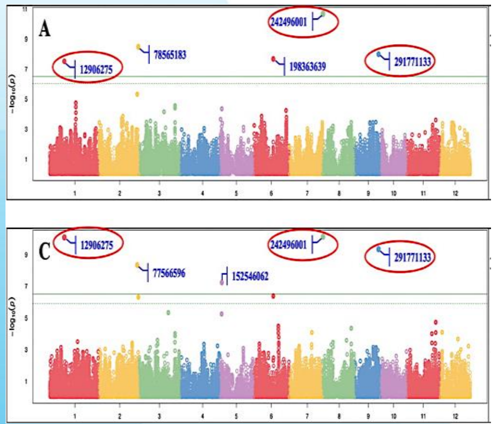
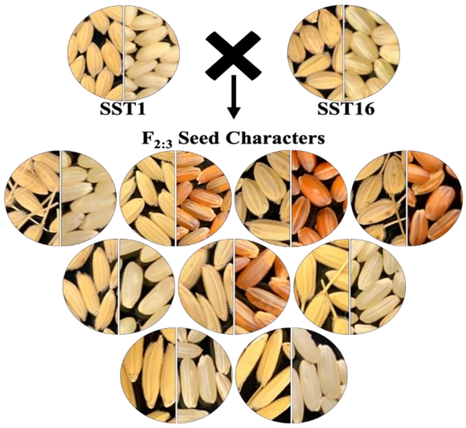
Annual Report 2023





Division of Seed Science and Technology

ICAR- Indian Agricultural Research Institute
New Delhi – 110012

Annual Report 2023

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Foreword

Seed is the basic and crucial input for sustainable agriculture and plays an important role in boosting the production and economy of the country. National Agricultural Research System along with Indian Seed Industry played a pivotal role in production and timely distribution of quality seeds to the farming community. In the recent times, significant advances have been made in the areas of hybrid seed production, seed quality assessment, assurance and up gradation. The Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi has undertaken basic and applied research on seed production and quality assessment in the major food crops, standardization of protocols for abiotic stress mitigation, seed quality testing and enhancement, health assessment and detection. The annual report of the division highlights the novel initiatives undertaken in different areas of Seed Science and Technology like hyperspectral imaging for seed quality assessment, identifying candidate genes for early seedling vigour, thermo tolerance in rice and seed storability in rice and soybean. I also compliment the scientists for undertaking research in the newer areas and acknowledge the support rendered by the technical and supporting staff of the division.

The significant research accomplishments have been compiled in the divisional annual report which is a useful compilation for the scientific community, seed personnel, researchers and students in the field of Seed Science and Technology. I congratulate Dr. Gyan Mishra, Head of the division and his team; Dr. Sudipta Basu, Dr. R.Y. Vishwanath and Dr. D. Vijay for compilation of the divisional annual report.

I wish the staff of Seed Science and Technology all the success in their future endeavors.

(Ashok Kumar Singh)

CONTENTS

EXECUTIVE SUMMARY

The Division of Seed Science and Technology at ICAR-IARI, established in 1968, played a very crucial role in the development of various seed policies, seed production and testing protocols and capacity building through several human resource development programs at national and international levels. The significant achievements of the division in research, education and extension during 2023 are summarized here.

On the research front, the division is involved in several fields of seed research, starting from seed production research, seed physiology and biochemistry, and seed testing in both basic and applied aspects through two in-house projects and several externally funded projects. In the hybrid seed production area, the technology for producing gynoecious cucumber under net house conditions were developed, and the basic studies on stigma receptivity of CMS lines of Indian mustard identified that the stigma receptivity of *Diplotaxis berthautii* is better than *Moricandia arvensis* and *Diplotaxis erucoides*. In the seed quality assessment front, new candidate genes for early germination traits in rice were identified through GWAS. A new vigour test, viz. head space ethanol content, could successfully differentiate rice seed lots with varying vigour. A set of high and low-vigour mustard lines was identified after screening 165 diverse lines for various vigour parameters, which can be used in breeding superior cultivars. Under the changing scenario of environmental extremes, the division started working on various abiotic stress in crop plants. In the studies on thermotolerance in rice at germination and early seedling stages, a concise methodology was developed to identify diverse thermotolerance reactions in both tolerant and susceptible genotypes. Similarly for salinity tolerance of four different wheat species were screened and further identified ascorbic acid (100 ppm) priming to alleviate the salinity stress during germination stage.

