot and mouth, mastitis and hemorrhagic septicaemia, Malignant catarrhal fever, Fowl pox and Rani khet disease, their prevention and control.

**Artificial Insemination:** Reproductive organs, collection, dilution and preservation of semen and artificial insemination, **role of artificial insemination in cattle improvement. Livestock Products:** Processing and marketing of milk and Milk products.

## **Unit-3: Crop Production**

**Introduction:** (a) Targets and achievements in food grain production in India since independence and its future projections, sustainable crop production, commercialization of agriculture and its scope in India. (b) Classification of field crops based on their utility-cereals, pulses, oilseeds, fiber, sugar and forage crops.

**Soil, Soil fertility, Fertilizers and Manures:** (a) Soil, soil pH, Soil texture, soil structure, soil organisms, soil tillage, soil fertility and soil health. (b) Essential plant nutrients, their functions and deficiency symptoms. (c) Soil types of India and their characteristics. (d) Organic manure, common fertilizers including straight, complex, fertilizer mixtures and biofertilizers; integrated nutrient management system.

**Irrigation and Drainage:** (a) Sources of irrigation (rain, canals, tanks, rivers, wells, tube wells). (b) Scheduling of irrigation based on critical stages of growth, time interval, soil moisture content and weather parameters. (c) Water requirement of crops. (d) Methods of irrigation and drainage. (e) Watershed management

**Weed Control:** Principles of weed control, methods of weed control (cultural, mechanical, chemical, biological and Integrated weed management).

**Crops:** Seed bed preparation, seed treatment, time and method of sowing/planting, seed rate; dose, method and time of fertilizer application, irrigation, interculture and weed control; common pests and diseases, caused by bacteria, fungi virus and nematode and their control, integrated pest management, harvesting, threshing, post-harvest technology: storage, processing and marketing of major field crops-Rice, wheat, maize, sorghum, pearl millet, groundnut, mustard, pigeon-pea, gram, sugarcane, cotton and berseem.

## **Unit-4: Horticulture**

(a) Importance of fruits and vegetables in human diet, Crop diversification & processing Industry. (b) Orchard- location and layout, ornamental gardening and kitchen garden. (c) Planting system, training, pruning,

intercropping, protection *from frost* and sunburn. (d) Trees, shrubs, climbers, annuals, perennials-definition and examples. Propagation by seed, cutting, budding, layering and grafting. (e) Cultivation practices, processing and marketing of: (i) Fruits - mango, papaya, banana, guava, citrus, grapes. (ii) Vegetables - Radish, carrot, potato, onion, cauliflower, brinjal, tomato, spinach and cabbage. (iii) Flowers - Gladiolus, canna, chrysanthemums, roses and marigold. (f) Principles and methods of fruit and vegetable preservation.

(g) Preparation of jellies, jams, ketchup, chips and their packing.

**Note: Besides above syllabi, any other question of scientific and educational importance may be asked.**

## **ANNEXURE II: SYLLABUS FOR ICAR'S ALL INDIA ENTRANCE EXAMINATION FOR ADMISSION TO MASTER DEGREE PROGRAMMES AND ICAR-PG SCHOLARSHIP/NTS (PGS)**

### **Code 01: MAJOR SUBJECT GROUP - PLANT BIOTECHNOLOGY**

**(Sub-Subjects: 1.1:** Plant Biochemistry/ Bio. Chem. **1.2:** Plant Biotechnology & Molecular Biology/ Biotechnology, **1.3:** Plant /Crop Physiology)

**UNIT-I:** Importance of agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato, and mango. Major soils of India; role of NPK and their deficiency symptoms. General structure and function of cell organelles; mitosis and meiosis; Mendelian genetics. Elementary knowledge of growth, development, photosynthesis, respiration and transpiration; Elements of economic botany. General structure and function of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Major pests and diseases of rice, wheat, cotton, chickpea, sugarcane and their management. Organic farming; bio-fertilizers; bio-pesticides. Recombinant DNA technology; transgenic crops. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India. Elements of statistics.

**UNIT-II:** Importance of biochemistry in agriculture. Acid-base concept and buffers; pH.

Classification, structure and metabolic functions of carbohydrates, lipids and proteins. Structure and function of nucleic acids. Enzymes: structure, nomenclature, mechanism of action; vitamins and minerals as coenzymes and cofactors. Metabolic pathways: glycolysis, TCA cycle, fatty acid oxidation, triglyceride biosynthesis. Electron transport chain; ATP formation. Photosynthesis: C-3, C-4 and CAM pathways. Nitrate assimilation; biological nitrogen fixation. Colorimetric and chromatographic techniques

**UNIT-III:** Characteristics of prokaryotic and eukaryotic organisms; differences between fungi, bacteria, mycoplasmas and viruses. Physical and chemical basis of heredity; chromosome structure. DNA replication, transcription and translation; genetic code; operon concept. Genetic engineering; restriction enzymes; vectors; gene cloning; gene transfer. Plant cell and tissue culture; micro-propagation; somaclonal variation. Transformation; recombination; Heterosis. General application of biotechnology. Molecular and immunological techniques. Concept of bioinformatics, genomics and proteomics.

**UNIT-IV: Plant Physiology/ Crop Physiology:** Plant physiology– importance in agriculture. Seed germination, viability and vigour. Photosynthesis- significance of C-3, C-4 and CAM pathway; photorespiration and its implications. Translocation of assimilates; dry matter partitioning; Harvest index of crops. Growth and development; growth analysis; crop-water relationship. Plant nutrients and their functions. Phytohormones and their physiological role. Photo-periodism, vernalisation; pollination/ fertilization in flowering plants. Post-harvest physiology and its significance.

### **Code 02: MAJOR SUBJECT GROUP - PLANT SCIENCES**

**(Sub-Subjects: 2.1:** Plant Breeding & Genetics, **2.2:** Plant Pathology, **2.3:** Agricultural Microbiology /Microbiology, **2.4:** Seed Science & Technology, **2.5:** Plant Genetic Resources)

**UNIT-I:** Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato, potato and mango. Major soils of India, role of NPK and their deficiency symptoms.

**UNIT-II:** Structure and function of cell organelles; mitosis and meiosis; Mendelian genetics; elementary knowledge of photosynthesis; respiration, and transpiration; structure and functions of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Major pests and diseases of rice, wheat, cotton, chickpea, sugarcane and their management.

**UNIT-III:** Characteristics of prokaryotic and eukaryotic organisms, differences between fungi, bacteria, mycoplasmas and viruses; physical and chemical basis of heredity; chromosome structure; genes/operon concept;

protein biosynthesis; transformation, recombination, Heterosis; Elements of economic botany; integrated diseases management; sterilisation, disinfection and pasteurization; Koch's postulates; etiological agents of rusts, smuts, powdery/downy mildews, wilts, yellows, mosaic, necrosis, enations, blights and witches- broom; pH, buffer, vitamins, role of plant hormones in seed germination and dormancy; pollination/ fertilization in flowering plants; methods of seed testing; breeders, foundation and certified seeds; seed production in self and cross pollinated crops, nitrate assimilation; biological nitrogen fixation and other uses of microorganisms in agriculture.

**UNIT-IV:** Food and industry; composting and biogas production. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India.

### **Code 03: MAJOR SUBJECT GROUP - PHYSICAL SCIENCE**

**(Sub-Subjects: 3.1:** Agricultural / Agro. Meteorology **3.2:** Soil Science & Agricultural Chemistry/ Soil Conservation and Water Management/ SWC/ Irrigation and Water Management, **3.3:** Agricultural Physics, **3.4:** Agricultural Chemicals, **3.5:** Environmental Science.)

**UNIT-I:** Importance of Agriculture in national perspective; basic principles of crop production, diversification, diversification of Agriculture, principle of nutrient and water management, package of practices for rice, wheat sorghum, maize, chickpea, pigeon pea, potato, sugarcane, groundnut, major vegetable crops. Role of essential plant nutrients, their deficiency symptoms and management options. Structure and function of plant cells, cell division, Basic concept of plant physiology relating to crop production- Biochemical compounds viz, carbohydrates, proteins, enzymes, fats, liquid vitamins and their function, developmental programmes relating to rural upliftment and livelihood security; organizational set up of agricultural education research and extension and future strategies for up gradation.

**UNIT-II:** Volumetric and gravimetric analysis including complexometric methods, periodic classification of element, Basic principle of instrumental analysis including Spectro-photometry (Absorption and emission spectrography), Atomic structure –elementary concept of radioactivity, element and compound common ion effect, solubility product— hydrolysis of salts, buffer solution indicates equivalent weights and standard solution.

Elementary concepts of organic compounds- nomenclature and classifications including hydrocarbons, alcohol, aldehydes, acids and esters, carbohydrates, fats and liquids, amino acids, nucleic acids. Pesticides, their classification and uses; biopesticides and botanical pesticides.

**UNIT-III:** Soil as a medium for plant growth, composition of earth's crust, weathering of rocks and minerals, components of soil- their importance, soil profile, soil partials- physical mineralogical and chemical nature. Mechanical analysis, Stokes law, assumptions, limitations and applications. Soil, physical properties- density, porosity, texture, soil structure and their brief descriptions. Rheological properties in soils, calculations of porosity and bulk density. Soil air-Aeration, causes of poor aeration, factors affecting aeration, importance for plant growth. Soil temperature - sources and losses of soil heat. Factors affecting soil temperature, its importance in plant growth. Soil water- structure of water, soil-water-energy relationship, classifications, surface tension and movement in soil. Soil colloids- properties, structure of silicate clay minerals, sources of negative charges, properties, kaolinite, illite, montmorillonite and vermiculite clay minerals, milli-equivalent concept, cation exchange capacity, anion exchange capacity, buffering of soils. Problem soils- acid, saline, sodic and acid sulphate soils – their characteristics, formation, problems and management. Irrigation, water quality and its evaluation. Waterlogged soils- basic features, distinction with upland soils.

**UNIT-IV:** Essential plant nutrients- criteria of essentiality, functions for plant growth, mechanisms for movement and uptake of ions in soils and plants, Forms of nutrients in soils, deficiency symptoms on plants, luxury consumption, nutrient interactions and chelated micronutrients. Soil fertility, evaluation and management for plant growth, soil testing and fertilizer recommendations. Soil classifications- diagnostic surface and sub- surface horizons, soil survey- types, objectives, uses, land capability classifications. Remote sensing and its application in agriculture, SIS, GIS and GPS- basic features and uses in agriculture, Elementary concepts of radio isotopes and uses in agriculture. Soil micro-organisms, Classifications and their roles. Organic matter- decomposition, C:N ratios, mineralization and immobilization processes, humus, role of organic matter in soil quality. Soil erosion,

types and control measures. Fertilizers and manures- classifications, NPK fertilizers, their reactions in soils, green manuring, recycling of organic wastes, composting. Soil and water pollution- sources, brief idea about different pollutants in soils and their managements.

#### **Code 04: MAJOR SUBJECT GROUP - ENTOMOLOGY AND NEMATOLOGY**

(Sub-Subjects: 4.1: Agricultural/ Horticultural Entomology, 4.2: Nematology, 4.3: Apiculture, 4.4: Sericulture, 4.5: Plant Protection.)

**UNIT-I:** Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato, Cole crops, mango, grapes, banana, oilseeds other than groundnut, soybean and mustard. Major soils of India, role of NPK and their deficiency symptoms. Mendelian genetics; elementary knowledge of photosynthesis; respiration, and transpiration; Major cropping systems (rice-wheat cropping, crop rotations, mixed cropping); soil degradation-soil salinity and acidity and management; some aspects of post-harvest technology; varietal improvement; importance of Heterosis in crop production; crop protection principles in field and storage. Major insect pests and diseases of agricultural crops like rice, cotton, pulses, oilseed crops like groundnut, soybean and mustard, vegetables like tomato, Cole crops; fruit crops like mango and banana and their management principles. Transgenic crops. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India; Elements of statistics.

**UNIT-II:** Classification of animal kingdom up to class; distinguishing characters up to orders in class Insecta; general organization of an insect external morphology with special reference to lepidopteran larvae, coleopteran adults; and honeybee; metamorphosis and moulting; different physiological systems; insect- plant relationship; insect pests of agricultural and horticultural crops, and their stored/processed products, insect vectors of plant diseases- identification, biology, nature of damage, and their management tactics; and pests of household, medical and veterinary importance and their control; useful and beneficial insects like honeybee, lac insect, silkworm and pollinators; Nematode taxonomy, biology of important plant parasitic nematodes and their control; entomopathogenic nematodes, basic principles of insect and nematode pest management- cultural, biological, insecticidal, quarantine, and regulatory aspects; insecticide classification and insecticide resistance management; and insect protective transgenic crops.

#### **Code 05: MAJOR SUBJECT GROUP – AGRONOMY**

(Sub-Subjects: 5.1: Agronomy 5.2: Tea Husbandry & Technology)

**UNIT-I:** General: Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, rapeseed and mustard, potato. Major soils of India, role of NPK and their deficiency symptoms. Structure and function of cell organelles; mitosis and meiosis; Mendelian genetics: elementary knowledge of photosynthesis; respiration, photorespiration and transpiration; structure and functions of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Major pests and diseases of rice, wheat, cotton, chickpea, sugarcane and their management. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India; Elements of statistics.

**UNIT-II:** Principles of Agronomy, Crop ecology and geography and Agricultural Meteorology: Agronomy – meaning and scope, National & International agricultural research institutes in India, Agro climatic zones of India, Tillage, crop stand establishment and planting geometry and their effect on crop, Physiological limits of crop yield and variability in relation to ecological optima, organic farming, Precision farming, Integrated farming systems, Principles of field experimentation. Principles of crop ecology and crop adaptation, climate shift and its ecological implications, Agro-ecological regions in India, Geographical distribution of crop plants, Greenhouse effect, Climatic factors and their effect on plant processes and crop productivity, Role of GIS and GPS in agriculture. Weather & climate, Earth's atmosphere, Solar radiation, Atmospheric temperature and global warming. Crops and atmospheric humidity, Weather forecasting.

**UNIT-III:** Field crops: Origin, distribution, economic importance, soil and climatic requirement, varieties, cultural practices and yield of cereals ( rice, wheat, maize, sorghum, pearl millet, minor millets, barley), pulses (chickpea, lentil, peas, Pigeon pea, mungbean, urdbean), oilseeds (groundnut, sesame, soybean, rapeseed & mustard,

sunflower, safflower, linseed), fiber crops (cotton, jute, sun hemp), sugar crops (sugarcane), fodder & forage crops (sorghum, maize, Napier, berseem, Lucerne, oats), medicinal & aromatic plants (menthe, lemon grass and isabgol) and commercial crops (potato, tobacco).

**UNIT-IV:** Weed management: Principles of weed management, Classification, biology and ecology of weeds, crop weed competition and allelopathy, concepts and methods of weed control, Integrated weed management, Classification, formulations, selectivity and resistance of herbicides, Herbicide persistence in soil and plants, Application methods and equipment's, Weed flora shifts in cropping systems, Special and problematic weeds and their management in cropped and non-cropped situations, Weed management in field crops.

**UNIT-V:** Water management: Principles of irrigation, Water resources and irrigation development in India, Water and irrigation requirements, Concepts and approaches of irrigation scheduling, Methods of irrigation, Measurement of irrigation water, application, distribution and use efficiencies, Conjunctive use of water, Irrigation water quality and its management, water management in major field, crops (rice, wheat, maize, groundnut, sugarcane) Agricultural drainage.

**UNIT-VI:** Soil fertility and fertilizer use: Essential plant nutrients and their deficiency symptoms, concept of essentiality of plant nutrients, Indicators of soil fertility and productivity, Fertilizer materials and their availability to plants, slow-release fertilizers, Nitrification inhibitors, Principles and methods of fertilizer application, Integrated nutrient management, site specific nutrient management.

**UNIT-VII:** Dryland Agronomy: Characteristics of Dryland farming and delineation of Dryland tracts, constraints of Dryland farming in India, Types of droughts and their management, contingency crop planning and mid-season corrections for aberrant weather and its recycling. Watershed management.

**UNIT-VIII:** Problem soils: Problem soils and their distribution in India, Characteristics and reclamation of these soils, Crop production techniques in problem soils.

**UNIT-IX:** Sustainable land use systems: Sustainable agriculture: parameters and indicators, Conservation agriculture, safe disposal of agri-industrial waste for crop production, Agro-forestry systems, shifting cultivation, Alternate land use systems, Wastelands and their remediation for crop production.

### **Code 06: MAJOR SUBJECT GROUP - SOCIAL SCIENCES**

**(Sub-Subjects: 6.1: Agricultural Economics, 6.2: Dairy Economics 6.3: Agriculture Extension/Extension Education/ Communication 6.4: Dairy Extension Education)**

**UNIT-I:** Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato and mango. Major soils of India, role of NPK and their deficiency symptoms. Structure and function of cell organelles, mitosis and meiosis; Mendelian genetics; elementary knowledge of photosynthesis; respiration, and transpiration; structure and functions of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Major pests and diseases of rice, wheat, cotton, chickpea, sugarcane and their management. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India; Elements of statistics. Measures of central tendency and dispersion, regression and correlation; concept of probability, sampling techniques and tests of significance.

**UNIT-II:** Theory of consumer behaviors, theory of demand, elasticity of demand, indifference curve analysis, theory of firm, cost curves, theory of supply, price determination, market classification, concept of macroeconomics, money and banking, national income. Agricultural marketing—role, practice, institutions, problems and reforms, role of capital and credit in agriculture, crop insurance, credit institutions, cooperatives, capital formation in agriculture, agrarian reforms, globalization, WTO & its impact on Indian agriculture.

**UNIT-III:** Basic principles of farm management, concept of farming system and economics of farming systems, agricultural production economics—scope and analysis, factor-product relationship, marginal cost and marginal revenue, farm planning and budgeting, Agricultural finance: nature and scope. Time value of money, Compounding and discounting. Agricultural credit: meaning, definition, need, classification. Credit analysis: 4R's, 5C's and 7 P's of credit, repayment plans. History of financing agriculture in India. Commercial banks, nationalization of

commercial banks. Lead bank scheme, regional rural banks, scale of finance. Higher financing agencies, RBI, NABARD, AFC, Asian Development Bank, World Bank, role of capital and credit in agriculture; credit institutions, co-operatives and agrarian reforms in India.

**UNIT-IV:** Extension Education- concept, meaning, principles, philosophy, scope and importance; Extension programme planning and evaluation- steps and principles, models of organizing agricultural extension; historical development of extension in USA, Japan and India. Rural development, meaning, importance and problems; Rural development programmes in India- Pre-independence era to recent ones; Extension teaching methods, definition and concept of sociology, differences between rural & urban communities, social stratification., social groups, social organization and social change. Rural leadership, educational psychology- learning and teaching, role of personality in agricultural extension Indian rural system- its characteristics; value system, cost and class; structure and customs; rural group organization and adult education.

**UNIT-V:** Communication, principles, concepts, process, elements and barriers in teaching methods. Different kinds of communication methods and media and AV aids/materials. Media mix, Campaign, Cyber extension- internet, cybercafé, Kisan Call Centers, teleconferencing, agriculture journalism, diffusion and adoption of innovations- adopter categories, capacity building of extension personnel and farmers- training to farmers, women and rural youth.

### **Code 07: MAJOR SUBJECT GROUP - STATISTICAL SCIENCES**

**(Sub-Subjects: 7.1: Agricultural Statistics, 7.2: Computer Application, 7.3: Bioinformatics)**

**UNIT-I:** Agriculture: Importance of Agriculture/Forestry/Livestock in national economy. Basic principles of crop production.

Major diseases and pests of crops. Elementary principles of economics and agri-extension. Important rural development programmes in India. Organizational set up of Agricultural research, education and extension in India.

**UNIT-II:** Mathematics: Real and complex numbers; polynomial and roots; de Moivre's theorem and its applications.

Elements of set theory- De Morgan's laws; vector space, linear independence, orthogonality; matrices- addition and multiplication, rank of a matrix, determinants, inverse of a matrix, solution of a system of linear equations, characteristic roots and vectors; convergence of infinite sequences and infinite series- tests for convergence, absolute convergence; co-ordinate geometry in two dimensions - line, circle, parabola, ellipse and hyperbola.

Differential calculus: limits, differentiation of function of a single variable; Taylor's and Maclaurin's theorems, mean-value theorem; maxima and minima; indeterminate form; curvature, asymptotes, tracing of curves, function of two or more independent variables, partial differentiation, homogeneous functions and Euler's theorem, composite functions, total derivatives, derivative of an implicit function, change of variables, Jacobians. Integral calculus: integration by simple methods, standard forms, simple definite integrals, double integrals, change of order of integration, Gamma and Beta functions, application of double integrals to find area. Ordinary differential equations: differential equations of first order, Exact and Bernoulli's differential equations, equations reducible to exact form by integrating factors, equations of first order and higher degree, Clairaut's equation, methods of finding complementary functions and particular integrals.

Calculus of finite differences, interpolation; numerical differentiation and integration, difference equations; solution of simple non-linear equations by numerical methods like Newton- Raphson method.

**UNIT-III:** Introduction: Statistics – definition, use and limitations; Frequency Distribution and Curves; Measures of Central Tendency: Arithmetic mean; Geometric mean, Harmonic mean, Median, Mode; Measures of Dispersion: Range, Mean deviation, Quartile deviation, Variance and Coefficient of Variation; Probability: Definition and concepts, law of addition and multiplication, conditional probability, Bayes' theorem; Binomial, multinomial, Poisson and normal distribution; Introduction to Sampling: Random Sampling; Standard Error; Tests of Significance - Types of Errors, Null Hypothesis, Level of Significance, Testing of hypothesis; Large Sample Test- SND test for Means, Single Sample and Two Samples; Student's t-test for Single Sample, Two Samples and Paired t test. F test;

Chi-Square Test for goodness of fit and independence of attributes; Correlation and Regression and associated tests of significance. Experimental Designs: basic principles, Analysis of variance, Completely Randomized Design (CRD), Randomized Block Design (RBD).

**UNIT-IV:** Computers: input, output devices, memory, hardware, software; Classification, booting computer. Viruses, worms and antivirus. Operating System- some DOS commands, FORMAT, DIR, COPY, PATH, MD, CD and DELTREE. Types of files. WINDOWS: Desktop and its elements, WINDOWS Explorer, working with files and folders; setting time and date. Anatomy of WINDOWS. Applications – MSWORD: Word processing features- Creating, Editing, Formatting and Saving; MSEXCEL: Electronic spreadsheets, concept, packages. Creating, editing and saving a spreadsheet. In-built statistical and other functions. Excel data analysis tools, Correlation and regression, t-test for two-samples and ANOVA with one-way classification. Creating graphs. MS Power Point and its features. MSACCESS: Concept of Database, creating database; Computer programming: Flow charts and Algorithms, Programming languages- BASIC, FORTRAN and C. Internet: World Wide Web (WWW), Concepts, web browsing and electronic mail. Bioinformatics - NCBI gene bank sequence database- primary and secondary database.

### **Code 08: MAJOR SUBJECT GROUP - HORTICULTURE**

**(Sub-Subjects: 8.1:** Horticulture, **8.2:** Vegetable Crops or Sci. / Olericulture, **8.3:** Pomology/ Fruit Sci., Fruit Sci. and Horticulture Technology **8.4:** Post-Harvest Technology of Horticultural Crops **8.5:** Floriculture & Landscaping Architecture **8.6:** Plantation Spices, Medicinal and Aromatic Crops)

**UNIT-I:** Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato and mango. Major soils of India, role of NPK and their deficiency symptoms. Structure and function of cell organelles; mitosis and meiosis; Mendelian genetics; elementary knowledge of photosynthesis; respiration, and transpiration; structure and functions of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Major pests and diseases of rice, wheat, cotton, chickpea, sugarcane and their management. Important rural development programmes in India; organizational set up of agricultural research, education and extension in India; Elements of statistics.

**UNIT-II:** Layout and establishment of orchards; pruning and training; propagation, climatic requirement and cultivation of fruits like mango, banana, citrus, guava, grape, pineapple, papaya, apple, pear, peach and plum; cultivation of plantation crops like coconut and cashew nut and spices like black pepper, coriander, turmeric, important physiological disorders; major vegetable crops of tropical, subtropical and temperate regions 'like Cole crops (cauliflower, cabbage and knol khol), cucurbits (pumpkin, bottle gourd, bitter gourd, luffa, muskmelon and watermelon, cucumber), root crops (radish, tapioca sweet potato and potato), leafy vegetables (fenugreek and spinach); solanaceous crops (tomato, chilies and brinjal); techniques for raising the nursery; nutritive value of fruits and vegetables and their role in human nutrition; basic physiology of ripening in fruits and vegetables and their products; type of fruits and vegetable products and control of fungal and bacterial diseases; major floricultural crops grown in India for commercial purposes like rose, carnation, chrysanthemum, marigold, tuberose, gladiolus, orchids; establishment and maintenance of lawns, trees, shrubs, creepers, hedges and annuals; type of gardens, methods of crop improvement; male sterility and incompatibility; pure line and pedigree selection; backcross, mass selection; heterosis; plant nutrients, deficiency symptoms of nutrients, manures and fertilizers, systems of irrigation, management of important pests and diseases of fruits and vegetables.

### **Code 09: MAJOR SUBJECT GROUP - FORESTRY/AGROFORESTRY & SILVICULTURE**

**(Sub-Subjects: 9.1:** Forest Production & Utilization **9.2:** Silviculture & Agroforestry **9.3:** Tree Physiology and Breeding **9.4:** Agroforestry, **9.5:** Forest NRM/Forest Mgmt. & Utilization **9.6:** Plantation Technology **9.7:** Wild Life Sc. (Forestry) **9.8:** Wood Science)

**UNIT-I:** Importance of Agriculture/Forestry/Livestock in national economy. Basic principles of crop production. Important rural development programmes in India Elementary principles of economics and agri- extension. Organizational set up of Agricultural Research, education and extension in India. Major diseases and pests of crops. Elements of statistics.

**UNIT-II:** Forest- importance, types, classification, ecosystem, biotic and abiotic components, ecological succession and climax, nursery and planting technique, social forestry, farm forestry, urban forestry, community forestry, forest management, silvicultural practices, forest mensuration, natural regeneration, man- made plantations, shifting cultivation, taungya, dendrology, hardwoods, softwoods, pulp woods, fuel woods, multipurpose tree species, wasteland management. Agroforestry – importance and land use systems, forest soils, classification and conservation, watershed management, forest genetics and biotechnology and tree improvement, tree seed technology, rangelands, wildlife – importance, abuse, depletion, management, major and minor forest products including medicinal and aromatic plants, forest inventory, aerial photo interpretation and remote sensing, forest depletion and degradation – importance and impact on environment, global warming, role of forests and trees in climate mitigation, tree diseases, wood decay and discoloration, tree pests, integrated pest and disease management, biological and chemical wood preservation, forest conservation, Indian forest policies, Indian forest act, forest engineering, forest economics, joint forest management and tribology.

### **Code 10: MAJOR SUBJECT GROUP - AGRICULTURAL ENGINEERING AND TECHNOLOGY**

(**Sub-Subjects:** 10.1: Soil & Water Conservation Engg. /Soil & Water Engg., 10.2: Irrigation Drainage Engg. / Irrigation Water Mgmt.Engg.10.3: Post Harvest Technology/ Processing and Food Engg. 10.4: Farm Machinery and Power Engg.10.5: Renewable Energy Engg.)

**UNIT-I:** Elementary Statistics and theory of probability, differential and integral calculus, linear algebra and Fourier series, differential equations, vector algebra & vector calculus, elementary numerical analysis.

**UNIT-II:** Electric motors: Types, performance, selection, installation and maintenance, measuring instruments, fundamentals of computers, power distribution.

**UNIT-III:** Thermodynamic principles; fluid mechanics, theory of machines.

**UNIT-IV:** Soil mechanics, soil classification, compaction & shear strength of soils, engineering mechanics, strength of materials.

**UNIT-V:** Importance of farm equipment and role of mechanization in enhancing productivity & profitability of Indian agriculture; analysis of forces, design and production of farm machinery and power units; mechanics of tillage

& Traction operation, repair and maintenance of farm machines and equipment, farm engines; tractors and power tillers; tractor stability and operator's comfort; field capacity and cost analysis; test codes and procedure; safety and ergonomic principles. Role of energy in economic development; solar, wind and bio- energy; biogas plants & gasifiers; biofuels from biomass; collection, characterization and storage of biomass, solar cookers & Solar refrigerators.

**UNIT-VI:** Biochemical and engineering properties of biological materials; quality control & safety of raw and finished products. Principles, practices and equipment's for drying, milling, separation and storage of agricultural produce and by-products; material handling equipment and operations; farmstead planning; heating & cooling load calculation; seed processing practices and equipment's; food preservation methods and products development; refrigeration and air conditioning; cold stores; waste management, cost analysis & food processing plants layout, feasibility reports.

**UNIT-VII:** Surveying and leveling; hydrology, water resources in India; efficiency in water use; irrigation system and equipment; water conveyances and associated efficiency; soil-plant-water relationship; estimation of evaporation and water requirements of crop; water harvesting and use, farm ponds and reservoirs, command area development, land use capability classification, ground water development, wells and pumping equipment, soil erosion and its control, land shaping and grading equipment and practices, hydraulic structures, drainage of irrigated and humid areas; salt balance and reclamation of saline and alkaline soils.

### **Code 11: MAJOR SUBJECT GROUP - WATER SCIENCE AND TECHNOLOGY**

(**Sub-Subject:** 11.1: Water Science and Technology)

**Unit-I:** Importance of Agriculture in national economy; basic principles of crop production; cultivation of rice, wheat, chickpea, pigeon-pea, sugarcane, groundnut, tomato and mango. Major soils of India, role of NPK and their deficiency symptoms. Structure and function of cell organelles; mitosis and meiosis; Mendelian genetics; elementary knowledge of photosynthesis; respiration, and transpiration; structure and functions of carbohydrates, proteins, nucleic acids, enzymes and vitamins. Pests and diseases of major crops and their management, important rural development programmes in India; organizational set up of agricultural research, education and extension in India.

**Unit-II:** Water resources of India, surface and groundnut resources, rainfall, rainfall-runoff relations, measurement and estimation of runoff, irrigation development in India, command area development, watershed management principles, government schemes in watershed management program, water harvesting structures including farm ponds, water quality including physical, chemical and biological properties.

**Unit-III:** Physical properties of soils—texture, structure, density and consistency, infiltration, field capacity, permanent wilting point, available water hydraulic conductivity, soil water flow including Darcy's law, mechanical analysis, chemical properties of pH, EC, atoms, molecules, colloids, clay mineral, major and trace elements, salinity and sodicity, cation exchange capacity, evaporation, evapotranspiration, water requirements of crop, plant growth process, soil and water conservation practices and tillage.

**Unit-IV:** Simultaneous and quadratic equations, differentiation and integration, differential equations, elements of statistics, frequency distribution, probability concepts, basic concepts of economics, energy, horse power, efficiency of machines, concepts of fluid flow, hydrostatic pressure, surface tension, irrigation water distribution and control, irrigation methods, irrigation efficiencies, irrigation scheduling, water lifting devices and pumps, construction of wells, drainage principles and applications, surface drainage, subsurface drainage, water pricing, water laws and irrigation acts.

### **Code 19: GROUP- FOOD SCIENCE TECHNOLOGY**

**(Sub-Subject: 19.1:** Food Technology/Food Science & Technology, **19.2:** Food Safety & Quality Assurance, **19.3:** Food Science & Nutrition)

**UNIT-I:** General chemistry of food constituents, physical properties of foods, properties of colloidal systems, gels and emulsions. Minerals in foods, physicochemical changes in foods during processing and storage, functions of food nutrients, dietary allowances and nutritional requirements. Metabolism of carbohydrates, lipids and protein. Biological value and PER. Food additives, contaminants and anti-nutritional factors. Food flavors and puff- flavors. National and international food standards, modern analytical techniques in food analysis.

**UNIT-II:** Engineering properties of food materials, System analysis, mass and energy balance, Principles operations and equipment for food materials flow handling, cleaning, de-husking, sorting and grading; peeling, size reduction, mixing and forming, bakery foods manufacture, extrusion, separation, filtration and membrane processes, expression, baking roasting, frying, extraction and leaching, crystallization, distillation, blanching, pasteurization, sterilization, evaporation, drying, freezing, packing, heat exchanging, dairy specific operations. Process equipment design, heat and mass transfer, equipment for steam generation, compressed air, refrigeration and air conditioning, water and waste water treatment, biochemical engineering and thermo bacteriology. Automation, on-line data acquisition and process control. Food plant layout and design. Energy audit.

**UNIT-III:** Preparation and manufacturing technology of cereals and bakery products, beef, pork, poultry, fish & sea foods and egg, sausages and table ready meats, dairy products, fresh fruits, fresh vegetables, processed fruits, processed vegetables, Post Harvest Handling and storage of Fruits and Vegetables. Sugars, sweets, fats and oils, fermented foods, alcoholic and non-alcoholic beverages, indigenous foods, fast, readymade and fashion foods. Dehydration and concentration methods, irradiation, microwave and solar processing of foods, food by-products & downstream processing, flavoring and pigment technology. Judging of food products, food plant management and legal aspects, food plant safety, risk and hazards. Effluent treatment and environment pollution, waste solids upgrading and treatment, food storage, functions of packaging, packaging operations, types of containers, FFS, Hermetics closures, canning packaging materials and package testing, transportation and marketing food products.

**UNIT –IV:** Role of intrinsic and extrinsic properties of food in relation to microbial growth. Microbiology of fruits, fruit products, vegetables, soft drinks, bakery products, milk and milk products, milk, fish, egg and marine produces. Spoilage of foods, food pathogens and their toxins in relation to human health. Food preservation by sugar, salt, chemicals, heat, cold, irradiation, dehydration and packaging. Microbiology of fermented foods and beverages and factors affecting their quality. Methods for microbiological examination of foods, food hygiene and safety regulations. Water quality and waste disposal in food industry.

### **Code 20: Group– Agri-Business Management**

**(Sub-Subjects: 20.1: Agri-Business Management (MBA),20.2: Agricultural Marketing & Cooperation (M.Sc.))**

**UNIT-I:** Social, political and economic structure in rural India. Importance of agriculture/forestry/ horticulture/ livestock in national economy. Cultivation of major cereal crops, legume crops, vegetable crops, fruits and their importance in human diet. Major soils of India, essential plant nutrients, their role, deficiency symptoms and sources. Pests and diseases of major crops, vegetables, fruits and their management. Forestry production, pests and diseases management of major trees grown in India. Watershed management. Organizational set up of agricultural research, education and extension in India. Elements of statistics.

**UNIT-II:** Farm equipment's and Farm Machinery in India, sources of energy and power on farms. Irrigation and drainage systems. Basics of post-harvest technology, Basics of energy in agriculture.

**UNIT-III:** Basics of veterinary, gynecology, veterinary microbiology, veterinary pathology and Parasitology, veterinary surgery, veterinary public health, veterinary pharmacology and toxicology.

**UNIT-IV:** Basics of human food and nutrition, human/child development, home and family resource management, clothing and textile.

**UNIT-V: Quantitative ability:** Test the ability of candidates to make mathematical calculations under stress conditions. All these calculations will be based on analytical skills of the candidates with understanding of mathematics at Intermediate level.

**UNIT-VI: Communicative ability:** Test English comprehension wherein the knowledge of language skills are tested as to how effectively the candidate communicates his thoughts and ideas.

**UNIT-VII: Data Interpretation:** Calculations requiring skills of interpretation of facts and figures. The questions can be posed as graphs, tables and charts.

**UNIT-VIII: Logical reasoning:** Evaluating logical thinking capacity by providing various options.

**UNIT-IX:** Fundamentals of managerial economics, market structure conduct and performance, agricultural marketing concepts- functions and institutions, trade in agriculture sector; principles of corporation; cooperatives in India; agribusiness institutions in India; entrepreneurship development.

**Besides above, any other topic of scientific, social and educational importance can also be included. Around 20–25% questions shall be related to agriculture and agriculture related science subjects including recent developments.**

# ANNEXURE III: SYLLABUS FOR THE ALL-INDIA COMPETITIVE EXAMINATION FOR ADMISSION TO DOCTORAL DEGREE PROGRAMMES AND THE AWARD OF JRF/SRF (PGS)

## 01. GENETICS & PLANT BREEDING

### Unit 1: General Genetics and Plant Breeding

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA – structure, function, replication and repair. Genetic code. Gene-enzyme relationship. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding. Epigenetics.

### Unit 2: Economics Botany and Plant Breeding Methods

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, small millets); pulses (pigeon pea, chickpea, black gram, green gram, cowpea, soybean, pea, lentil, horse gram, lab-lab, rice bean, lathyrus, lima bean; oilseeds (groundnut, sesamum, castor, rapeseed mustard, sunflower, safflower, Niger, linseed); fibre and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and asexually propagated crops. Combination, recombination and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding, Concept of tree breeding. Speed breeding methods, Pre-breeding, Reverse Breeding.

### Unit 3: Genome Organization and Cytogenetics of Crop Plants

Chromosome number, structure, function and replication. Sex determination & sex linkage. Recombination and crossing over. Molecular and cytological mechanism of crossing over. Karyotype analysis. Chromosomal theory of inheritance. Cell cycle and its regulation. Banding techniques. *In situ* hybridization. GISH and FISH Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids, their utility and their meiotic behaviors. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-and post- fertilization barriers in wide hybridization. Genome organization and Cytogenetics of important crop species- wheat, maize, rice, sorghum, *Brassica*, groundnut, cotton, *Vigna*, potato and sugarcane. Cytogenetic techniques for gene location and gene transfer, Construction and use of molecular marker-based chromosome maps.

### Unit 4: Quantitative and Biometrical Genetics

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection their effects on population mean and variance. Metric characters under natural selection. Repeatability and asymmetry of response. Breeding value. Dominance and interaction deviations. Hardy Weinberg law and changes in gene frequency due to migration, mutation and selection. Linkage disequilibrium. Genetic load. Polymorphism. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combining ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions, stability of performance and stability analysis. Heterosis and its basis (Genetic, biochemical and physiological). Mating system and mating design- diallel, line X tester, NC-I NC-II and NC-III designs, approaches to estimate and exploit components of self- and cross-pollinated crops. GGE biplot

analysis, Principal component analysis, AMMI and GGI analysis.

### **Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding**

Somatic hybridization, micropropagation, somaclonal variation, *in vitro* mutagenesis. Anther culture. Cryopreservation. Genetic and molecular markers, generation of molecular markers and their application in genetic analyses and breeding. Molecular markers in genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping, MAS, MARS and MABB. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nucleic acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Gene transfer methods. Artificial synthesis of gene. Genetic transformation, transgenics and cisgenics. Antisense RNA, RNAi and micro-RNA techniques in crop improvement. Genome editing using CRISPER/cas, Genomic selection, RNA Seq analysis,

### **Unit 6: Plant Breeding for Stress Resistance and Nutritional Quality**

Genetic and molecular basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits. Role of molecular markers in stress resistance breeding using biotechnological tools (MAS, MARS and MABB and transgenics). Biofortification.

### **Unit 7: Plant Genetic Resources and their Regulatory System; Varietal Release and Seed Production**

Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resources. Types of genetic resources. Centres of diversity of cultivated plants. Genetic erosion and genetic vulnerability. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights and its different forms for protection of plant genetic resources. Biodiversity Act. Protection of Plant Varieties and Farmers' Rights Act and its features. System of variety release and notification. Types of seeds and seed chain. Maintenance breeding- nucleus and breeder seed production. Seed production and certification.

### **Unit 8: Statistical Methods and Field Plot Techniques**

Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probability distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Designs of experiments - basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.

## **02. SEED SCIENCE & TECHNOLOGY**

### **Unit 1: Seed Biology**

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development and physiological and harvestable maturity. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and maturation drying in orthodox and recalcitrant seed. Seed chemical composition. Seed dormancy - types, causes, methods to overcome dormancy. Seed germination - phases, types and requirements. Physiological and biochemical changes in germinating seed. Role of hormones in dormancy and germination.

### **Unit 2: Seed Production**

Genetic purity - concept and factors responsible for deterioration of varieties. Maintenance breeding. Generation system of seed multiplication. Seed production agencies - public and private. Compact area approach / seed village concept in seed production. Seed Replacement Rate, Seed Multiplication Ratio, Seed Renewal Period, Varietal Replacement Rate. Seed production planning. Factors affecting pollination and seed set *viz.*, temperature, humidity, wind velocity, insect pollinators and supplementary pollination. Male sterility, self-incompatibility and their role

in hybrid seed production. Techniques of hybrid seed production - emasculation and pollination, detasseling, male sterility, sex expression, self-incompatibility and chemical hybridizing agents. Principles and methods of seed production of varieties and hybrids of cereals - wheat, paddy, sorghum, pearl millet and maize; pulses - chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds - groundnut, brassica, sesame, sunflower and castor; fibre crops - cotton and jute; vegetable crops - tomato, brinjal, okra, chilli, cabbage, cauliflower, radish, knol khol, turnip, carrot and cucurbitaceous crops; important forage legumes - lucerne, desmanthus and grasses - cumbu napier and fodder sorghum ; plantation crops - coffee, tea, rubber, cocoa, cardamom, coconut and pepper. Disease free clonal propagation of crops - potato, sugarcane, tapioca, fruit crops - mango, citrus, apple, pear, plum. Clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Micro propagation.

### **Unit 3: Seed Processing**

Principles of seed processing. Processing sequence for different crops. Layout of seed processing unit. Seed drying - principles and methods. Pre-cleaning, grading, upgrading, seed treatment and packaging. Working principles of seed processing machines viz., cleaner cum grader, specific gravity separator, indented cylinder separator and seed treater. Seed quality maintenance during processing. Seed enhancement techniques - seed coating, pelleting and priming.

### **Unit 4: Seed Quality Control**

Seed legislation - the Seeds Act 1966, Seed Rules 1968, Seed Control Order, 1983 and Seed Bill 2004. Seed certification - history, concept, organization, phases and Indian minimum seed certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre-and post- processing quality testing of seed. Seed testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance limit and seed testing equipment's. Quick viability test and seed standards. Seed vigour, its significance and testing methods.

Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, Biochemical Techniques - electrophoresis of proteins and isoenzymes and DNA fingerprinting. (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade. OECD seed certification guideline - agricultural and vegetable crops.

### **Unit 5: Seed Storage**

Seed storage - principle - purpose and types - short-, medium- and long-term storage. Factors affecting seed storage and role of moisture, temperature and relative humidity. Viability nomographs. Longevity of orthodox and recalcitrant seeds. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Controlled storage. Germplasm storage. Cryo preservation. Seed storage containers, types - safe moisture content. Storage structures. Methods of stacking and their impact on seed quality. Seed storage go down maintenance and sanitation. Management of carry over seed.

### **Unit 6: Seed Health**

Significance of seed health. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

### **Unit 7: Seed Industry Development and Marketing**

National and International seed industry development. Role of OECD and WTO in International seed trade. International Seed Federation (ISF). Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Economics of seed production. Role of Government, semi-Government, cooperative

and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

### **Unit 8: Protection of Plant Varieties**

Plant Variety Protection (PVP) and its significance. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant Breeders Rights and Seed Industry Development. UPOV 1978 and 1991 Acts. Plant Breeders Rights and exceptions to it. Breeders' exemption and farmer's privilege. Plant patent v/s Plant breeders' rights. Impact of PVP on seed supply system. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. Criteria for protection of different types of plant varieties. DUS testing principles and application. Breeders, Researchers and farmers rights. Compulsory licensing. Indian Biological Diversity Act, its essential features. Access to Biological resources, benefit sharing.

## **3 ECONOMIC BOTANY & PLANT GENETIC RESOURCES**

### **Unit 1: Biodiversity and Plant Genetic Resources**

Biodiversity- an overview, genetic, species and ecosystem diversity; determinants of biodiversity, species richness and endemism, agriculture as friend and foe of biodiversity, harmonizing biodiversity, conservation and agricultural development, origin and history of agriculture; dynamics of domestication; centers of crop plant origin and diversity; geographical distribution of crops of Indian origin, plant genetic resources management (importance and usefulness of germplasm, germplasm conservation, threat of genetic vulnerability, global concerns) *in situ* conservation of genetic resources, collecting genetic resources and managing genetic resources, biotechnology and germplasm conservation.

### **Unit 2: Exploration and Germplasm Collecting**

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. 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. 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. Ethnobotanical aspects of PGR, crop botany, farming systems, collecting wild relatives of crop plants. Post-exploration handling of germplasm collections, collection and preservation of specimens, importance and use of herbaria and preparation of herbarium specimens. 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.

### **Unit 3: Germplasm Exchange and Plant Quarantine**

History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange.

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.). 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. Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust. 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.

#### **Unit 4: Principles and Methods of Germplasm Conservation**

*In situ* and *ex situ* conservation: concept of biosphere reserves, gene sanctuaries, on-farm conservation, field gene banks, botanical gardens, herbal gardens, *in vitro* repositories cryo-banks and DNA banks, 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. gene bank management: acquisition, accessioning and processing of germplasm samples for storage, gene bank standards for various crops, ISTA, AOSA, IPGRI guidelines, monitoring and regeneration of plant germplasm. Design of storage facilities, maintenance and operation of storage modules. Information management in gene banks, strategies for revival and rescue of rare genetic material.

#### **Unit 5: Principles and Practices of Germplasm Regeneration and Evaluation**

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces. 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. Measuring diversity using agro-morphological data; gene markers and their use in PGR management. Evaluation and maintenance of wild relatives of crop plants; genetic enhancement/pre-breeding and use of alien/unadapted genetic resources in crop improvement.

#### **Unit 6: Biotechnology in Plant Genetic Resource Management**

History and importance of Tissue culture, Tissue culture media, Sterilization techniques, *in vitro* clonal multiplication, Somatic embryogenesis, Meristem culture and virus elimination, *In vitro* conservation – Introduction and principle, Strategies for *in vitro* short- and medium-term conservation, *In vitro* collection, *in vitro* exchange of germplasm.

Plant Cryopreservation-Introduction, Principle of cryotolerance, Techniques of cryopreservation: slow cooling, desiccation, pre-growth, encapsulation-dehydration, vitrification, droplet freezing, Cryoprotectants, Cryopreservation of seeds and pollen, Cryopreservation of *in vitro* cultures, Application of *in vitro* cryopreservation techniques, 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 7: Economic Botany**

Origin, evolution, botany, cultivation, genetic resource activities and utilization of genetic diversity of important crops of cereals, millets, legumes, forage and fodder crops, medicinal and aromatic plants, beverages, oil yielding plants, spices and condiments, wood and timber yielding taxa, fumigatory 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, pseudo-cereals, important taxa in agro-forestry, horticulture and floriculture, processing and use of crop residues.

#### **Unit 8: Information Management in Plant Genetic Resources**

Statistical techniques in management of germplasm, developing core collection, estimation of sample size during plant explorations, impact of sampling on population structure, 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,

Germplasm documentation; basics of computer and operating systems, database management system, use of statistical software's, pictorial and graphical representation of data; Introduction to communication network.

#### **Unit 9: Plant Taxonomy**

Classical and modern species concepts, differentiation and evolution of species and biosystematics -variation within species, population genetics, phenotypic plasticity, environmental effects on populations, Modern evidences for Morphology and Anatomy, Embryology and Palynology; Biogeography and Cytotaxonomy; Modern evidences for Comparative studies on phytochemistry, Chemotaxonomy; Molecular taxonomy methods; Numerical methods

in taxonomy; Biosystematic approaches in plant taxonomy- some Indian case studies, 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, Taxonomic databases: Taxonomic databases and documentation methods.

### **Unit 10: Plant Biosecurity**

History and Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases, 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 agro-terrorism event, mitigation planning, integrated approach for biosecurity, Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

### **Unit 11: Fundamentals of Molecular Biology for PGR Management**

Structure and function of DNA, genome organization, Tools for genetic manipulation, Introduction to molecular markers, classification and comparison of markers, basis for DNA polymorphism and principles of generating molecular markers, - RFLP, PCR, sequencing; Principles, merits and demerits of RAPD, ISSR, SSR, SCAR, SCOT, SRAP, AFLP, SNPs markers; data handling and statistical analysis, Overview of molecular marker applications, Introduction to transgenics, monitoring strategies and methods for detecting transgenics.

## **04. PLANT PATHOLOGY**

### **Unit 1: History and Principles of Plant Pathology**

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, legislative, cultural and biological protection measures including classification of plant diseases. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection, colonization and development of symptoms.

### **Unit 2: Laboratory and Analytical Techniques**

Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease.

Detection and Diagnosis of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Laboratory equipment and their use: autoclave, hot air oven, laminar flow, spectrophotometer, electrophoresis, light and electron microscopy, incubator, ultracentrifuge, ELISA Reader, Freeze dryer, Nano drop, GC-MS, HPLC, Thermocycler.

### **Unit 3: Physiological and Molecular Plant Pathology**

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: elicitors, recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance, Structural and Biochemical defense mechanisms. R- Genes, Phytoanticipins. Phytoalexins. PR proteins, Hydroxyproline rich glycoproteins (HRGP). Antiviral proteins. SAR and ISR. HR and active oxygen radicals. Elementary genetic engineering. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, RNA interference, plantibodies, hypovirulence, cross protection. Useful genes and promoters, plant transformation techniques, biosafety and bioethics.

#### **Unit 4: Mycology**

Classification of fungi (According to the Classification – Kirk *et al.*, 2008). Life cycles of important phytopathogenic fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

#### **Unit 5: Plant Bacteriology**

Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in relation to function. Growth curve, nutrition and auxotrophic mutants. Resting cells in elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression.

Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes.

#### **Unit 6: Plant Virology**

Nature, composition and architecture of viruses and viroids. Properties of viruses. Nomenclature and classification of viruses. Variability in viruses. Satellite viruses and satellite RNA. Mycoviruses and baculoviruses. Assay of plant viruses including biological, physical, chemical, serological and molecular methods. Conventional and biotechnological techniques used in detection and diagnosis. Behavior of viruses in plants including infection, replication and movement. Histopathological changes induced by viruses in plants, inclusion bodies. Transmission of viruses: virus - vector relationships.

#### **Unit 7: Plant Disease Epidemiology**

Concepts in epidemiology. Development of disease in plant population. Monocyclic and polycyclic pathogens. Role of environment and meteorological factors in the development of plant disease epidemics. Survey, surveillance (including through remote sensing), and prediction and forecasting of diseases. Epidemic analysis and prediction models. Crop loss assessment: critical and multiple point models. Decision support system, cloud computing, GPS, GIS and GS in plant disease epidemiology.

#### **Unit 8: Phanerogamic Parasites and Non-parasitic Diseases**

Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavorable soil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary air pollutants and acid rain.

#### **Unit 9: Fungal Diseases of Crop Plants**

Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices, medicinal and ornamental crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management. Postharvest diseases in transit and storage; aflatoxins and other mycotoxins and their integrated management.

#### **Unit 10: Bacterial and Viral Diseases of Crop Plant**

Crop diseases of cereals, pulses, oilseeds, sugar crops, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management.

#### **Unit 11: Management of Plant diseases**

General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hypothesis;; breeding for disease resistance.

Production of disease-free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassay and compatibility with other agricultural chemicals; resistance to

fungicides/ antibiotics; effect on environment. Spraying and dusting equipment's, their care and maintenances. Important cultural practices and their role in disease management, solarization, integrated disease management. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria. Biotechnology for crop disease management.

## **05. NEMATOLOGY**

### **Unit 1: History and Economic Importance**

History and development of Nematology at National and International level. Position of nematodes in animal kingdom. Economic importance of nematology; distribution of economically important nematodes (*Pratylenchus*, *Radopholus*, *Hirschmanniella*, *Meloidogyne*, *Heterodera*, *Globodera*, *Rotylenchulus*, *Tylenchulus*, *Ditylenchus*, *Anguina*, *Aphelenchoides*, *Tylenchorhynchus*, *Helicotylenchus*, *Hoplolaimus*, *Scutellonema*, *Paratylenchus*, etc.). Beneficial nematodes. (Entomopathogenic nematodes – *Steinernema* and *Heterorhabditis*), Parasites of insects (*Mermis*, *Agamermis*, *Romanomermis*). Entomopathogenic nematodes. Importance of saprophytes in organic matter recycling. Nematodes as indicators of pollution and toxicity. Predacious Nematodes.

### **Unit 2: Nematode Taxonomy and Morphology**

Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny and systematics. Classification of soil and plant-parasitic nematodes and their relationships with other related phyla. Detailed classification of plant - parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes (cuticle, hypodermis, sense organs, pseudocoelom). Various systems: digestive, excretory, nervous, reproductive etc., developmental biology of nematodes.

### **Unit 3: Nematological Techniques**

Different methods of sampling for nematodes. Methods of extraction of nematodes from soil and plant material. Extraction of cysts nematodes. Microscopy - principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology, Microtome techniques and culturing of nematodes - plant parasitic and entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics. Techniques for mass culturing of entomopathogenic nematode antagonistic bioagents.

### **Unit 4: Nematode Ecology**

Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modelling. Community analysis.

### **Unit 5: Plant Nematode Relationships**

Types of parasitism in nematodes. Classification of nematodes based on feeding habit. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved.

Pathotypes and races of root knot, cyst and burrowing nematodes. Histopathological changes due to root knot and cyst nematode infestation including syncytia, giant cell formation and their modification etc. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

### **Unit 6: Nematode Physiology and Cytology**

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Biology of root knot, cyst, Reniform, citrus, burrowing and lesion nematodes. Nematode as biological models - *Caenorhabditis elegans*. Cytological

changes in plants due to infection including syncytia, giant cell formation and their modification etc.

### **Unit 7: Nematode pests of crops**

Major nematode parasites and management in cereals (rice, wheat and barley), millets (sorghum, and maize), pulses (redgram, blackgram, greengram cowpea and chickpea), oilseeds (castor, groundnut and gingely), fibre crops (cotton and jute), vegetables (tomato, brinjal, bhendi, chilli and potato), cole crops (cabbage, carrot, cauliflower), beet root, sugarbeet, tapioca, tobacco, tuber crops (yam, dioscorea), fruits (banana, citrus, grapevine, guava, papaya, pomegranate), spices and plantation crops (turmeric, pepper, betelvine, arecanut and coconut), flower crops (crossandra, jasmine, carnation, rose, gerbera, chrysanthemum, eustoma and tuberose) and medicinal and aromatic plants, (medicinal coleus, geranium and patchouli), mushroom.

### **Unit 8: Nematode Management**

Principles and methods of nematode management - physical, cultural biological, chemical and legislative (plant quarantine), Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Resistance sources for different nematodes. Integrated nematode management. Nematode management in protected cultivation.

### **Unit 9: Interactions of Nematodes with Soil Organisms**

Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorrhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

### **Unit 10: Statistics**

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions: normal, binomial and Poisson. Correlations: regression, partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.

## **06. AGRICULTURAL ENTOMOLOGY/ENTOMOLOGY**

### **Unit 1: Systematics**

History and development of Entomology, Evolution of insects, position of insects in the animal kingdom, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families.

### **Unit 2: Morphology**

Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures, Insect Colors. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders.

### **Unit 3: Embryology, Internal Anatomy and Physiology**

Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function, physiology and modifications of Digestive, Circulatory, Respiratory, Reproductive, Nervous, Excretory systems, Endocrine system and Sense Organs. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets.

#### **Unit 4: Ecology**

Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, diapause, population structure and dynamics, distribution and dispersal. Principles of biogeography and insects' biodiversity. Assessment of diversity indices. Biotic potential and environmental resistance. Climate change and adaptations. Ecosystems, agroecosystem analyses, ecological niche, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host- parasitoid interactions. Food chain, food web and trophic relations. Life table studies, population models. Arthropod population monitoring, pest forecasting. Causes of pest out breaks.

#### **Unit 5: Biological Control**

Importance and scope of biological control, history of biological control: Biocontrol agents- parasitoids, predators, insect pathogens and weed killers. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests. Use of biotechnological tools in enhancing the potentials of Bio-Control Agents.

#### **Unit 6: Chemical Control and Toxicology**

History, scope and principles of chemical control. Insecticides, classification and mode of action - Conventional and IRAC. Formulations of insecticides. Penetration of insecticides. Physical, chemical and toxicological properties of different groups of insecticides. rodenticides, insect growth hormones. Insecticide induced resurgence. Combination insecticides. Pesticide hazards and environmental pollution. Safe use of pesticides, precautions, first aid treatments and antidotes. Insecticides Act 1968, Functions of CIB & RC, registration and quality control of insecticides. Evaluation of toxicity, methods of toxicity testing, determination of LD 50, LT 50, RL 50 etc. Pesticide residues in the environment and their dynamics of movements, methods of residue analysis. Good laboratory practices. Pharmacology of insect poisons. Metabolism of insecticides; detoxification enzymes and their role in metabolism. Selectivity of insecticides insecticide resistance; mechanism, genetics and management of insecticide resistance.

#### **Unit 7: Host Plant Resistance**

Principles of HPR. Basis of resistance (Antixenosis, Antibiosis, Tolerance). Host plant selection by phytophagous insects. Biophysical and biochemical bases of defense against phytophagous insects. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotype development and break down of resistance. Tritrophic interactions, induced resistance. Breeding for insect resistant crops and evaluation techniques. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

#### **Unit 8: Novel Approaches in Pest Control**

Behavioural control: semiochemicals pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Genetic improvement and genetic engineering of bio control agents. Pest management in organic agriculture. Pest management in precision agriculture.

#### **Unit 9: Integrated Pest Management**

History, concept and principles of IPM. Components of IPM: Host plant resistance, cultural, mechanical, physical, chemical, biological, genetic and behavioural control etc. System approach, Agro ecosystem and cropping system vs. IPM. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. IPM strategies for field and horticultural crops. IPM case histories. Constraints and Strategies of IPM implementation. Plant quarantine laws and regulations.

## **Unit 10: Pesticide Application Equipment**

Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Types of nozzles, international classification, their uses, spray patterns, particle size, measurement, drift and non-target effects of pesticides. Maintenance of appliances. Aerial application- principles, guidelines, factors affecting the effectiveness, systems, advantages and disadvantages.

## **Unit 11: Pests of Field Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, millets, nutricereals, oilseeds, pulses, fibre crops, green manures, sugarcane and tobacco. Pests of importance: locusts, termites, hairy caterpillars, cut worms white grubs and invasive alien pests. Vertebrate and molluscan pests.

## **Unit 12: Pests of Horticultural Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits, plantation crops, spices, condiments, medicinal and aromatic crops, ornamentals, underutilized and exotic fruits. Pest management under protected cultivation. Pests of mushrooms. Vertebrate and molluscan pests.

## **Unit 13: Pests of Stored Products and their Management**

Principles of grain storage. Storage structures, bulk storage and bag storage their merits and demerits. Grain drying methods and aeration. Storage losses, sources of infestation, factors influencing losses. Insect pests in storage, biology, and nature of damage. Non-insect pests (rodents, birds, mites) and their nature of damage. Management methods: Physical, Mechanical, Chemical, Biological, Behavioural, Legal and special storage methods. Microflora in storage environment and their control. Regulated and quarantine pests. Integrated management of storage pests.

## **Unit 14: Insect and mite vectors of Plant Diseases**

History of vector pathogen interactions, important vectors of plant diseases, ecology of vector pathogen interaction Common insect and mite vectors *viz.*, aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psyllids, beetles, weevils, flies, and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission: Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases. Role of climate change in vector borne diseases.

## **Unit 15: Honey Bees and Bee-keeping**

History of bee-keeping. Honey bees and their economic importance. Bee products. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipment's, seasonal management. Bee poisoning. Bee enemies including diseases and their management. Quality analysis of honey. Pollinators and their role in production of various crops. Conservation of pollinators.

## **Unit 16: Silkworms and Sericulture**

Silkworm species, salient features, systematic position. Production techniques of mulberry, muga, eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltinism and moulting, seed production and its economics. Different molecular approaches in developing silkworm breeds. transgenic silkworm- Mulberry pests, diseases and their management. By products of sericulture and its value addition, uses in pharmaceutical industry. Enemies and diseases of silkworms and their management. Sericulture organization in India.

## **Unit 17: Lac Insect**

Lac insect, its biology, habit and habitats, lac products, uses. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control

### **Unit 18: Helpful and Useful Insects**

Pollinators and their role in production of various crops. Conservation of pollinators. Pollinators, insects as food, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Insects as bio-indicators. Usefulness of insects in scientific investigations

### **Unit 19: Statistics and Computer Application**

Frequency distribution, mean, mode and median. Standard, normal, binomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi-square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, completely randomized block design, Latin square design, Split-plot designs. Probit analysis. Use of software packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

## **08. PLANT BIOCHEMISTRY/ BIOCHEMISTRY**

### **Unit 1: Basic Biochemistry and Biomolecules**

Scope and importance of biochemistry and molecular biology in plants. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages, cell organelle's function and their fractionation. Chemical bonding in biological systems, pH and buffers. Thermodynamics and bioenergetics- concept of entropy, and free energy changes in biological reactions, Redox reactions, Role of high energy phosphates. Bio membranes. Classification structure, chemistry, properties and function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins.

### **Unit 2: Intermediary Metabolism**

Anabolism, catabolism and their regulation. Metabolism of carbohydrates – glycolytic pathway, HMP pathway, TCA cycle, glyoxylate pathway and gluconeogenesis. Biological oxidation- electron transfer and oxidative phosphorylation. Lipid metabolism, degradation and biosynthesis of fatty acids, ketogenesis and causes of ketosis. Biosynthesis of sterols and phospholipids. Protein degradation by proteases and ubiquitin- Proteasome System, Amino acid metabolism – catabolism of amino acids, transamination and deamination, urea cycle, biosynthesis of amino acids. Conversion of amino acids into bioactive compounds. Metabolism of nucleic acids-degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites, Alkaloids, Phenolics and Isoprenoids, biotransformation and over expression. Role of oligosaccharides and polysaccharides in cellular metabolism.

### **Unit 3: Enzymes, Vitamins and Hormones**

Major classes of enzymes, general properties, kinetics, active site and its mapping, activation energy and transition state. Mechanisms of enzyme action, inhibition and activation. Coenzymes and cofactors. Isoenzymes and immobilized enzymes. Abzymes, pseudoenzymes, bifunctional enzymes and enzyme promiscuity. Regulation of enzyme activity, allosteric regulation. Multi substrate reactions, kinetic experiments to determine the mechanism of multi substrate reactions. Isolation, purification and measurement of enzyme activity. Enzyme units. Enzyme engineering. Role of enzymes in agriculture, industry, and medicine. Structure, mode of action and metabolic functions of vitamins. Deficiency diseases associated with vitamins. General description of nature hormones and disorders associated with endocrine glands, viz. pituitary, thyroid, adrenal, pancreas and gonads. Peptide and steroid hormones. Phytohormones – auxins, gibberellins, cytokinins, ethylene, abscisic acid and new plant bio-regulators like SA, Brassino steroids. Molecular mechanism of plant hormone action.

### **Unit 4: Molecular Biology**

Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression

in prokaryotes and eukaryotes. Chloroplast and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization. Computer application in molecular biology, primer designing, sequence analysis and phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips.

### **Unit 5: Techniques in Biochemistry**

Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Electrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. PCR, Quantitative PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. MALDI-TOF and metabolite profiling techniques such as ICP-MS. X-ray diffraction, IR, NMR, FTIR, GC-MS, LC-MS. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression.,

### **Unit 6: Biochemistry of Food-grains, Fruits and Vegetables**

Fundamentals of nutrition, concept of balanced diet. Nutritional quality of protein and its evaluation. Dietary fibre. Vitamins- biochemical functions and deficiency diseases. Fats and lipids-types of fatty acids and their significance in health. Biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables. Biochemistry of fruit ripening, Biochemical aspects of post-harvest technology, storage and preservation of cereals, pulses, oilseeds, fruits and vegetables. Food enzymes. Biochemical basis of quality improvement of food grains, vegetables and fruits. Antioxidants, nutraceuticals. Food toxins and anti-metabolites, food additives, storage proteins. Processability of food grains. Bioavailability of nutrients and effect of food matrices, storage and processing on the functionality and bioavailability of nutrients.

### **Unit 7: Photosynthesis**

Photosynthesis – photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Conversion of C3 to C4 plants. Regulation of Rubisco. Chemiosmotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplast morphology, structure and biochemical anatomy. Cytosolic and organelle interactions. Nature and exchange of metabolites through translocators. Seed reserve biosynthesis.

### **Unit 8: Plant Metabolic Processes**

Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates.

### **Unit 9: Plant Molecular Biology**

General organization of nuclear, mitochondrial and chloroplast genomes. Genomics and functional genomics. Transcriptomics and Proteomics. Tissue specific expression of genes. Molecular biology of various stresses – drought, salinity and temperature. Signal transduction and its molecular basis: Structure, organization and regulation of nuclear genes. Genes involved in photosynthesis and nitrogen fixation. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Molecular markers in plants and their uses.

## **Unit 10: Plant Biotechnology/Genetic Engineering**

Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplast fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer – direct and vector mediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – nutritional and processing quality improvement, shelf life enhancement, insect-pest resistance (insect, viral, fungal and bacterial diseases), abiotic stress tolerance and herbicide resistance, Biosafety and IPR issues. Genome editing techniques and tools.

## **09. PLANT PHYSIOLOGY/ CROP PHYSIOLOGY**

### **Unit 1: Cell Organelles and Water Relations**

Cell organelles and their physiological functions Structure and physiological functions of cell wall, cell inclusions. Cell membrane structure and functions. Water and its role in plants, properties and functions of water in the cell, water relations, water potential of plant cells. Mechanism of water uptake by roots transport in roots, movement of water in plants, water loss from plants, energy balance, solar energy, input energy dissipation at crop canopy level. Evapotranspiration, plant factors influencing transpiration rate. Stomata, structure function - Mechanism of stomatal movement, antitranspirants. Physiology of water high temperature and salinity stress in plants. Influence of water stresses at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

### **Unit 2: Metabolic Processes and Growth Regulation**

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bio productivity. Photochemical process-Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, CO<sub>2</sub> fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides. Translocations of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism. Inorganic nitrogen species (N<sub>2</sub>, N<sub>3</sub>, NH<sub>3</sub>) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism- storage, protective and structural lipids. Secondary metabolites and their significance in plant defence mechanism. Growth and differentiation, hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cytokinin's, ABA, ethylene, etc.), biosynthesis of growth hormones and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photo-morphogenesis, photo- receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation.

### **Unit 3: Crop Productivity and Modelling**

Role of crop physiology in agriculture, crop growth and productivity, crop growth models describing yield (Duncan/Passioura), phenology-crop productivity, growth factors related to biomass - concept of growth rates canopy photosynthesis (leaf area and net assimilation rates as determining factors). Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink, factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.

### **Unit 4: Abiotic Stress Responses in Plants**

Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought 21 characteristic features, water potential in the soil plant-air continuum. Development of water deficits, energy balance concept, transpiration and its regulation – stomatal functions/VPD. Physiological process affected by drought. Drought resistance mechanisms: Escape, dehydration

postponement (Drought avoidance), Dehydration tolerance, and characteristics of resurrection plants. Osmotic adjustment Osmoprotectants, stress proteins. Water use efficiency as a drought resistance trait. Molecular responses to water deficit stress perception, expression of regulatory and function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as negative signal. Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSPs chilling stress; effects on physiological processes. Crucial role of membrane lipids. Salinity: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatin (heavy, metal binding proteins).

### **Unit 5: Plant Growth Regulators and Plant Development**

Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteroids, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinin's, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction Hormone mutants. Hormonal regulation of gene expressions at various developmental stages of plant-flowering, seed maturity, seed dormancy. Action of hormones on cellular functions: Auxins- cell elongation, retardation of abscission of plant parts, gibberellins – stem elongation, germination of dormant seeds, cytokinin's-cell division, retardation of senescence. Abscisic acid stomatal closure and induction of drought resistance, ethylene- fruit ripening, acceleration of senescence of leaves. Interaction of hormones in regulation of plant growth and development processes. Synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Growth and differentiation, hormonal concept of growth and differentiations. Rooting of cuttings- flowering- physiological and molecular aspects of control of reproductive growth. Apical dominance, senescence and abscission. Fruit growth and development, physiological and molecular aspects of ripening processes and improving post- harvest life of fruits. Induction and breaking dormancy in seeds and buds. Synthetic growth regulators. Practical utility in agriculture and horticulture. Herbicides, classification and their mode of action.

### **Unit 6: Mineral Nutrition**

Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of bio-membranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplast) to sieve across the root cortical cells-factors contributing to xylem loading. Long distance transport in xylem and phloem, xylem unloading in leaf cells. Uptake and release of mineral nutrients by foliage. Rhizosphere and root biology, root growth, influence of microorganism in nutrient acquisition, release and uptake by plant roots. Yield and mineral nutrition-concept of nutrient use efficiency, Mineral nutrition under adverse soil situations-drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc. Soil less culture – Hydroponics - Role of Macro, Micro and beneficial nutrients- Identification of nutrient deficiencies and toxicities.

### **Unit 7: Climate and Climate Change**

Climate-Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable <sup>18</sup>O discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warming. CO<sub>2</sub> as an important greenhouse's gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric CO<sub>2</sub> level. Effect of elevated CO<sub>2</sub> on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCM models, effects on climate and biota. High temperature and CO<sub>2</sub> interaction on plant growth and productivity, ionising radiation UV-B chlorofluoro carbon (CFC)– their impact on ozone layer- ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution, SO<sub>2</sub>, NO, methane, ozone, peroxy

acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent-their effect, on aquatic ecosystem, plant growth and development.

### **Unit 8: Seed Physiology**

Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Hydration of seeds. Physiological processes. Seed respiration, mitochondrial activity Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored reserves. Role of embryonic axes. Gibberellin and  $\alpha$ -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy.

### **Unit 9: Physiology of Flowering and Reproduction**

Evolutionary history of flowering plants (angiosperms). Semelparous and iteroparous reproduction, monocarpic and perennial life etc. Flowering phenomenon, effect of plant age, juvenility- transition to flowering. Flowering nature and classification of plants. Photoperiodic responses and the mechanisms in short- and long-day plants. Theories related to flowering. Endogenous substances and flowering. Gene expression in flowering. Control of flowering. Thermoperiodism - photo and thermo-period interactions. Vernalization- mechanism. Photomorphogenesis, photoreceptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalization. Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology. Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (pollen-stigma interactions), seed and fruit development, seed and fruit abortion and means to overcome it. Molecular biology of seed development, physiological basis of cytoplasmic male sterility and fertility restoration. Physiology of heterosis.

### **Unit 10: Physiology of Horticultural and Plantation Crop Species**

Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots, patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration rate and water use efficiency. Sexual and asexual propagation. Rootstock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops: mango, banana, grapes, citrus, papaya and pineapple etc. Physiological aspects of plantation crops: tea, coffee, cardamom, coconut, and black pepper. Physiological constraints and remedial measures of horticultural and plantation crops.

### **Unit 11: Post-Harvest Physiology**

Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds. Physiological and biochemical changes during fruit ripening and storage. Senescence and post-harvest life of cut flowers. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life. Edible vaccine.

### **Unit 12: Morphogenesis, Tissue Culture and Plant Transformation**

Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and diffusive growing cells. Control of cell division and differentiation, Phyto-chromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry of differentiation, in organ cell, tissue and cultures, micropropagation strategies, application of tissue culture in agriculture, horticulture, forestry and industry: plant transformation; transformation vectors, concept of selectable and scorable markers. Agrobacterium mediated

transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis. PCR, Southern analysis evaluation of transgenic plants.

### **Unit 13: Phenomics**

Phenotyping methods, phenotyping under different abiotic stress like drought, High temp., salinity etc. Image based phenotyping traits, Use of UAV in phenotyping and trait dissection under field conditions

## **10. AGRICULTURAL BIOTECHNOLOGY/BIOTECHNOLOGY/MOLECULAR BIOLOGY & BIOTECHNOLOGY**

### **Unit 1: Cell Structure and Function**

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: Nucleus, vacuoles, mitochondria, plastids, Golgi apparatus, ER, lysosomes, peroxisomes, glyoxisomes. Cell cycle-Regulation of cell cycle. Cell division, growth and differentiation. Protein secretion and targeting. Transport across cell membrane, Cell signaling, Developmental biology of plants, programmed cell death (apoptosis), Cell renewal and cancer, stem cell applications.

### **Unit 2: Biomolecules and Metabolism**

Structure and function of carbohydrates, lipids, proteins and nucleic acids, Synthesis of carbohydrate, glycolysis, HMP, Citric acid cycle and metabolic regulation, Oxidative phosphorylation and substrate level phosphorylation, Vitamins, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

### **Unit 3: Enzymology**

Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catalytic specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

### **Unit 4: Molecular Genetics**

Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operon, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

### **Unit 5: Gene Expression**

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA- protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications. Epigenetic control of gene expression; Regulatory RNA in gene regulation - Small RNAs, RNA interference and its applications.

### **Unit 6: Molecular Biology Techniques**

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Spectroscopy, Polymerase chain reaction, real time PCR, RT-PCR, ultracentrifugation, chromatography, FISH, RIA, etc. Next generation genome sequencing techniques, basic bioinformatics, microarray, etc. Proteomics, 2D and protein sequencing, metabolomics.

## **Unit 7: Gene Cloning**

**DNA manipulative and modifying enzymes**-restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagemids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gateway cloning vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Gene pyramiding and gene fusion, ribozyme technology. Biological risk assessment and IPR.

## **Unit 8: Molecular Biology**

Genome complexity-C value and C-value paradox; DNA re-association kinetics. Analysis of repetitive sequences. Molecular events in DNA replication, transcription and translation. RNA processing and post transcriptional modifications. Ribosome structure and function. Protein biosynthesis in prokaryotes and eukaryotes. Post-translational modification. Gene regulation, DNA damage-types and repair mechanisms. Bioprospecting. Non coding RNA.

## **Unit 9: Plant Molecular Biology**

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Advances in conversion of C3 to C4 pathway. Molecular biology of various stresses, viz. abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action, Hormone regulatory pathways, mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis. Crop genome sequencing projects.

## **Unit 10: Tissue Culture**

Basic techniques in cell culture and somatic cell genetics. Clonal propagation. Concept of cellular totipotency. Androgenesis and gynogenesis, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. In vitro mutagenesis, cryopreservation and plant tissue culture repository. Synthetic seeds, Virus indexing.

## **Unit 11: Plant Genetic Engineering**

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, viz. direct and vector-mediated. Molecular analysis of transformants. RNAi technology. Cisgenesis. Molecular pharming, bioremediation. GM detection methods. Resistance management strategies for target traits. Potential applications of plant genetic engineering for crop improvement, i.e., insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, biofortification, Genetic engineering for pollination control, Induction of male sterility in plants. Current status of transgenics, biosafety norms and controlled field trials and release of transgenics (GMOs). IPR, genome editing technique.

## **Unit 12: Molecular Markers and Genomics**

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA sequences (RAPD), amplified fragment length polymorphism (AFLP), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), DaRT, SRAP, TRAP markers. Structural and functional genomics, gene mapping, genome mapping-GWAS and Genomic selection, gene tagging and comparative genomics and application of genomics. TILLING and ECOTILLING applications. Development of mapping population and types of mapping populations-RILs, NILs, F2, BILs, DH, MAGIC, Mutant populations. Linkage mapping. Association mapping, Molecular mapping of complex traits and Marker Assisted Selection and other applications of markers: MABC, MARS and Genomic Selection. DNA fingerprinting and barcoding. Phylogeography, conservation genetics. DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Proteomics, Metabolomics and ionomics.

## 11. AGRICULTURAL MICROBIOLOGY/MICROBIOLOGY

### Unit 1: History of Microbial World

Microbial world, History of microbiology and types of micro-organisms, Prokaryotic and eukaryotic cell, Classification and major characteristics of different microbial groups.

Morphological characteristics, Internal structures and their functions in bacteria, archaea, algae, cyanophages, viroids, prions, fungi, actinobacteria, mycoplasma, rickettsias, chlamydia, viruses, bacteriophages.

Basics of microbial growth and reproduction, Bacterial communication, Environmental and nutritional requirements for microbial growth, Pure cultures, Control of microorganisms: Principles, methods including radiation, Chemicals, Antibiotics etc.

Classification of fungi. Life cycles of important phytopathogenic fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

### Unit 2: Basic Microbiological Techniques

An introduction to laboratory instruments, Safety rules in laboratory, Handling of different glassware. Methods of sterilization and disinfection. Handling of autoclave, Hot air oven, BOD incubator, Laminar flow, Colony counter, pH meter, biological filters; Spectrophotometer.

Isolation and preservation of different types of microorganisms; Microscopy: Light, Compound, Dark field, Phase Contrast, Fluorescent, EM, TEM, SEM; Wet mount, Hanging drop technique, Stains and staining techniques.

Types of culture and culture media, Inoculation techniques, Isolation of pure culture, Proof of purity of cultures, Maintenance and preservation of pure cultures, Culture collections.

Identification of bacteria using biochemical tests, Introduction and importance of Bergey's Manual, Bioassay techniques, Antibiotic sensitivity of bacteria.

Isolation of Genomic DNA and PCR amplification in bacteria and cyanobacteria, RAPD and RFLP, Isolation of plasmids, Protein profiling by SDS-PAGE.

### Unit 3: Microbial Physiology

Microbial growth, Requirements for growth; Bacterial division, growth kinetics, Energetics of growth; Types/modes of growth - Batch culture, Synchronous growth, Continuous growth, Chemostat and Turbidostat, Growth characteristics, Measurement of microbial growth: Plate counts, Filtration, The Most Probable Number (MPN) method, Direct microscopic count, Indirect methods; Growth yield and its significance. Energy yielding pathways in microorganisms, Catabolic and anabolic reactions – Aerobic respiration: Glycolysis, Substrate level phosphorylation, Electron transport chain and oxidative phosphorylation, 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, Catabolism of other kind of organic substrates, Anaerobic respiration, Dissimilatory and assimilatory reductions, Types of fermentation, Fermentation balances.

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, 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. Physiology of chemolithotrophs.

Enzymes and chemical reactions, Enzyme specificity and efficiency, Classification, Enzyme components, Mechanism and Factors influencing enzymatic activity: Temperature, pH, substrate concentration, Inhibitors, Feedback inhibition, Ribozymes, Coenzymes.

Cell wall and its biosynthesis; Polysaccharide biosynthesis, Lipid biosynthesis, Biosynthesis of nitrogenous compounds-Amino acid and proteins, Purine and pyrimidines, Nucleic acids. Proteins 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. 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.

#### **Unit 4: Microbial Genetics**

Principles of microbial genetics; Gene organization in bacteria, Archeae, Eukaryotes and viruses; Gene regulation and expression in these organisms; Plasmids and their inheritance; Transposons and insertion sequences; DNA replication; Mutations and DNA repair mechanisms; Gene and genetic code; Nucleic acid synthesis and Protein synthesis: Transcription, Translation and Post Translational modifications; Genetic recombination in bacteria: Transformation, Conjugation, Transduction; Restriction enzymes; vectors; Virus multiplications and Genetics analysis of bacteriophages and cyanophages.; Genome and gene editing. Introduction to gene cloning.

#### **Unit 5: Soil Microbiology**

Role of microorganisms in soils, Major microbial indicators of soil health and their significance, Direct and indirect methods of studying soil microorganisms and their activities. Soil microbial interactions: Types and significance. Carbon cycle: Biodegradation of starch, Cellulose, Hemicellulose, Pectin and lignin in soil, Decomposition of organic matter, Humus and fulvic acid, Quantity and distribution of organic matter in soil, role of microorganisms in decomposition of soil organic matter, Dynamics of microorganisms during different stages of OM decomposition, Humus and its fractions, contribution of humus to soil quality. Nitrogen cycle: Ammonification, Nitrification, Denitrification, Non-symbiotic and symbiotic nitrogen fixation through bacteria and nitrogen assimilation. Environmental influences on microorganisms, Effect of temperature, aeration, moisture, osmotic pressure, pH. Recent development on the role of microbial communities and role in nutrient cycling. Transformation of phosphorus, Sulphur, Iron, Manganese, Magnesium, Copper, Mercury and Arsenic.

Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root- soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Biofertilizers – definition, classification, specifications, and role in crop production.

#### **Unit 6: Microbial diversity and Ecology**

Molecular approaches for measuring the microbial diversity: RISA, TGGE, DGGE, T-RFLP, BIOLOG, FAME analysis. Plant-microbe interactions, Endophytic and pathogenic interactions, Rhizosphere, Rhizoplane, Spherosphere and phyllosphere, Root exudates, Quorum-sensing in bacteria, Flow of signals in response to carbon substrates. 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. Mycorrhizae: Types of mycorrhizae, Mycorrhizal links with plants and their functioning. Biochemical/ Molecular aspects. Type three secretion systems, Plant growth promoting rhizobacteria (PGPR) and their direct and indirect mechanisms of action, Biocontrol agents and their mechanisms.

#### **Unit 7: Microbiology of food and water**

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. 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. Mycotoxins, Microbiological quality assurance, Hazard analysis and critical control point (HACCP) concept, Methods for examination of microorganisms in food. Composition of milk and factors affecting the composition, Microbiology of milk, Fermented milk products, Cheese, Pasteurisation, Spoilage of milk and its products, Microbiological methods for examination

of milk and its products, Probiotics -concept, microorganisms and proteins used in probiotics; Bacteriological standards for milk and milk products.

Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne diseases and their spread and prevention. Modern tools in food and aquatic microbiology- PCR based techniques, microarrays, sensors.

### **Unit 8: Industrial Microbiology**

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.

New approaches and advances in downstream processing, Primary and secondary metabolites, Ethanol, Second generation biofuels, Beer, Wine and Cider fermentation.

Enzyme production: Rennet, Cellulase, Amylase *etc.*, Microbial enzymes, Immobilisation of enzymes, Organic acid, Vinegar production, Amino acid production: Glycine and Glutamic acid, Biomass production, Microbial insecticides. Single cell protein production for use as food and feed, Vitamin and related compounds (Carotenoid, Vitamin B12, Riboflavin), Antibiotic production, Biotransformation, Bioplastics, Bioprocess cost evaluation. High and low volume/value products, Bioprocess cost evaluation, Product finishing, formulation, encapsulation, immobilization, preservation, quality. Current advances in production of antibiotics, vaccines, Biotransformation, Bioplastics, Production of recombinant DNA products; production of vitamins and fine chemicals, source of single cell protein (SCP). Yeast technology, Genetics and strain improvement for brewing, baking and distilleries.

### **Unit 9: Applications of microorganisms in agriculture**

Role of microbes in bioindustries, Value addition, Production of recombinant vaccines and hormones, Biosensors, Bio flavors, Biowarfare, Bioremediation Bioprocess engineering; Process design for various classes of products. Microorganisms in aquatic environment, pollution control, Bioindicators of pollution, Metal detoxification, Controlled photosynthesis and its application, Bioremediation, carbon sequestration, mitigation of global warming and environmental sustainability. Pesticides: Types, Resistance to microbes and metabolism; Residual effects of pesticides. Extremophiles as source of novel bioproducts, Microbial biofilms and their applications, Anaerobes in industry and environment, Serology and Immunodiagnostics in agriculture, Transplantation immunology. Microbial ore leaching (biomining), Microbial enzymes in clinical diagnostics, Metabolic pathway engineering, Principles of crop inoculation with microbial agents, Overview of microbial inoculants and their production, Carriers for inoculants- types and their characteristics, Strain selection 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. *Rhizobium*-evaluation as biofertilizer, *Azotobacter*-evaluation as biofertilizer, Phosphate solubilizing microorganisms: Methods for their identification, AM fungi, Ecology of inoculants/ microorganisms in soil, Biocontrol agents. Biogas production technology, Methanogens, Methanotrophs and their applications. Retting and Silage production, Techniques of composting and vermicompost and their evaluation. Microbial inoculants: Formulation and application methods; Quality standards of inoculants.

Role of microorganisms in sewage treatment, Phyto and microbial remediation approaches; Biological oxygen demand, Effluent management, Integrated systems for pollution abatement and clean water. Microbial strategies for mitigation of stress. Patents and IPR issues in microbiology.

### **Unit 10: Microbial omics**

Microbial Genomics, metagenomics, metatranscriptomics, Proteomics, Microbial functional genomics; Principles, methods and recent advances in DNA sequencing; RNA and protein sequencing; Microbial Gene Manipulation- Gene fusions and reporter genes; Microbial genes for improving resistance to biotic stresses and tolerance to abiotic stresses in crop plants; Microbial genes for quality improvement in agricultural products and value addition; Concept of Microbiome: Soil and Plant Microbiome. 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. Bioinformatics, Bioprospecting, Microbial diversity and global environment issue, IPR and biosafety.

### **Unit 11: Data Analysis**

Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; t-test, chi-square ( $\chi^2$ ), F test, Probit analysis. Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

## **12. VEGETABLE SCIENCE / OLERICULTURE**

### **Unit 1: Production Technology of Cool Season Vegetable Crops**

Introduction, climatic and soil requirement, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of potato, chow chow, Cole crops: cabbage, cauliflower, knol khol, sprouting broccoli, Brussels sprout, root crops: carrot, radish, turnip, and beetroot, bulb crops: onion and garlic, Peas and beans, leafy vegetables : palak

### **Unit 2: Production Technology of Warm Season Vegetable Crops**

Introduction, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of: Tomato, eggplant, hot and sweet pepper, Okra, vegetable cowpea, Dolichos lablab and cluster bean, Cucurbitaceous crops, and sweet potato, cassava, yams, coclocasia, moringa and amaranths.

### **Unit 3: Breeding of Vegetable Crops**

Cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, biotechnology and their use in breeding in vegetable crops - molecular marker, genomics, marker assisted selection and QTLs. Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot, beetroot, radish, moringa, Amaranthus, cassava, sweet potato, lab, onion and garlic

### **Unit 4: Growth and Development**

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production; Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinin's and abscisic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; sex expression in cucurbits and checking flower and fruit drops and improving fruit set in Solanaceous vegetables Role and mode of action of antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production; Role of light, temperature and photoperiod on growth, development of underground parts, apical dominance; Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening; Plant growth regulators in relation to morphogenesis and tissue culture techniques in vegetable crops.

### **Unit 5: Seed Production**

Introduction, importance and present status of vegetable industry.; modes of propagation in vegetables; Seed morphology and development in vegetable seeds; Floral biology of these plant species; classification of vegetable crops based on seed dormancy pollination and reproduction behavior; steps in quality seed production; identification

of suitable areas/locations for seed production of these crops; methods of seed production; comparison between different methods e.g. pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage; Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceae, Cole crops, leafy vegetables, root, tuber and bulb crops; harvesting/picking stage and seed extraction in fruit vegetables, grading, storage, seed quality testing and seed certification standards; clonal propagation and multiplication in tuber crops e.g. Potato and sweet potato, seed-plot technique in potato, TPS (True Potato Seed); hybrid seed production technology of vegetable crops; maintenance of parental lines; use of male sterility and self-incompatibility in hybrid seed production.

### **Unit 6: Systematics of Vegetable Crops**

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops; Origin, history, evolution and distribution of vegetable crops, taxonomy, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Floral biology, Cytological level of various vegetable crops; descriptive keys for important vegetables; Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops :Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot ,beetroot, radish, moringa, Amaranthus, cassava, sweet potato, lab, onion and garlic

### **Unit 7: Production Technology of Underexploited Vegetable Crops**

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, planting time and method, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of: Asparagus and leek; Chinese cabbage, Chinese potato, and kale; Amaranth, , parsnip, rhubarb, basella and bathu (chenopods); lima bean, winged bean, vegetable pigeon pea and sword bean; Sweet gourd, spine gourd, pointed gourd, Ivy gourd

### **Unit 8: Post-Harvest Technology of Vegetable Crops**

Importance and scope of post-harvest management of vegetables; Maturity indices and standards for different vegetables; methods of maturity determinations; biochemistry of maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, regulation methods; Harvesting tools, harvesting practices for specific market requirements; grading, post-harvest physiological and biochemical changes, disorders- chilling injury in vegetables, influence of pre-harvest practices and other factors affecting post-harvest losses, packaging house operations, commodity pre-treatments- chemicals, wax coating, pre-packaging and irradiation; packaging of vegetables, post-harvest, diseases and prevention from infestation, principles of transport; Methods and practices of storage-ventilated, refrigerated, MA, CA storage, hypobaric storage, precooling and cold storage, zero energy cool chamber; HACCP, Codex ,FSSAI.

### **Unit 9: Organic Vegetable Production Technology**

Importance, principles, prospective, concept and component of organic production of vegetable crops, managing soil fertility, pest, disease and weed problem in organic farming system, crop rotation in organic vegetable production. Method of enhancing soil fertility, mulching, raising green manure crops, indigenous methods of compost, panchgavya, biodynamics preparation, ITKs organic farming. Role of botanicals and bio- control agents. GAP and GMP, organic certification standards, opportunity and challenges in organic production of vegetables.

### **Unit 10: Hi-tech Production Technology of Vegetable Crops**

Importance and scope of protected cultivation of vegetable crops, principles used in protected cultivation and greenhouse technology, effect of temperature, carbon dioxide, humidity; energy management, low cost structures, training methods, engineering aspects, classification of protected structures including low cost poly-house/ green houses and other structures in vegetable production, types of cladding material, types of media, Mulching, solarisation, fumigation, Drip and sprinkler irrigation, fertigation, ,special horticultural practices, hydroponics,

vertical farming and soilless culture for enhancing productivity and off-season of high value vegetable crops like tomato, capsicum and cucumber.

### **13. FRUIT SCIENCE/POMOLOGY**

#### **Unit 1: Tropical and Dry Land Fruit Production**

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, canopy management, nutrient management, water management, fertigation, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders—causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Mango, Banana, Citrus, Papaya, Guava, Sapota, Annonas, Aonla, Bael, Wood apple, Jamun, Pomegranate, Ber and minor fruits of tropics.

#### **Unit 2: Subtropical and Temperate Fruit Production**

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio - regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Avocado, Pineapple, Jackfruit, Mangosteen, Carambola, Fig and Rambutan, Litchi, Loquat, Apple, Pear, Quince, Grapes, Plums, Peach, Apricot, Cherries, Persimmon, Kiwifruit, Strawberry, Walnut, Almond, Pistachio, Hazelnut.

#### **Unit 3: Biodiversity and Conservation**

Biodiversity and conservation; issues and goals, centres of origin of cultivated fruits; primary and secondary centres of genetic diversity; present status of gene centres; exploration and collection of germplasm; Role of NAGS; Conservation of genetic resources—conservation *in situ* and *ex situ*. Germplasm conservation – problem of recalcitrancy-cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine; intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group; GIS and documentation of local biodiversity, geographical indication. Crops: Mango, Sapota, Citrus, Guava, Banana, Papaya, Grapes, Jackfruit, Custard apple, Ber, Aonla, Malus & Prunus sp., Litchi and Nuts.

#### **Unit 4: Canopy Management in Fruit Crops**

Canopy management - importance and advantages; factors affecting canopy development; Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies; Spacing and utilization of land area - canopy classification; Canopy management through rootstock and scion; Canopy management through plant growth retardants, training and pruning and management practices; Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, Grapes, Mango, Sapota, Guava, Citrus and Ber.

#### **Unit 5: Breeding of Fruit Crops**

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, breeding constraints ideotypes, approaches for crop improvement – introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops. Crops: Mango, Banana, Pineapple, Citrus, Grapes, Guava,

Sapota, Jackfruit, Papaya, Custard apple, Aonla, Avocado, Ber, Litchi, Jamun, Phalsa, Mulberry, Raspberry, Apple, Pear, Plums, Peach, Apricot, Cherries and Strawberry.

### **Unit 6: Post-Harvest Technology**

Maturity indices, harvesting practices and grading for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration; Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling; Treatment prior to shipment, *viz.*, chlorination, waxing, chemicals, bio-control agents and natural plant products, fungicides, hot water, vapour heat treatment, Sulphur fumigation and irradiation. Methods of storage-ventilated, refrigerated, MAS, CA storage, physical injuries and disorders; Packing methods and transport, quality evaluation, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jelly, candy; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management and food safety standards; Role of HACCP.

### **Unit 7: Growth and Development**

Definition, parameters of growth and development, growth dynamics, morphogenesis; Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism; Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinin's, abscisic acid, ethylene, brassinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors, developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development; Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

### **Unit 8: Biotechnology of Fruit Crops**

Harnessing bio-technology for improvement of horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture; Callus culture -types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, *ex vitro*, establishment of tissue culture plants; Physiology of hardening - hardening and field transfer, organ culture-meristem, embryo, anther, ovule culture, embryo rescue, soma clonal variation, protoplast culture and fusion; Construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering and transformation in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops and application of gene editing tools in horticultural crops.

### **Unit 9: Protected Fruit Culture**

Greenhouse – world scenario, Indian situation; present and future, different agro-climatic zones in India, environmental factors and their effects on plant growth; Basics of greenhouse design, different types of structures-glasshouse, shade net, poly tunnels-Design and development of low cost greenhouse structures;

Interaction of light, temperature, humidity, CO<sub>2</sub>, water on crop regulation - Greenhouse heating, cooling, ventilation and shading; Types of ventilation-Forced cooling techniques-Glazing materials-Micro irrigation and Fertigation; Automated green houses, microcontrollers, waste water recycling, management of pest and diseases-IPDM.

### **Unit 10: Principles and Practices of Plant Propagation**

Introduction, life cycle in plants, cellular basis for propagation. Sexual propagation – apomixis, polyembryony, chimeras. Factors influencing seed germination, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing. Rooting of cuttings under mist and hot beds.

Physiological, anatomical and biochemical aspects of root induction in cuttings. Selection of elite mother plants. Establishment of bud wood bank. Stock, scion and inter stock relationship and incompatibility. Physiology of dwarfing rootstocks. Rejuvenation of senile and seedling orchards progeny orchard and scion bank. Micropropagation *In vitro* clonal propagation, director ganogenesis, embryogenesis, micro grafting and meristem culture. Hardening, packing and transport of micro-propagules.

## **14. FLORICULTURE & LANDSCAPING/ FLORICULTURE & LANDSCAPE ARCHITECTURE**

### **Unit 1: Breeding**

Principles – Evolution of varieties, origin, distribution, genetic resources, genetic divergence. Patents and Plant Variety Protection in India; Genetic inheritance of flower colour, doubleness, flower size, fragrance, post-harvest life; Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants – introduction, selection, domestication, polyploidy and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops; Breeding constrains and achievements made in commercial flowers – rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliiums, Breeding constrains and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliage's – Introduction and selection of plants for water scaping and xeriscaping.

### **Unit 2: Production Technology of Cut Flowers**

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India – Patent rights, nursery management, media for nursery, special nursery practices; Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO<sub>2</sub> on growth and flowering; Flower production – water and nutrient management, rationing, fertigation, weed management, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes; Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation; Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage and transportation, marketing, export potential, institutional support, Agrl. Export Zones; Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, lilies, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliage.

### **Unit 3: Production Technology for Loose Flowers**

Scope of loose flower trade, Significance in the domestic /export markets, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shade nets, transplanting techniques; Soil and climate requirements, field preparation, systems of planting, precision farming techniques; Water and nutrient management, weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM; Flower forcing and year-round flowering production for special occasions through physiological interventions, chemical regulation; Harvest indices, harvesting techniques, post-harvest handling and grading, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agrl. Export Zones; Crops – Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, celosia, gomphrena, non-traditional flowers (barleria, Nyctanthes, Tabernaemontana, ixora, lotus, pandanus, etc.).

### **Unit 4: Landscaping**

Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanas, Buddha garden; Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates; Garden plant

components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants; Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves; Bio-aesthetic planning, eco- tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

### **Unit 5: Protected Floriculture**

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation; Environment control – management and manipulation of temperature, light, humidity, air and CO<sub>2</sub>; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation; Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM; Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.), Staking and netting, Photoperiod regulation; Harvest indices, harvesting techniques, post-harvest handling techniques, Pre-cooling, sorting, grading, packing, storage, quality standards.

### **Unit 6: Value Addition**

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management; Types of value-added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement styles, ikebana, moribana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations; Dry flowers – Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Plant pigments: Significance of natural pigments, Applications; Selection of species and varieties, Types of pigments - carotenoids, anthocyanin, chlorophyll, betalains; Extraction methods; Packing and storage, .

### **Unit 7: Turfing and Turf Management**

Prospects of landscape industry, History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment; Turf grasses – Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement – Adaptation; Turfing for roof gardens; Preparatory operations; Growing media used for turf grasses – Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing; Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing – mowing equipment's, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs; Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

### **Unit 8: Computer Aided Designing (CAD) for Outdoor and Indoor scaping**

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing; 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LOT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects; Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for

outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout; 3D drawing methods, ARCHICAD file system, Tools and Info box, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD; ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, data management, plotting and accessories for designing, inserting picture using Photoshop, Making sample drawing for outdoor and indoor gardens.

## **15. POST HARVEST TECHNOLOGY**

### **Unit 1: Post-Harvest Technology of Vegetable Crops**

Scope and importance of post-harvest management of vegetables; Nature and causes of post-harvest losses; Maturity indices and standards for different vegetables; methods of assessment of maturity, physiological and biochemical changes during maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, regulation methods; Influence of pre-harvest practices and other factors affecting shelf life and post-harvest quality; Harvesting methods, tools, harvesting practices for specific market requirements; pre cooling methods; grading, washing, pack house operations, pretreatments- chemicals, wax coating, edible coating, prepackaging and irradiation; packaging of vegetables, packaging materials; Storage methods - ventilated, refrigerated, MA, CA storage, hypobaric storage, cold storage, zero energy cool chamber; Storage disorders -chilling injury in vegetables, post-harvest diseases and pests - prevention from infestation; principles of transport; food safety standards and export standards.

### **Unit 2: Post-Harvest Technology of Fruit Crops**

Scope and importance of post-harvest management of fruits; Factors leading to post-harvest losses; Maturity indices, methods of assessment of maturity, harvesting practices and grading for specific market requirements; Physiological and biochemical changes during maturity and ripening, ethylene evolution and ethylene management; enzymatic and textural changes, respiration, transpiration; Influence of pre-harvest practices and other factors affecting shelf life and post-harvest quality; Harvesting methods, tools, harvesting practices for specific market requirements; Pre cooling methods; grading, washing, pack house operations, pretreatments treatment prior to shipment, viz., chlorination, waxing, chemicals, bio-control agents and natural plant products, fungicides, hot water, vapour heat treatment, Sulphur fumigation and irradiation; Prepackaging and irradiation, packaging of fruits, packaging materials; Storage methods - ventilated, refrigerated, MAS, CA storage ; Physical injuries and disorders; Transportation and marketing standards for international markets, quality evaluation, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards and export standards.

### **Unit 3: Value Addition of flowers**

Prospects of value addition; National and global scenario, production and export; Women empowerment through value added products making, supply chain management; Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations; Value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, floral craftsets; Selection of containers and accessories for floral products and decorations; Aromatherapy, pigment and natural dye extraction techniques; Dry flowers – Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packaging and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications ; Export standards.

#### **Unit 4: Processing of Plantation Crops, Spices, Medicinal and Aromatic Plants**

Prospects of processing and value addition, National and global scenario, production and exports; Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils; Processing of produce from plantation crops, viz. coconut, arecanut, cashewnut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber etc.; Processing of medicinal plants– dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safedmusli, senna, aloe, catharanthus, etc. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on active principles; Extraction and analysis of active principles using TLC/HPLC/GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Extraction of aroma compounds and aromatherapy; Extraction of pharmaceutical and nutraceutical compound from medicinal and aromatic crops; Application of nano technology in medicinal and aromatic plants. Applications; Export standards.

### **16. FARM MACHINERY AND POWER ENGINEERING**

#### **Unit 1: Design of Tillage and Planting Machinery**

Modern trends, principles, procedures, fundamentals and economic considerations for design and development of farm machinery. Design considerations, procedure and their applications in tillage and planting machinery. Design of coulters, shares, mould boards, landside, frog, jointer. Forces acting on plough bottom and their effect. Draft on ploughs. Design of disk ploughs, concave disk working tools and forces acting on disc ploughs. Machines and implements for surface and inter row tillage, peg toothed harrow, disk harrows, graders, rollers, cultivators, design of V shaped sweeps -rigidity of working tools. Rotary machines, trajectory of motion of rotary tillertynes, forces acting and power requirement. Machines with working tools executing an oscillatory motion. Methods of sowing and planting. Grain hoppers, seed metering mechanism, furrow openers and seed tubes. Planting and transplanting, paddy transplanters and potato planters.

#### **Unit 2: Design of Plant Protection and Harvesting Equipment's**

Modern trends, principles, procedures, fundamentals and economic considerations for design and development of plant protection and harvesting machinery. Machines for fertilizer application and discs type broadcasters. Organic fertilizer application, Properties of organic manure and spreading machines. Liquid fertilizer distributors. Function of sprayer, atomization principles, hydraulic sprayers. Air blast spinning disc and electrostatic sprayers. Design of sprayer components, pumps, pressure vessel, nozzle, materials of construction. Spraydroplets and distribution pattern. Spray application to orchards. Physico-mechanical properties of grass and cereal stalks, resistance to cutting, speed of cutting of stalks, cutting angle of the knife segment. Kinematics of the drive mechanisms of cutting equipment's. Mowers, Design and construction, mowers with rotary cutting units, mower pick up chopper and loader. Grain harvesting, combines and its features. Threshing unit, types and separation process. Straw walker, separation of straw in oscillating straw walker. Grain cleaning and grading and principal parameters. Root crop harvesting, potato other root crop.

#### **Unit 3: Testing and Evaluation of Agricultural Machinery**

Types of tests; test procedure, need for testing & evaluation of farm equipment's and standardization of testing machinery, available national and international codes. Need of test codes and advantages of certification. Measurement & calculation of operating speed, wheel slip, draft of manual, trailed & mounted implements, fuel consumption, field capacity, Soil moisture, bulk density, soil inversion, soil pulverization, size & shape of furrow, field efficiency, calibration of test equipment and its usage limitations. Prototype feasibility testing and field evaluation. Laboratory and field testing of primary & secondary tillage equipment. Test code for performance testing for tractors & power tillers - evaluation and interpretation of results. Dynamometers. Review and interpretation of test reports for selected farm machinery.

#### **Unit 4: Tractor Design Principles**

Functional Requirement and Limitations, Systems and power outlets, technical specifications of tractors available in India and modern trends in tractor design and development. Special design features of tractors in relation to Indian agriculture. Parameters affecting design of tractor engine and their selection. Design of fuel- efficient engine components and tractor systems like transmission, steering, front suspension, hydraulic system. Studying tractor performance. Tractor mechanics, Ideal Analysis with and without losses, Engine Performance, Tractor Drawbar performance. Tractor Performance on a Firm Surface and soft soil. Rolling resistance. Tire selection. Hitching and mechanics of the tractor chassis, Weight transfer. Computer aided design and its application in agricultural tractors. Tractor implements matching and operation.

#### **Unit 5: Ergonomics and Safety in Farm operations**

Ergonomics, scope, concepts and areas of application. System concept to human factors. Human factor in system development, basic processes in system development. Human Skeletal system, muscle, structure and function. Muscle metabolism. Direct and indirect calorimetry Physiological stress and measurement of human energy expenditure during rest and physical activities. Work physiology in various agricultural tasks. Mechanical efficiency of work, fatigue and shift work. Anthropometric data and measurement techniques, joint movement and method of measurement, analysis and application of anthropometric data in design of foot and hand controls and operator' seat for tractors and agricultural equipment. Measurement of physical and mental capacities. Effect of illumination, noise, vibration and dust on work performance and health of workers. Thermal and cold stress and its effect on human performance. Field of vision and colour discrimination. Work psychology, basic concepts, Subjective rating scales and quantification techniques. Safety standards at work place. Accidents and prevention. Occupational health hazards of agricultural workers.

#### **Unit 6: Soil Dynamics in Tillage and Traction**

Dynamic properties of soil, stress strain relations and distribution, soil strength. Yield in soil, shear, compression, tension and plastic flow. Rigid body soil movement, momentum, friction, adhesion and absorption. Dynamic versus static properties. Dynamic parameters, measuring in dependent parameters and composite parameters. Measuring gross dynamic behavior and rupture. Mechanics of tillage tools: The reaction of soil to tillage tools, mechanics of simple reactions, soil behavior in simplified systems, geometry of soil tool systems, mechanics of complex reactions. Dimensional analysis of different variables related to soil- tyre system; soil vehicle models; mechanics of steering of farm tractor; special problems of wet land traction and floatation. Introduction of traction devices, tyres-types, function & size, their selection; mechanics of traction devices. Deflection between traction devices and soil, slippage and sinkage of wheels, evaluation and prediction of traction performance. Design of traction and transport devices - Soil compaction by agricultural vehicles and machines.

#### **Unit 7: Manufacturing Technology**

Specification of materials, surface roughness, production drawing, computer aided drawing heat treatment, workshop practices applied in prototype production, common tools and press operations, metal cutting and machining, jigs, fixtures and gauges, casting and die-casting processes; basic joining processes, welding processes, testing of joints and metallurgy.

#### **Unit 8: Instrumentation and Measurement Techniques**

Mechanical measurements, sensors and transducers, application of electrical strain gauges, signal transmission and processing, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power vibrations etc.; determination of calorific value, fluid flow rates etc., signal conditioning and monitoring, data acquisition and storage.

#### **Unit 9: Energy in Agriculture**

Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection, storage and applications; solar photovoltaic conversion and SPV powered systems. Types of wind mills and their applications; thermo-chemical conversion of biomass, direct combustion, Pyrolysis and gasification, chemical conversion processes, carbonization, briquetting, pelletization

and densification of biomass; bioconversion into alcohols, methyl and ethyl esters, organic acids, solvents of amino acids; types of biogas plants, biogas properties, uses and distribution, alternate fuels for IC engines. Energy requirement in agricultural production systems, energy ratio and specific energy value, inflow and outflow of energy in unit agricultural operation, energy audit, accounting and analysis.

## **17. SOIL AND WATER CONSERVATION ENGINEERING/SOIL AND WATER ENGINEERING**

### **Unit 1: Groundwater Development, Wells and Pumps**

Water resources of India. Present status of development and utilization of water resources of India and scope for additional use. Irrigation potential and contribution of groundwater, scope of groundwater development. Application of groundwater models for groundwater development and management. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Salt water intrusion in inland and coastal aquifers. Groundwater exploration techniques. Hydraulics of fully and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Conjunctive use of surface and groundwater.

### **Unit 2: Open Channel Hydraulics**

Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump, classification and its use as energy dissipater. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution.

### **Unit 3: Soil, Plant, Water and Atmosphere Relationship**

Soil physical characteristics influencing irrigation. Soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting water storage profile. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget: water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential. Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rainfed regions.

### **Unit 4: Watershed Hydrology**

Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Intensity duration frequency analysis. Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff estimation, hydrographs, S-hydrograph, IUH, Synthetic hydrograph, unit hydrograph theory and its application. Concept of hydrologic flood routing: channel and reservoir routing.

### **Unit 5: Soil and Water Conservation**

Soil erosion and types of erosion. Quantitative soil loss estimation, universal soil loss equation and its subsequent modifications. In-situ measurement of soil loss. Field practices in controlling erosion by water and wind. Soil and Water conservation structures and their design. Gully control: vegetative measures, temporary, semi-permanent and permanent structures for gully control and reclamation and their design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis on slopes. Application of RS and GIS in soil and water conservation.

## **Unit 6: Watershed Management**

Watershed concept, Identification and characterization of watersheds. Surveying: topographic, reconnaissance. Soil types and depth properties. Soil maps and their scales. Meteorological observations, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines. Hydrological and geomorphological characteristics of watersheds. Land capability and irrigability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, Criteria for land levelling, design methods. Machineries and equipment's for land levelling.

## **Unit 7: Irrigation Water Management**

History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and climatic parameters. Methods of irrigation, surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management.

## **Unit 8: Management of Degraded, Waterlogged and Other Problematic Soils and Water**

Problem soils and their distribution in India. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils. Agricultural field drainage, drainage techniques and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. Steady state flow into drains. Hooghoudt Equation. Design and installation of surface and subsurface drainage system. Interceptor and relief drain and their design. Drain pipe and accessories. Drainage requirements of crops. Drainage in relation to salinity and water table control. Bio drainage.

Reclamation of ravine, waterlogged, swampy areas and polders. Salt-affected soils and their reclamation. Command area development organizational structures and activities. Irrigation water users' association concept and responsibilities. Environmental considerations in land and water resources management.

## **Unit 9: Protected Cultivation**

Production technology for vegetables under Protected conditions in soil and soilless media - hydroponics and aeroponics. Types of Greenhouses - orientation and layout. Construction of Green house. Solar radiation – Diffused radiation – Inside and Outside greenhouse radiation. Naturally ventilated and forced ventilated system. Automation for climate control in protected structures. Thermal Modeling of greenhouse Environment for protected cultivation.

# **18. AGRICULTURAL PROCESSING AND FOOD ENGINEERING**

## **Unit 1: Engineering Properties and Quality of Biomaterials**

Engineering Properties and Quality of Biomaterials Uniqueness of bio-materials, Importance of engineering properties of biological materials, Physical characteristics viz. shape, size, volume, density, porosity, surface areas, Frictional characteristics viz., rolling resistance, angle of repose. Properties of bulk particulate solids viz. specific surface area, mean diameter, flow rate, Aerodynamics characteristics viz. drag coefficient and terminal velocity. Pressure drop through packed beds, Thermal properties viz. specific heat, thermal conductivity, thermal diffusivity, Dielectric properties viz. dielectric and microwave radiation, dielectric constant, energy absorption, heating, Optical properties and transmittance and reflectance, Rheological properties and stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses, Food Quality and BIS specifications for quality of

food materials, milling quality analysis, cooking and baking qualities, Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, colour, hardness, texture, nutritive value, bio-availability and microbial loads, Maturity, ripening stages and indices of fruits and vegetables.

### **Unit 2: Heat and Mass Transfer**

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC, sorption and desorption isotherms, water activity and psychrometry. Modes of heat transfer, heat exchanger. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Dimensional analysis and simulation.

### **Unit 3: Post Harvest Unit Operations**

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), pasteurization and sterilization of liquid foods, kinetics of microbial death, size reduction, cryogenic grinding, granulation, crystallization, membrane separation processes *viz.* micro filtration, ultra-filtration, nano-filtration, reverse osmosis; Evaporation, Distillation, Mixing, coagulation, mechanical separation processes, *viz.* sedimentation, clarification filtration, pressing, expelling, leaching, extraction, pelleting, extrusion and industrial fermentation and processing.

### **Unit 4: Process Technology and Machinery**

Pre-milling/conditioning treatments. Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums. Bioprocess engineering, enzyme reaction kinetics, Industrial fermentation and processing, down-stream processing, bio-separation. Minimal processing of fruits and vegetables, high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nano encapsulation of food ingredients, Food nanotechnology. Seed processing and technology, Agricultural by-products/residue utilization, Waste disposal of food processing plants, different methods and equipment.

### **Unit 5: Design of Processing Machinery**

Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bioreactors, fermenters, centrifuges, cyclone separator, heat-exchanger, evaporators, filters, extrusion cookers. Computer aided design and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selection of standard parts *viz.* pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses.

### **Unit 6: Material Handling, Packaging and Transport**

Bulk conveying equipment's, *viz.* belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement and capacity, damage to products during mechanical handling. Operation and maintenance of conveying equipment. Packaging material characteristics and selection. Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Cold chain design and operation. Safety standards in handling, packaging and transport of agricultural produce.

### **Unit 7: Storage Engineering**

Storage environment and its interaction with stored product, factors/parameters influencing the shelf life of the stored product and deterioration index. Prediction of storage life, quality deterioration mechanisms and their control. Storage practices (including fumigation) for food grains. Design of bulk storage and aeration system. Analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, controlled and modified atmosphere storage systems and their design, smart storage system. Quality analysis of stored produce.

## **Unit 8: Process Plant Design**

Plant design concepts and general design considerations, plant location, product and process design, process flow charts, equipment selection, plant layout. Design and selection of machinery for handling utilities like water, steam, fuel etc. and disposal of effluents and residues.

## **Unit 9: Instrumentation and Process Control**

Static and dynamic characteristics of instruments, Transducers elements, intermediate elements, indicating and recording elements. Measurement of motion, force, torque, power, temperature, humidity, pressure and flow. Physical and chemical sensors, biosensors, Fuzzy logic, neuralnetworks and control. Monitoring of plant parameters through Internet, Programmable logic controller, Data loggers, Data Acquisition Systems (DAS). Introduction to Direct Digital Control (DDC), Supervisory Control and Data Acquisition Systems (SCADA), and Virtual Instrumentation.

## **Unit 10 : Agri-Project Planning and Management**

Project development. Market survey and time motion analysis. Selection of equipment, technology option, techno - economic feasibility. Processing in production catchment. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning. BIS/ FSSAI/ ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

# **19. EXTENSION EDUCATION AND COMMUNITY MANAGEMENT**

## **Unit 1: Home Science extension education**

Concept, principles, philosophy, objectives and approaches. Genesis of rural development programmes in India. Community Development and Integrated Rural Development- concept, principles and objectives. Institution and its importance, types, etc. Relationship between family and community development. Gender sensitivity in extension education programmes. Leadership-concept, types, identification, leadership styles, training and mobilizing local leaders for community participation. Problems of women leaders. Panchayati Raj-philosophy, concept, functioning and scope. Extension methods and audio-visual aids. classification, selection, use and production. Modularized communication- concept, approach, need, process of designing instruction for transfer of communication. Concept, functions, key elements, theories and models of communication. Barriers to communication. Revolution in communication strategies. Advanced techniques in mass communication and software production, importance of media in TOT, importance of ICT in TOT. Participatory communication – theories and models, designing and developing participatory message. Concept, need and constraint of community-based learning. Concept, steps, principles and theories of programme planning. Application of programme planning for Home Science Extension through PERT and CPM. Evaluation – concept, significance, methods and tools for monitoring and evaluation. Motivation and its importance. Development programmes, viz. Integrated Rural Development Programme (IRDP), Development of Women and Children in Rural Areas (DWCRA), Training of Rural Youth for Self-Employment (TRYSEM), Krishi Vigyan Kendras (KVKs). Role of Non-governmental Organizations (NGOs) in extension, SWOT analysis of development programmes. Programmes and agencies promoting women as entrepreneurs. Types and techniques of training for developing entrepreneurial activities in Home Science areas. Self Help Groups-concept, organization, mobilization and functioning of SHGs for sustainability. Human Resource Development-concept, need and strategies.

- NITI Aayog
- Diffusion and Adoption of Technologies: Concept and element of diffusion process, adoption: meaning, process, factors & constraints, adaptor categories.
- Journalism: meaning, type, fundamentals of good writing editing & proof reading for print media.
- Video production: terminology related to video production; steps involved in video production.

- Information and communication Technology (ICT): meaning, types, use of ICT in extension.

## 20. ENVIRONMENTAL SCIENCES

### Unit 1

Definition and scope of environmental science and its interrelationship with other sciences and agriculture; Segments atmosphere: hydrosphere, Lithosphere and biosphere; Components of environment - biotic, abiotic and social; Ecological Foot prints. Natural resources: land, soil, water and forest and; present status - Land degradation – Wasteland: their extent, characteristics and reclamation; water conservation : watershed management and rain water harvesting - Major river projects and its impacts; Mineral resources - Environmental effects of mining; Food resources – problems; Ecology concepts – types – habitat ecology, systems ecology, synecology, autecology; Ecosystem: Structure- Functions; Population -characteristics and measurement; Communities - habitats, niches, biomes, population dynamics, species and individual in the ecosystem; Recent trends in ecology; Characteristic features - structure and function of forest, grassland, plantation, desert; Aquatic and agro-ecosystem. Energy flow in ecosystems and environment; Energy exchange and productivity-food chains and food webs-ecological pyramids; Ecological succession - types and causes. Biogeochemical cycles; nutrient cycles and recycle pathways.

### Unit 2

Biodiversity concepts, levels and types, Values and Significance of biodiversity; Theories on biodiversity; Agro-biodiversity – Transgenic crops and animals – Impact on Environment. Plant genetic resources, exploration and collection; Biogeographical zones of India; Biodiversity hot spots in India and world; Loss of biodiversity – Causes - Crop domestication, plant introductions - exotics and invasive plants - IUCN clauses and concept of threatened and endangered species; - Methods of conservation - *in-situ* and *ex-situ*-national parks, wildlife sanctuaries, biosphere reserves; National and global conservation measures - institutions and conventions - Indian Biodiversity Act 2002; World heritage sites; Wetlands – Mangroves – Ramsar convention.

### Unit 3

Environmental Pollution - Point and non-point sources - Atmosphere – stratification - Composition of air-; Air pollution: sources and classification - Criteria pollutants - Indoor and out-door air pollution,; Types - primary and secondary pollutants – Thermal Inversion - Air pollution Episodes -Air Quality standards –Greenhouse gases – Global warming – Ozone depletion – Acid rain – Impacts on Environment - Effects of air pollutants on vegetation, animals and human health; mitigation measures for combating air pollution; Automobile pollution, Noise pollution-source and effects, Disasters and their management: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Adaptation and mitigation strategies of climate change - Carbon sequestration and clean development mechanism. National and international laws and policies on air pollution. Environmental treaties; Role of NGOs in environmental protection; Corporate Social Responsibility (CSR) of industries in environmental protection; Advance tools for ecosystem analysis – Remote Sensing (RS) and Geographic Information Systems (GIS). EIA and Environmental Auditing.

### Unit 4

Urban and Industrial wastewater - Pollution of ponds, lakes, rivers and ground water. Impacts of water pollutants on Environment- Effluent Treatment Processes –Energy production recycling of treated wastewater and value addition to wastes -Permissible limits.

Soil pollution - sources - Organic and inorganic contaminants, Xenobiotics and their effect on agriculture: Heavy metals and pesticides -Effects of pollutants on soil health and productivity; Radioactive pollutants – Impacts; Remediation of contaminated soil – Microbial, chemical ameliorants, phytoremediation and Nano remediation; Permissible limits of organic and inorganic pollutants.

### Unit 5

Solid waste – sources – Categories - hazardous and non-hazardous - impact on Environment – Management strategies – 5 R concepts - Thermal conversions – Pyrolysis – Gasification – Incineration; Biodegradation of

organic wastes - Composting, Vermicomposting, Mushroom production, SCP; Energy recovery- biogas, landfill, etc. E- waste - impacts and resource recovery; Solid waste management rules in India.

## **Unit 6**

Energy - Types -of renewable sources of energy; Solar energy: Energy transfer and applications- Solar thermal system and their applications Wind energy –Types Geothermal and tidal energy; Bioenergy from biomass Liquid fuels from petro crops, -Concepts of producer gas; types of gasifiers; Briquetting of agro-wastes for fuel; Potential of renewable energy sources in India, Integrated rural energy programme; Nuclear energy–

## **Unit 7**

Frequency distribution, mean, median, mode and standard deviation; Normal, binomial and poisson distribution; Correlations - partial and multiple; Regression coefficients and multiple regression. Tests of significance F and Chi-square ( $X^2$ ) tests; Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

# **21. AGRICULTURAL PHYSICS**

## **Unit 1: Basic Physics**

Conservation of mass, energy and momentum; Forces in nature; Measurement of heat, specific heat, transfer of heat; Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; Optics theory, principles of optical instruments; Change of phase and polarization, equation of state, Laws of thermodynamics; Free energy, Entropy and concept of negative entropy; Vont Hoff's law; Cathode rays; Radio activity, alpha-, beta-, and gamma- rays, detection and measurement of radiation; Properties of X- rays; Bragg's law; Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power; Radioactivity and its applications in agriculture.

## **Unit 2: Soil Physics**

Factors and processes of soil formation; Physical, physicochemical and biological properties of soils; Soil water retention and movement under saturated and unsaturated conditions; Infiltration, redistribution and evaporation of soil water; Field water balance and water use efficiency; Soil aeration; Thermal properties of soil and heat transport; Influence of soil water, temperature and aeration on crop growth and their management; Soil erosion and control; Soil physical constraints and their management..

## **Unit 3: Radiation Physics**

Basics of Electromagnetic spectrum and its interaction with matter; Laws of radiation, scattering, reflection, transmission, absorption, emission, diffuse and specular radiations; Radiation units, flux, intensity, emittance, inter conversion of radiometric units; Energy balance of land surfaces.

## **Unit 4: Plant Biophysics and Nano Technology**

Introduction and scope of biophysics; Structure and properties of water; Experimental techniques used for separation and characterization of biomolecules sedimentation, ultra- centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography; Fibre physics; Basic Spectroscopic techniques, UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction; Chlorophyll fluorescence; Nanostructures, Properties and characterization of nanomaterials; Nano-biology, hazards of nanomaterial; Applications of nanotechnology in agriculture.

## **Unit 5: Remote sensing**

Electromagnetic radiation, and interactions with the matter, remote sensing system – active and passive, sensor and platform; Radiometric quantities; Spectral signatures of natural targets and its physical basis, spectral indices; Satellite characteristics, spatial, spectral, radiometric and temporal resolutions; Air borne remote sensing; Imaging and non-imaging systems; Multispectral, hyperspectral, thermal and microwave remote sensing; Digital

image processing; National and International satellite systems for land, weather, ocean and other observations; Applications of remote sensing in agriculture.

### **Unit 6: Geoinformatics**

Basic concepts and principles: Hardware and software requirements; Common terminologies of geographic information system (GIS); Maps and projections, principles of cartography; Basic geodesy: Geoid /Datum/ Ellipsoid; Cartographic projections, coordinate systems, types and scales; Accuracy of maps; Raster and Vector data model; DBMS; Geostatistical analyses; Spatial interpolation - Thiessen polygon; Inverse square distance; Digital Elevation Model; Principles of GPS; DGPS; Errors in GPS data and correction; GPS constellations; Geoinformatics application in agriculture and natural resource management.

### **Unit 7: Atmospheric physics**

Weather and climate: Atmosphere and its constituents; Meteorological elements and their measurements; Heat balance of the earth and atmosphere; Climatic classification systems; climatology of India, agro- ecological regions; Monsoon, western disturbances, cyclones, droughts; Wind system, precipitation, cloud, pressure pattern. Atmospheric stability; Weather forecasting: numerical weather prediction; El Nino, La Nina and ENSO; Climate change, global warming, impacts of climate change on agro-ecosystems; Physiological response of crop plants to weather (light, temperature, CO<sub>2</sub>, moisture and solar radiation); Heat units, thermal time and thermal use-efficiency and their applications; Micro-, meso- and macro-climates; Exchange of mass, momentum and energy between surface and atmosphere, exchange coefficients; Richardson number & Reynold's analogy; Boundary layer; Eddy covariance techniques; Wind profile; Modification of microclimate; Radiation distribution within the plant canopy; Concept of evapotranspiration: potential, reference and actual evapotranspiration, crop coefficient; Measurement of evapotranspiration.

### **Unit 8: Mathematical Modelling of soil-plant-atmosphere system**

Applications of matrices: Differentiation and integration; Numerical modelling: finite difference and finite element; Spatial statistics: Variogram and interpolation techniques; Surface modelling; Root water uptake models; Simulation models for water, heat, and solute movement in two- and three dimensional porous media; Fundamentals of dynamic simulation, systems, models and simulation; Mechanistic, stochastic and deterministic models; Model calibration, validation and sensitivity analysis; Crop weather models and its use in crop yield estimation; Advantage and limitations of modelling.

## **22. AGRONOMY**

### **Unit 1: Crop Ecology and Geography**

Principles of crop ecology; Ecosystem-concept and determinants of crop productivity; Physiological limits of crop yield and variability in relation to ecological optima; Crop adaptation; Climate shift and its ecological implication; Greenhouse effect; Agro-ecological and agro climatic regions of India; Geographical distribution of cereals, legumes, oilseeds, vegetables, fodders and forages, commercial crops, condiments and spices, medicinal and aromatic plants; Adverse climatic factors and crop productivity; Photosynthesis, respiration, net assimilation, solar energy conversion efficiency and relative water content, light intensity, water and CO<sub>2</sub> in relation to photosynthetic rates and efficiency; Physiological stress in crops, detection and indices; Remote sensing: Spectral indices and their application in agriculture.

### **Unit 2: Weed Management**

Scope and principles of weed management; Weed classification, biology, ecology and allelopathy; Weed seed dormancy, Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistence of herbicides in soils and plants; Application methods and equipment; Cultural, physical, chemical and biological weed control, bio-herbicides: Integrated weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non-cropped lands; weed control schedules in field crops, vegetables and plantation crops; Role of Genetically Modified (GM) crops in weed management.

### **Unit 3: Soil Fertility and Fertilizer Use**

History of soil fertility and fertilizer use; Concept of essentiality of plant nutrients, their critical concentrations in plants, nutrient interactions, diagnostic techniques with special emphasis on emerging deficiencies of secondary and micro-nutrients; Soil fertility and productivity and their indicators; Fertilizer materials including liquid fertilizers, their composition, mineralization, availability and reaction in soils; Water solubility of phosphate fertilizers; Slow release fertilizers, nitrification inhibitors and their use for crop production; Principles and methods of fertilizer application including fertigation; Integrated nutrient management and bio-fertilizers; Agronomic and physiological efficiency and recovery of applied plant nutrients; Criteria for determining fertilizer schedules for cropping systems - direct, residual and cumulative effects; Fertilizer related environmental problems including ground water pollution; Site-specific nutrient management.

### **Unit 4: Dryland Agronomy**

Concept of dryland farming; dryland farming Vs rainfed farming; History, development, significance and constraints of dryland agriculture in India; Climatic classification and delineation of dryland tracts; Characterization of agro-climatic environments of drylands; Rainfall analysis and length of growing season; Types of droughts, effect on plant growth, drought resistance, drought avoidance, drought management; Crop Planning including contingency, crop diversification, varieties, cropping systems and mid-season corrections for aberrant weather conditions; Techniques of moisture conservation in-situ to reduce evapotranspiration, runoff and to increase infiltration; Rain water harvesting and recycling concept, techniques and practices; Summer ploughing, seed hardening, pre-monsoon sowing, weed and nutrient management; Concept and importance of watershed management in dryland areas.

### **Unit 5: Crop Production**

Crop production techniques for cereals, millets, pulses /grain legumes, oilseeds, fiber crops, sugarcane, tobacco, fodder and pasture crops including origin, history, distribution, adaptation, climate, soil, season, modern varieties, seed rate, fertilizer requirements, crop geometry, intercultural operations, water requirement, weed control, harvest, quality components, industrial use, economics and post-harvest technology. Package of practices in the respective locations.

### **Unit 6: Agricultural Statistics**

Frequency distribution, standard error and deviation, correlation and regression analyses, co-efficient of variation; Tests of significance t test, F test and chi-square ( $\chi^2$ ); Data transformation and missing plot techniques; Design of experiments and their basic principles, completely randomized, randomized block, split plot, strip-plot, factorial and simple confounding designs; Efficiency of designs; Methods of statistical analysis for cropping systems including intercropping; Pooled analysis.

### **Unit 7 : Sustainable Land Use Systems**

Tillage - Concept, types, tillage, tools and implements; Modern concepts of tillage and conservation agriculture; Land capability classification, Alternate land use and Agro forestry systems; Types, extent and causes of wasteland; Shifting cultivation; Concept of sustainability; Sustainability parameters and indicators; Agricultural and agro-industrial residues and its recycling.

### **Unit 8: Soil-Plant-Water Relationship**

Importance of water in agriculture; Hydrological cycle; runoff and infiltration, factors affecting infiltration; Soil water relations, water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water; Soil irritability classifications, Determination of soil water content, computation of soil water depletion, soil water potential and its components; Movement of soil water- saturated and unsaturated water flow; Evapotranspiration (ET), PET, AET and its measurements. Crop co-efficient; Plant water relations: Concept of plant water potential, its components; Methods of moisture estimation in plants. Soil and water conservation – measures – agronomical, mechanical and agrostological.

## **Unit 9: Irrigation Water Management**

History of irrigation in India; Major irrigation projects in India; Water resource development; Crop water requirements; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Concept of critical stages of crop growth in relation to water supplies; Methods of irrigation viz. surface, subsurface and pressurized irrigation methods, merits and demerits; Measurement of irrigation water, application and distribution efficiencies. Conjunctive use of water; Interaction between irrigation and fertilizers.

## **Unit 10: Management of Problematic Soils and Crop Production**

Problem soils and their distribution in India, acidic, saline, waterlogged and mined- soils; Response of crop to acidity, salinity, excess water and nutrient imbalances; Reclamation of problem soils, role of amendments and drainage; Crop production techniques in problem soils – crops, varieties, cropping system and agronomic practices; Degraded lands and their rehabilitation. Management strategies for flood prone areas; Drainage for improving water logged soils for crop production; Crop production and alternate use of problematic soils and poor quality water for agricultural.

## **Unit 11: Cropping and Farming Systems and Organic Farming**

Cropping system – Definition, principles, classification; Cropping system for different ecosystem; Interaction and indices; non-monetary inputs and low-cost technologies. LEIA, HEIA and LEISA; Farming systems – type – natural, bio-dynamic, bio-intensive, response, precision, biological and organic farming; organic and bio inputs, Soil health and organic matter and Integrated organic farming systems; IFS – concepts, models for different ecosystem, resource recycling and evaluation.

## **23. SOIL SCIENCE/SOIL SCIENCE & AGRICULTURAL CHEMISTRY**

### **Unit 1: Pedology**

Concept of land, soil and soil science. Composition of earth crust and its relationship with soils; Rocks, minerals and other soil forming materials; Weathering of rocks and minerals; Factors of soil formation; Pedogenic processes and their relationships with soil properties; Soil development; Pedon, polypedon, soil profile, horizons and their nomenclature. Soil Taxonomy - epipedons, diagnostic subsurface horizons and other diagnostic characteristics, soil moisture and temperature regimes, Interpretation of soil survey data for land capability and crop suitability classifications, Fertility Capability Classification- Nutrient indexing. Macro-morphological study of soils. Application and use of global positioning system for soil survey. Soil survey- types **and** techniques. Soil series characterization and procedure for establishing soil series, benchmark soils and soil correlations. Study of base maps: cadastral maps, toposheets, aerial photographs and satellite imageries. Use of geographical information system for preparing thematic maps. Application of Remote Sensing in soil survey and mapping. Soils of India

### **Unit 2: Soil Physics**

Significance of soil physical properties. Soil texture – Stoke's Law- textural classes. Soil structure – classification, soil aggregation and significance, soil consistency, bulk density and particle density of soils and porosity, their significance and manipulation. Soil water- retention and potentials. Soil moisture constants. Movement of soil water- saturated and unsaturated flow- Darcy's law - hydraulic conductivity - infiltration, percolation, permeability, drainage and methods of determination of soil moisture. Thermal properties of soils, soil temperature. Soil air-composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil physical constraints affecting crop production and their management strategies. Methods of soil analysis - particle size distribution, bulk and particle density, moisture constants. Soil erosion - types, effects, Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management. Soil conservation measures. Characterization and evaluation of soil and land quality indicators; Causes of land degradation; Management of soil physical properties for prevention/restoration of land degradation; management of waste lands; Concept of watershed – its characterization and management.

### **Unit 3: Soil Chemistry**

Chemical composition of soil; Soil colloids - structure, composition, constitution of clay minerals, amorphous clays and other non-crystalline silicate minerals, oxide and hydroxide minerals; Charge development on clays and organic matter; pH-charge relations; Buffer capacity of soils. Inorganic and organic colloids- surface charge characteristics, diffuse double layer, zeta potential. Soil organic matter fractionation, humus formation and theories clay-organic interactions. Cation exchange – Hysteresis-definition. Nitrogen, potassium, phosphorus and ammonium fixation in soils and management aspects.

### **Unit 4: Soil Fertility**

Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and movement of nutrients (Macro and micro nutrients) in soil; Manures and fertilizers; Fate and reactions of fertilizers in soils; Slow release fertilizers and nitrification retarders- Soil fertility evaluation- Concepts and approaches; FCO Soil fertility evaluation – soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Nutrient Management concepts- INM, IPNS, SSNM- Soil test-crop response correlations; Fertilizer application methods- Nutrient use efficiency- Macro and micronutrients. Nature, properties and development of acid, acid sulphate, saline and alkali soils and their management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC. Fertility status of soils of India. Pollution: types, causes, and management. Carbon sequestration and carbon trading. Modern methods of soil, plant and fertilizer analysis; Flame photometry and inductively coupled plasma optical emission spectroscopy; Spectrophotometry - visible, ultra-violet and infrared; Atomic absorption spectrophotometry; Potentiometry and conductimetry; X-ray diffractometry; Mass spectrometry.

### **Unit 5: Soil Microbiology**

Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Soil characteristics influencing growth and activity of microflora. Microbial transformations of N, P, K, S, Fe and Zn in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. Humus formation. Cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

### **Unit 6: Statistics**

Experimental designs for pot culture and field experiments; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Computer use in soil research, Geostatistics.

## **24. AGRICULTURAL CHEMICALS**

### **Unit 1: General Chemistry**

Surface chemistry, pH, Buffer solutions; Redox reactions, Chemical kinetics, Stereochemistry and chirality, Di stereoisomerism, tautomerism, atropisomerism, asymmetric synthesis, nomenclature of organic molecules, displacement, elimination, addition, rearrangement, SN1 and SN2 reactions, reaction involving free radicals, and carbene intermediates, Organic reagents and catalysts in organic synthesis, Beckmann, Claisen condensation, Hofmann-Löffler-Freytag reaction, Petrucci-Buchi reaction, Curtius, Michael, Kolbe, Arndt-Eistert and Wittig reaction. Reformatsky reaction, Barton reaction, Umpolung reaction, Norrish Type I & II reactions.

### **Unit 2: Chromatography and Spectroscopic Techniques**

Basic principles and application of chromatography; column, paper, thin layer, and ion exchange chromatography; gas liquid chromatography (GLC); high performance liquid chromatography (HPLC); UV, FTIR; NMR and mass spectroscopy; GC-MS and LC-MS techniques and their applications.

### **Unit 3: Chemistry of Natural Products**

Extraction of natural products; Classification, structure, chemistry, properties and function of carbohydrates, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, and polymers. Chemistry of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and sapogenins; juvenile and moulting hormones; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products.

### **Unit 4 : Naturally Occurring Insecticides**

Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; microbial macrolides (avermectins and milbemycins), agricultural antibiotics, semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators; Plant hormones, phytoalexins, essential oils and their pest control properties; advantages and limitations of natural pesticides; juvenile hormones, juvenile hormone mimics and anti-JH; chemosterilants, insect antifeedants, insect attractants and repellents; microbial pesticides; Application of plant biotechnology in crop protection, herbicide tolerant and insect resistant transgenic plants

### **Unit 5: Synthetic Insecticides, Fungicides, Nematicides and Rodenticides**

History, scope and principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus, organo- carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's, phenols, quinines, carboxamides, azoles, methoxyacrylates), rodenticides, Insect growth regulators; Chitin synthesis inhibitors, insecticide synergists, fumigants. Mode of action of different groups of insecticides, fungicides and nematicides.

### **Unit 6: Herbicides and Plant Growth Regulators**

Physical, chemical and toxicological properties of different groups of herbicides (phenoxyacids, carbamates, amides, tiazines, phenyl urea's, dinitroanilines, bipyridiliums, sulfonyl urea's), Herbicide safeners, Plant growth regulators – auxins, gibberellins, cytokinin's, ethylene, abscisic acid; Brassinolides; Mode of action of different groups of herbicides.

### **Unit 7: Agrochemical Formulations**

Basic concepts of pesticide formulation - classification, solid and liquid formulations; preparation, properties, uses; controlled release formulations; Formulants - carriers/ diluents, surfactants, encapsulants, binders, antioxidants, stabilizers; Application - devices and quality of deposits; Types of spray appliances, seed treatment and dressing; nanotechnology in crop protection, Tools to develop and measure nanoparticles.

### **Unit 8: Pesticide Residues and their Dynamics in the Environment**

Pesticide residues- concepts and toxicological significance; pesticide dynamics in agro ecosystem, biotic and abiotic transformations affecting fate of pesticides. Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of ELISA and radiotracer techniques in pesticide residue analysis; new cleanup techniques, QUECHERS, ASE (Accelerated solvent extraction); multi-residue methods; Bound and conjugated residues; Method validation - linearity, LOD and LOQ, microbial and photochemical degradation, adsorption/ desorption, leaching in soil.

### **Unit 9: Agrochemicals – Regulation and Quality Control**

Production, consumption and trade statistics of pesticides and fertilizers; banned and restricted pesticides, registration and quality control of insecticides; Laws, Acts and Rules governing registration and regulations of agrochemical production and use; key provisions of the Insecticides Act (1968), Environmental Protection Act (1986). Pesticide Management Bill, EPA, Food Safety and Standards Act, WHO, FAO, CODEX and national/ international guidelines; Quality Control, Sanitary/ phyto-sanitary issues in relation to food safety, good laboratory practices, Accreditation certificate, Pesticide stewardship. (at PG level syllabus-SRF).

## **Unit 10: Natural Resource Management**

Soil, plant and microbial biodiversity, Characteristics and classification of natural resources; Major soil groups of India their characteristics, management strategies for natural resources; integrated pest and pesticide management; Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc); production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems; benefits, disadvantages and environmental toxicity. Nitrification inhibitors to enhance nitrogen use efficiency, Hydrogels and their application in agriculture, soil conditioners and amendments, toxicity issues.

## **Unit 11: Environment Pollution: Implications and Remediation**

Problems of pesticide hazards and environmental pollution; Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms; Effect of pesticide on soil health, persistent organic pollutants, and their effect on ecosystem. Adverse effect of industrial effluent on the soil and aquatic environment; disposal of obsolete and outdated pesticides; physical, chemical and microbial decontamination and detoxification of pesticides. Agrochemicals and homeland security, misuse of agrochemicals (pesticides and fertilizers), hazard mitigation plans or strategies, analytical and bioassay techniques to assess off-farm migration of agrochemicals into natural waters, ozone depletion causing agrochemicals.

## **Unit 12: Data Analysis**

Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; t-test, chi-square ( $\chi^2$ ), F test, Probit analysis.

# **25. WATER SCIENCE AND TECHNOLOGY**

## **Unit 1: General Concepts of Water Resources Management**

Water Resources of India, their Development; History of irrigation in India; Major irrigation projects in India; Type of Water-Green/Blue/Grey; Water Resources Distribution. Present Water requirement and needs for future in different Sectors. Rainfall (South-west monsoon, north-east monsoon, winter and hot weather period); Water budget of India; Irrigation Legislation- interstate water dispute, Concept of Water Pricing, Sustainable use and management of Water Resources, Impact of Climate Change on Water Resources and its availability in space and time, Interlinking of rivers.

## **Unit 2: Soil Water Plant and Atmosphere Relationships**

Soil characteristics in relation to profile and soil horizon, Soil water potential, its various components and method of their measurements. Movement of water in soils and its measurement, Properties of soil in relation to irrigation. Physical, Chemical, Biological Properties of Water; Plant water relations and role of water in plants, water loss through transpiration and factors affecting it, its measurement and the factors influencing it, Water stress in plants and its effect on growth, quality and yield. Water relationship of cell and whole plant, Water uptake by plants and its movement mechanism. Weather parameters influencing soil- water-plant relations and its measurements, Water footprint.

## **Unit 3: Crop Water Requirement**

Concepts of crop water requirements, irrigation planning and its factors, factors affecting irrigation water requirement. Soil Moisture Constant and its management, Soil Moisture Characteristics Curve, Soil Moisture Measurement; methods and its constraints, Introduction to Methods of estimation of reference evapo- transpiration and crop consumptive use, soil and land irrigability assessment, Water Productivity, Concept of field water balance, various components of field water balance their estimation of crop planning in relation to changing scenario of input availability, 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.

#### **Unit 4: Soil and Water Conservation**

Concept of Soil and Water conservation, Relevance of soil and water conservation in Agriculture, Problems caused by soil erosion, factors affecting soil erosion, Types of soil erosion, mechanics of water and wind erosion, Erosivity and Erodibility, Measurement of soil erosion, Hydraulic jump and energy dissipater for erosion central structures, design of Soil and Water Conservation Structures-Drop structures, Drop-inlet Spillway, Chute Spillways; Farm ponds and temporary storage reservoirs, Sediment yield and transport, water detention structures.

#### **Unit 5: Hydrology and Watershed Management**

Hydrological cycle, Precipitation; types and forms, characteristics, Rainfall measurement and analysis, Abstraction/Initial loss from precipitation, Principles of Evaporation and its measurement Rainfall-Runoff Relationship, Stream flow measurement, Hydrographs, flood routing.

Concept of watershed, principles and objectives, characterization, priority watershed, integrated watershed management, Water harvesting technique small storage and traditional methods, Integrated watershed management, people participation; Watershed management programme in the country-overview, planning and guidelines success and failures, economic evaluation, watershed policy formulation for planning and management, evaluation and environmental assessment, watershed policy formulation for planning and management, Extension strategy, RRA, PRA and PAR, economic issues, institutions and water users associations.

#### **Unit 6: Irrigation Water Management & Drainage**

Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and ground water) for agricultural production; Management of irrigation water; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Soil water depletion plant indices and climatic parameters; Concept of critical stages of crop growth in relation to water supplies; crop coefficients, Methods of irrigation viz. surface methods, merits and demerits of various methods, design and evaluation of irrigation methods, Conjunctive use of irrigation water, irrigation strategies under different situation of water availability, Irrigation efficiencies; Canal water Distribution, Design of irrigation structures.

Drainage- concepts and classification; Field drainage system 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 method of field drainage, their layout and spacing.

#### **Unit 7: Management and Remediation of Poor-quality Soil and Water**

Irrigation water quality, rating and suitability; Eutrophication, Management of brackish water for irrigation, Salt Balance, Area and distribution of problem soil – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible for it. Morphological features and of saline, sodic and saline-sodic soils; Basic Concept of Soluble salts, ESP, pH, physical, chemical and microbiological properties. Acid soils–nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement. Management of acid soils. Management of saline and sodic soils; salt tolerance of crops – mechanism and rating; monitoring of soil salinity in the field.

#### **Unit 8: Basics of pressurized irrigation system**

Introduction to Micro- Irrigation, Merits and Demerits of Micro Irrigation, Scope and Applications of Micro Irrigation, Types & components of Micro-Irrigation Systems -Drip, Sprinkler, Sub-Surface, Bubbler; Basic Design, operation and maintenance of Sprinkler System. Fertigation System.

#### **Unit 9: Rainfed Agriculture**

Prospects of rainfed agriculture, climate change and its impact, characterization of rainfed areas, moisture stress and low productivity, rainfall analysis, dry and wet spells, Application of Remote Sensing in rainfed farming, Resource conservation techniques, Drought- types and constraints , Drought resistance in crops, mechanism for drought tolerance and crop adaptability to drought situations, Soil moisture conservation and utilization,

moisture retention and availability concepts, water adsorption by plants under stress conditions. Water loss through evaporation and transpiration, conservation tillage, irrigation techniques, mulches and evaporation suppressant its management under stress conditions, mulches, anti-transparent – their kinds, effectiveness and economics.

### **Unit 10: Ground Water Management, Wells and Pumps**

Scope of groundwater development, Aquifer types, properties and parameters, Principles of groundwater flow, Management of declining and rising water table, Natural and artificial groundwater recharge, Groundwater recharge basins and injection wells, Groundwater management in irrigation command, conjunctive water use, water lifting, different types of pumps, selection of pumps, pump characteristics curve, cost of groundwater pumping.

## **26. AGRICULTURAL ECONOMICS**

### **Unit 1: Economic Theory**

Nature, Scope and methods of economics-Economic systems- Basic economics concepts in economics- Theory of consumer behaviour –cardinal utility approach-ordinal utility approach- indifference curve analysis- income and substitution effect-derivation of demand – applications of indifference curve analysis- revealed preference hypothesis- elasticity of demand and determinants-consumer surplus- Neo-classical theory of Production- Production function – Isoquants – Properties – homogenous production functions and Returns to scale - Technical progress– definition and types. -Profit maximization –Neoclassical theory of costs – Derivation of various types of cost curves- Cost minimization vs. profit maximization. Modern theory of costs- Derivation of supply and lay of supply-producer's surplus.

Market classification-pure and perfect competition. Characteristics and price determination under perfect and imperfect markets (monopoly, oligopoly and monopolistic competition) - Theory of income distribution and factor shares- General Equilibrium theory- Pareto optimality- Social welfare function- National income- concepts and measurement methods- Theory of employment- classical. Keynesian and post Keynesian theories of income determination. Consumption, Investment and saving functions-Concept of multipliers and accelerators- general equilibrium of product and money markets-IS and LM framework-inflation-types and control measures, Monetary and fiscal policies-instruments and effectiveness.

### **Unit 2: Economic and Agricultural Development**

Concept of economic development and economic growth-indicators and measurement-Criteria and characteristics of developing nations-economic and non-economic factors of economic growth-, stages and theories of economic development- economic growth models-classical and neo-classical growth models, role of state, markets and civil society in economic development, institutions and economic development, international development institutions Objective and processes for economic planning in India, economic and trade reforms in India.

Role of agriculture in economic development, theories of agricultural development, agricultural policies (price, land, credit, R&D, trade, subsidy, etc.)-agricultural development issues-poverty, inequality, unemployment and environmental degradation-agricultural development programmes in India, issues of water, energy, environment, food and nutrition security, agro-eco -regional planning, assessment of ecosystem services, farm-non-farm linkages.

### **Unit 3: Public Finance and International Economics**

Public Finance: Public and private finance. General principles of public finance. Principle of maximum social advantage. Public revenue. Incidence of tax and financial policies. Public expenditure and economic development. Balanced and unbalanced budgets. Limitations of fiscal policies. Fiscal policy as an instrument of development. Structure of development taxation. Public debt policy and economic development, international Economics: Principle of comparative advantage. Factor endowment theory, Balance of payments.

Trade with many goods and countries; Leontief paradox; human skills; technological gaps; the product cycle Trade policy: Protection; tariff and non-tariff measures; trade and market structure; trade liberalization; factor mobility and movements; role of multinational enterprises. National competitive advantage – Porter's diamond Problems

of international monetary systems, foreign trade and foreign capital. Export promotion and input substitution. Past experiences and future strategies.

#### **Unit 4: Farm Management Economics**

Definition of farm management and its relationship to technical and social sciences. Characteristics of modern farming. Role and functions of farm management under Indian condition. Measurement of management. Measures of farm efficiency. Cost concepts. Evaluation of farm assets and liabilities. Decision theory and decision-making models. Decision making under different knowledge situations. Tools and techniques in farm decision making. Farm planning and budgeting-sources of data and illustration. Linear programming. Problem formulation in farm planning. Farm records and accounts. Farm inventory with applications to farming enterprises. Farm cost accounting for managerial analysis. Management of farm resources-land, labour, capital and machinery. Review of farm management research, education and extension in relation to changing needs. Systems approach in agriculture. Farming systems, identification of farming system inputs and outputs, sub- systems and the circuitry connecting these systems. Systems analysis to find out needed changes in policies and programmes.

#### **Unit 5: Agricultural Production Economics**

Nature and scope of agricultural production economics vis-à-vis farm management. Relative importance of farm production economics and farm management in developed and developing countries. Economics of farm production- resource allocation and use under static and dynamic conditions. Resource — product relationships in agriculture. Types of production functions, frontiers technical and allocative efficiency. General rules of their economics application. Technological change and production function analysis. Principles of choice and allocation of resources. Resource combination and cost minimization economies of scale and economies of size. Types of risk in agriculture, resource allocation and enterprise combination under risk and risk diffusion mechanisms. Nature of costs and family farm theory. Returns to scale and farm size. Dualities between production, cost and profit functions; Derivation of supply and factor demand functions from production and profit functions.

#### **Unit 6: Agricultural Finance and Co-operation**

Role of credit in agriculture and rural development. Estimates of agricultural credit requirements-investment, production, marketing and consumption. Role of public and private section banks and cooperatives in development financing. Classification of agricultural credit. Rural credit structure. Principles of agricultural finance and financial management. Agricultural finance as a part of public finance. Nexus between commercial banks and cooperative credit institutions. Recent innovations in extension of credit to agriculture. Rural credit supply and credit gap. Multiagency approach and coordination of credit structure at different levels. Agriculture credit policy. Principles and practices of cooperation. Success and failure of cooperative sector in India. Credit and non-credit institutions. National federations of cooperative organizations. Review of reforms in cooperative structure. Single window approach in agricultural input supply and output marketing. Bureaucracy and cooperatives. Management of cooperative institutions. Professionalization and revitalization of cooperatives. Role of cooperatives under new economic policy Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather-based insurance and their applications.

#### **Unit 7: Agricultural Marketing**

Nature and scope of marketing in a developing economy. Classification of markets. Problems of marketing agricultural produce. Functions of marketing. Marketable surplus and marketed surplus. Channels of marketing agricultural produce and price spread Market Structure, Conduct and Performance (SCP). Marketing institutions, their role and functions. Regulated markets and other state interventions in agricultural marketing. Role of commission on agriculture cost and prices and parastatal organizations in agricultural marketing. Cooperative marketing. Marketing practices and cost-marketing of grains, pulses, commercial crops, fruits, vegetables, livestock and livestock products and inputs. Processing, transportation, storage and warehousing, equity aspects of marketing. Marketing efficiency. Marketing finance-methods and practices. Forward trading and speculation. Future markets. Market management. Agricultural price analysis. Seasonal and spatial variations in prices in agricultural price

policy. Agricultural exports, problems and prospects. Role of information technology and telecommunication in agricultural marketing.

### **Unit 8: Agricultural Project Analysis**

Definition of project in agriculture. Need for project approach for agricultural development. Project cycle. Project identification and formulation. Project appraisal-ex-ante and ex-post. Projection worth measures- discounting techniques, network techniques –PERT and CPM. Project monitoring and mid-course corrections. Project funding.

### **Unit 9: Research Methodology and Econometrics**

Agricultural economics research, steps and themes, collection and analysis of data, scientific report writing, econometric and statistical methods, sampling methods, probability theory. Multiple regression analysis, ordinary and generalized least squares estimators, BLUE, multicollinearity, heteroscedasticity, auto correlation, dummy variables. Simultaneous equation methods

## **27. AGRICULTURAL EXTENSION/EXTENSION EDUCATION/COMMUNICATION**

### **Unit 1: Fundamentals of Extension Education and Programme Planning**

Extension Education – Meaning, objectives, concepts, principles and philosophy. Adult Education and Distance Education. Steps in Extension Teaching-Teaching Learning process and Extension approaches of ICAR. Pioneering Extension efforts and their implications in Indian Agricultural Extension –ICAR and SAU, State Departments Extension system and NGOs. Community development and Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development. National level agricultural development programmes - NADP, NMAE&T, NFSM, Prime Minister seven-point strategies for doubling the income of farmers and ARYA. Extension efforts and Rural Development Programmes in pre-independence era (Sriniketan, Marthandam, Firka Development scheme, Gurgaon Experiment, Sevagram, IVS, GMFC) Post – independence era (Etawah pilot project, Nilokheri Experiment, CDP, NES, IAAP, IADP, HYVP, MCP, IRDP, ICDS, DWCRA, TRYSEM, IAY, JRY, SFDA, MFAL).

Ongoing development programmes in Agriculture/ Rural/ Animal Husbandry launched by ICAR/Govt. of India (T & V System, BBES, KVK, ATIC, ATMA, NAAP, NATP, NARP, NAIP, NADP, SADP, MGNREGS, PM Kisan, ARYA, NMAET, PMFBY). Different Approaches in Extension- PRA, RRA, PTD, PLA, FAR, PAME, AEA, FSRE, Market – Led – Extension, Farmers’ Field School, Kisan Call Centers and ATMA. Programme Planning –Steps, Principles. Monitoring and Evaluation- Steps, Keys and Principles

### **Unit 2: Extension Methods & Farm Journalism**

Extension Methods – Definition, Individual, group and mass approaches in extension, audio- visual aids-classification, selection, use and production. Traditional media for communication in development programmes. Modularized communication- concept, approach, need, process of designing instruction for transfer of communication. Basics of agricultural journalism, types of publications – bulletins, folders, leaflets, booklets, newsletters, popular and scientific articles.

Selection, planning and use of different extension teaching methods like demonstration, exhibition, farmers fairs, field days, tours, extension literature, etc. Preparation and presentation of different projected and non- projected audio-visual aids. Public speaking. Preparation of radio/video script. Principles of photography and its use in extension.

### **Unit 3: Information & Communication Technologies and Development Communication**

Communication – models, types, elements, characteristics and barriers, Modern extension approaches(Private Extension, PPP, Market and Farmer led Extension, Group approaches – FIGs, CIGs, FPOs and ICT enabled extension), Transfer of Technology – Models, Development Communication– Theories. ICT and Development Communication – Role in abridging Digital divide. Concept of ICT and its role in agriculture and rural development.

ICT tools- print and electronic media- Satellite Radio, Community Radio, Internet Radio, Television, Interactive Television, Newspapers, e-publications, e-mail, Internet, Multimedia, Mobile phony, Video and teleconferencing, computer-assisted instructions, web technologies – Web portals, Mobile apps and Social Media tools, e-learning- information resources, information kiosks, sharing and networking. Types of networks – PAN, LAN, WAN. AGRISNET, AKIS, Indian National Agricultural Research database. ICT programmes in agriculture and allied sectors - Problems and prospects. Artificial Intelligence in Agricultural Extension- Expert system, Decision Support System.

#### **Unit 4: Training and Human Resource Development**

Human Resource Development – Meaning & importance. Steps in HRD- Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective. Organizational and Managerial values and ethics, organizational commitment; Motivation- Theories – Maslow’s hierarchy of needs, techniques & productivity. Job description, Job analysis and Performance appraisal. Human Resource management: Collective bargaining, Negotiation skills, Human Resource Accounting (HRA): Information Management for HR.: Collective behaviour, learning, and perception; Stress and coping mechanisms. Communication and Feedback and Inter personal processes & interpersonal styles. Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition. HRD & role of supervisors: Task Analysis, Capacity Building, Counseling and Mentoring; Role of a Professional Manager. Task of a Professional Manager. Managerial skills and Soft Skills required for Extension workers. Decision Making: Decision making models, Management by Objective. Leadership styles – Group dynamics. Training – Meaning, types, models, methods and evaluation, techniques for trainees’ participation.

#### **Unit 5: Research Methodology in Extension Education**

Science – Four methods of knowing things. Research – Meaning, importance, Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Different steps in scientific research– selection of problem, hypothesis, review of literature, objectives, variables and types, different data collection tools, Sampling techniques and different statistical analysis. Measurement – Meaning, postulates and levels of measurement, Steps in test construction, Item writing and Item analysis. Research Designs– types, MAXMINCON Principle. Meaning and Types of Reliability & validity, Rating scales, Observation, Case studies. Social survey – Meaning, objectives, types and steps. Data processing – meaning, coding, preparation of master code sheet, Analysis and tabulation of data – Parametric and Non- Parametric statistical tools. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

#### **Unit 6: Diffusion and Adoption of Innovations**

Diffusion – Elements, Innovation- Development process; Adoption – Process, Stages; Innovation decision process- Types of innovation decision-Optional, collective and authoritative and contingent; Consequences of innovation decisions- Desirable or undesirable, direct or indirect, anticipated or unanticipated consequences. Innovativeness – concept and types; Adopter categories- Characteristics of adopter categories, Attributes of innovation, Rate of adoption of innovation and barriers in adoption process, Factors influencing rate of adoption; Diffusion effect, Over adoption, Re-invention; Opinion leadership- Measurement and characteristics of opinion leaders- Monomorphic and polymorphic opinion leadership. Models and theories of diffusion- One step flow model, Hypodermic Needle model, multi-step flow of innovation. Concept of homophily and heterophily and their influence on flow of innovation, Decision making-Meaning, definition and theories, Process and steps and factor influencing of decision making- Role of Change Agents.

#### **Unit 7: Management in Extension**

Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Extension Management - Concept, Importance, Principles and functions of management, Planning – Concept, Nature, Importance, Types. Change Management- Decision making – Concept, Types of decisions - Steps in Decision Making Process, Organizing - Meaning of Organization, Concept, principles, Span of Management,

Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations Management by Objective (MBO) and Total Quality Management (TQM). Logical Frame Working (LFW) and Project Management Techniques. Personal management, scope of Agribusiness Management and Institutions - National Institute of Agricultural Extension and Management (MANAGE). Indian Institute of Plantation Management (IIPM), NIRD, EEL and NAARM. Monitoring, evaluation and impact analysis of extension programmes. Critical analysis of organizational set up of extension administration at various levels.

### **Unit 8: Entrepreneurship Development**

Entrepreneurship – Concept, characteristics, Approaches, Theories and Need. Agri – entrepreneurship – Concept, characteristics, Nature and importance for Sustainable Livelihood. Traits of entrepreneurs. Leadership, Decision making, Planning, Organizing, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise, steps to be considered in setting up an enterprise, Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects. Micro enterprises – Profitable Agri- enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Product sales and promotion.

### **Unit 9: Market - Led Extension**

Agricultural marketing- Concept. Market led extension – Dimensions, emerging perspectives issues and challenges. Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviors; Market Intelligence, Supply Chain Management, Marketing communication and promotional strategies; Marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPR agreements on agriculture; Agreement on SPS and TBT. Commodity features marketing. Public private linkages in market led extension; FPOs and SHG in market led extension; Contract farming.

### **Unit 10: Gender Sensitization and Empowerment**

Gender concepts, Gender roles, gender balance, status, need and scope; Gender analysis – Tools and Techniques. Gender development policies of Govt. of India – The historical evolution. Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors. Gender budgeting. Women empowerment – Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role. Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women rights, issues and development.

## **28. AGRICULTURAL STATISTICS**

### **Unit 1: Statistical Methods I**

Descriptive statistics. Elements of probability theory, conditional probability, Bayes' theorem. Random variable- discrete and continuous. Mathematical expectation. Moment generating and characteristic functions. Laws of large numbers. Central limit theorem. Discrete probability distributions: binomial, Poisson, negative binomial, geometric, multinomial and hypergeometric. Continuous probability distributions: normal, rectangular, Cauchy, exponential, gamma and beta. Sampling distributions: chi-square, t, and F. Bivariate normal distribution: conditional and marginal.

Point estimation: unbiasedness, consistency, efficiency, sufficiency. Completeness. Minimum variance unbiased estimator. Cramer-Rao Inequality. Rao-Blackwell theorem and Lehman- Scheffe theorem. Methods of point estimation like Maximum likelihood, Moments, Minimum chi-square. Confidence interval estimation. Testing of hypotheses - two types of errors, level of significance and power of a test. Neyman-Pearson Lemma. Uniformly most powerful tests and their construction. Unbiased test, Likelihood ratio test. Tests of significance based on Z, t, chi- square and F distributions.

### **Unit 2: Statistical Methods II**

Correlation, rank correlation, correlation ratio, intra-class correlation. Simple and multiple regression analysis, partial and multiple correlation. Examination of residuals. Model-adequacy, Selecting best regression. Compound

and truncated distribution, Order statistics. Non-parametric tests: run, sign, rank, Wilcoxon, Kruskal-Wallis, Mann-Whitney, Cochran and Friedman's tests. Contingency tables. Log linear models. Sequential analysis, sequential probability ratio test. Components of time series. Multivariate normal distribution: estimation of mean vector and dispersion matrix. Wishart distribution, Hotelling  $T^2$ , multivariate analysis of variance, principal component analysis, factor analysis, discriminant analysis, cluster analysis. Linear Programming: formulation and graphical solution, simplex method, duality, transportation and assignment problems.

### Unit 3: Statistical Genetics

Statistical analysis of segregation, detection and estimation of linkage. Gene and genotypic frequencies. Random mating and equilibrium in large populations. Disequilibrium due to linkages for two pairs of genes and for sex linked genes. Selection, mutation and migration. Equilibrium between forces in large population. Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Concepts of breeding value, dominance, average effect of gene and epistatic interactions. Genetic variance and its partitioning. Correlation between relatives. Regular system of inbreeding, effects of inbreeding. Genotype and environment interaction, stability parameters. Estimation of heritability, repeatability and genetic correlation. Path coefficient analysis. Heterosis, concepts of general and specific combining abilities. Diallel crosses and line  $\times$  tester analysis. Response due to selection. Prediction of response to individual, family and combined selections. Construction of selection index.

### Unit 4: Design of Experiments

Linear models: Random, fixed and mixed effects. Nested and crossed classifications. Gauss- Markoff theorem. Analysis of variance. Principles of design of experiments. Uniformity trials. Completely randomized design. Randomized complete block design. Latin square design. Factorial experiments:  $2^n$  and  $3^n$  series and asymmetrical factorial experiments, confounding in  $2^n$  and  $3^n$  experiments, split and strip-plot designs, crossover designs. Multiple comparison procedures. Missing plot techniques. Analysis of covariance. Variance stabilizing transformations. Analysis of general block design. Balanced incomplete block designs: construction and analysis. Partially balanced incomplete block designs with two associate classes, lattice designs. Youden square design. Groups of experiments.

### Unit 5: Sample Surveys

Sampling versus complete enumeration. Concept of probability sampling. Simple random sampling. Stratified sampling, allocation in stratified sampling, choice of strata, construction of strata boundaries and collapsing of strata. Use of auxiliary information in sample surveys, ratio and regression methods of estimation. Systematic sampling. Cluster and multi-stage sampling with equal probability. Sampling with unequal probabilities with and without replacement, sampling schemes with inclusion probabilities proportional to size. Double sampling, sampling on successive occasions. Non-sampling errors: sources and classification. Randomized response techniques, imputation methods. Design and organization of pilot and large- scale surveys. National sample surveys. Agricultural statistics system in the country-land use statistics, crop estimation surveys, livestock and fishery statistics.

## 29. BIOINFORMATICS

### Unit 1: Molecular Biology and Biotechnology

Structure of DNA and RNA, Basics of replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, genomic and cDNA library construction, chromosome walking. Basics of genome organization and mapping, Non-coding RNA, Genome Editing, Gene silencing. Bio-chips.

### Unit 2: Preliminaries of Bioinformatics

Overview of available genomic resources on the web; NCBI/ EBI/ EXPASY etc; Nucleic acid sequence databases;

GenBank/ EMBL/ DDBJ; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms: Needleman & Wunsch, Smith & Waterman; BLAST, FASTA; Scoring matrices for Nucleic acids and proteins: PAM, BLOSUM, Multiple sequence alignment: PRAS, CLUSTALW.

### **Unit 3: Genome assembly**

Types and methods of genome sequence data generation; Shot gun sequencing method; Problems of genome assembly, Approaches of genome assembly: Comparative Assembly, DE novo Assembly; Read coverages; Sequencing errors, Sequence Quality Matrix, Assembly Evaluation; Challenges in Genome Assembly. Various tools and related methods of genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAPdenovo etc.

### **Unit 4: Evolutionary Biology**

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. Probabilistic models of evolution, Maximum likelihood algorithm; Approaches for tree reconstruction: Character optimization; delayed and accelerated transformation, Reliability of trees, Bootstrap, jackknife, decay, randomization tests.

### **Unit 5: Statistical Genomics**

Frequency distributions, Graphical representations and Descriptive statistics. Elements of probability theory, Conditional probability, Bayes' theorem. Random variable- discrete and continuous. Mathematical expectation. Moment generating and characteristic functions. Probability distributions-Binomial, Poisson and Normal distribution and its application. Sampling distributions and its properties- Chi-square, t, and F. Testing of hypotheses - types of errors, level of significance and power of a test, Tests of significance based on Z, t, chi-square and F distributions. Concept of sampling, Sampling vs. Complete Enumeration, Simple Random Sampling. Correlation and regression analysis.

Fundamentals of Population genetics: Gene and genotypic frequencies. Random mating and equilibrium in large populations, Hardy –Weinberg law, Effect of systematic forces on changes in gene frequency- Selection, mutation and migration. Equilibrium between forces in large population. Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Principles of Quantitative genetics: Values, Means and Variances, Concepts of breeding value, dominance, average effect of gene and epistatic interactions. Detection and Estimation of Linkage, Genetic variance and its partitioning. Correlation between relatives. Genotype and environment interaction. Estimation of genetic parameters. Genome wide association study.

### **Unit 6: Protein Structure Prediction**

Nature of proteomic data; Overview of protein data bases; SWISSPROT, UniProtKB; PIR-PSD, PDB, Prosite, BLOCKS, Pfam/ Prodom etc.; 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 using molecular visualization software's such as RasMol, Cn3D, SPDBV, Chime, Mol4D etc.

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; along with analysis and interpretation of results. Molecular dynamics simulation and docking.

### **Unit 7: Biological Database Management System**

Database Management System (DBMS): definition and purpose of DBMS, Advantages of DBMS, DBMS Architecture- Three level Architecture for DBMS –internal, conceptual and external levels and their Schemas

and Mapping, Role of Schemas, Data Abstraction, Data Independence-Physical and Logical data independence. Data Models-Relational, Network, Hierarchical. Relational data models (binary, ternary, quaternary & n-ary relations) Components: Relation, Tuple, cardinality, degree. Network model- Entity Relationship (E-R) model-Components of E-R model: Entities, Attributes, Relationships. Relational Databases-, Important terms in relational database system, Primary and Foreign keys. Relational Data Integrity and constraints: Domain Constraints, Entity Integrity, Referential constraints. Normal forms. Structured Query Language- Commands, Queries, Data Definition Language (DDL), Data Manipulation Language (DML). Primary, secondary and derived biological databases, submitting sequence to the Database and retrieval.

### **Unit 8: Bio-programming and Computational Biology**

Object oriented programming, classes, objects, Abstract data types, Data types, Operators (Arithmetic, Logical and Comparison) and expressions. Data encapsulation- modules and interfaces; Polymorphism - Static and dynamic binding, Inheritance: class and object inheritance. Perl: Introduction, Scalar, Arrays and List Data, Control Structures, Hashes, String Handling, Regular Expressions; Subroutines, File handling, BioPERL modules. Machine learning techniques, Supervised and unsupervised learning, Decision tree, hidden markov model, Artificial Neural Network, Support Vector Machine and genetic algorithms. Pre-processing of gene expression data; Data Normalization techniques, Data quality control: Modelling of errors, Imputation etc.; High-throughput screening.

## **30. COMPUTER APPLICATION & IT**

### **Unit 1: Computer organization and architecture**

Boolean algebra, Number system, Basic concepts of floating-point number system, Sequential and combinational circuits, Input/Output unit, Memory Organization, ALU and Control unit, Instruction and execution cycle in CPU, Introduction to microprocessors, Interrupts, CISC and RISC Architecture.

### **Unit 2: Programming language (C++/JAVA)**

Computer algorithms, Flow Charts, Encapsulation, Inheritance, Polymorphism, Building blocks, Control structures, Arrays, Pointers, Dynamic memory allocation, File management.

### **Unit 3: Internet programming**

Hyper Text Markup Language (HTML), Building static and dynamic web pages, Client side and server-side scripting languages, Interaction with database.

### **Unit 4: Data structures**

Representation of character, string and their manipulation, Linear list structure, Stack, Queue, Heaps, Linked list, Arrays, Tree, Graph, Sorting and Searching algorithms.

### **Unit 5: Software engineering**

Requirement analysis and specification, Software Development Phases, Process models, Project structure, Project team structure, Role of metrics, Measurement, Software quality factors, Coding tools and techniques, Testing, Maintenance, Gantt charts, PERT and CPM, CASE tools.

### **Unit 6: Networking**

Types of Networks, Network topology, Network Management, Data communication and transmission, ISO-OSI reference model, TCP/IP reference model, Internet standards and services, Cryptography, Data compression, Authentication and firewalls.

### **Unit 7: Compilers and translators**

Regular expression, Finite automata, Formal languages, Finite state machines, Lexical analysis, Semantic analysis, Parsing algorithms, Symbol tables, Error handling, Intermediate code optimization, Machine code generation, Machine dependent optimization.

### **Unit 8: Operating system**

Process management: Inter-process communication, Process scheduling; Memory management: Swapping, Virtual memory, Paging and segmentation; Device management: Deadlocks, Semaphores; File systems –Files, Directories, Security and protection mechanisms; Distributed operating systems.

### **Unit 9: Data base management system**

Definition and features, Data models, Relational database: Logical and physical structure, Relational algebra, Relational calculus, Database design, Normalization, Concurrency control, Security and integrity, Query processing and optimization, Indexes, Backup and recovery; Distributed Databases – Concepts, Architecture, Design; Structured Query Language (SQL), PL/SQL.

### **Unit 10: Numerical analysis**

Interpolation, Numerical integration, Solution of ordinary differential equations, Solution of linear and non-linear system of equations; Statistical methods – Summarization of data, Frequency distribution, Measures of central tendency, Dispersion, Skewness and kurtosis, Theory of Probability, Random variable and mathematical expectation, Correlation and regression, Basic Principles of Design of Experiments: Analysis of Variance, Completely randomized design (CRD), Randomized complete block design (RCBD), Latin Square Design (LSD). Probability Distributions: Binomial, Poisson, Normal Distributions and their Applications. Concept of sampling, Sampling vs. Complete Enumeration, Sampling from a Finite Population, Simple Random Sampling. Test of significance based on normal, chi-square, t and F distributions, Curve fitting, Point estimation.

**NOTE 4: The syllabus mentioned above is illustrative only. Questions relating to recent/current developments taking place in agriculture and allied sciences in general and in the concerned subject areas in particular can also be included in the question papers as may be deemed appropriate by subject- paper experts.**