The maintenance of seed longevity during storage is very important for the successful supply of quality seed. The hyperspectral analysis of seed longevity in differentially stored rice seeds indicated that the most prominent sensitive bands can be identified using the multivariate technique, Partial Least Square Regression (PLSR), to predict germination. Studies on the effect of oxygen levels on seed storability indicated that hypoxia enhances seed longevity across genotypes compared to normoxia and hyperoxia conditions. Screening of 81 maize inbreds for longevity and vigour using a moderate experimental ageing condition helped identify four good storer inbreds that can be used for breeding purposes. The genome-wide association studies of 270 soybean genotypes screened using accelerated and ambient ageing conditions helped identify 3 and 5 significant SNPs for high germination. Seed storability studies in onion identified a significant positive correlation between 12 different fatty acids with germination, and storage studies on quality mustard indicated that they can be stored for up to 10 months under ambient conditions. Seed dormancy, an important seed physiological trait studied in 138 mung bean genotypes using GWAS, helped identify seven significant MTAs for dormancy index, 12 MTAs for dormancy depth and one for dormancy intensity. The high dormancy (79%) exhibited by buckwheat seeds could be successfully broken down using 0.4% KNO_3 or 20 mM H_2O_2. This treatment can be used in seed testing laboratories during germination studies. Similarly, seed treatment with GA_3 (1000 ppm) or KNO_3 (1%) or dry heat (70˚C for 3 days) was effective in mitigating the seed dormancy of cucumber.

In the applied aspect, the seed quality can be enhanced by using various processing, priming or seed treatments. The rice seed quality, such as germination, 1000 seed weight, seedling dry weight, and vigour indices, was enhanced by passing through a series of seed processing machines. A novel methodology for seed priming based on the imbibition phase combined with low drying temperature was developed for rice seeds, which can be used for priming experiments in different water potential conditions. Screening soybean genotypes with different seed coat colours indicated that the black seed coat genotypes could tolerate higher salinity stress than green, brown and yellow seed coat genotypes. Further, the salinity stress can be mitigated using Jasmonic acid (20 µM) priming by enhancing the antioxidant enzymes and proline content. An eco-friendly seed priming treatment using humic acid for mitigating the heat stress at the germination stage developed for lentil seeds enhances the germination and vigour by increasing the chlorophyll, proline, phenolic contents and antioxidant activity. For chilli, the solid matrix priming (vermiculite: 24h/250 C) and magnetic treatment (50mT/ for 30 min) were found most effective for improving seed vigour, root growth, emergence, field performance, stand establishment, fruit and seed yield under suboptimal conditions. The seed coating with Biofilm (An-Tr) and Cyanobacterial Consortium microbial formulations saved the nitrogen dose up to 25% with at par yield of RDN. Also, the seed coating with microbial formulations resulted in better germination, seedling vigour and uniformity in germination throughout the storage period. Similarly, seed coating with a BF1-4 cyanobacterial consortium and biofilm (An-Rh) had a beneficial impact on overall plant growth and crop performance, along with savings in nitrogen dose in chickpea. The Zn-NCPC (1:4) seed coating fertilizer has enhanced the seed quality attributes, Zn use efficiency and storability of mung bean seeds.

Seed health is an important aspect of seed quality. An eco-friendly approach to manage seed-borne pathogens using different organic compounds revealed that 12% *Beejamrit* could inhibit 81% of mycelial growth and enhance the seed germination, seedling length and dry weight compared to control in chickpea. An integrated disease management study for onion Stemphylium blight revealed three sprays of *A. indica* (5 ppm) reduced disease severity in the field by over 50% and enhanced seed yield, comparable to Mancozeb and Zineb. The DAC-ELISA test of 150 soybean leaf samples showing crinkling, mosaic and mottling symptoms of various soybean lines showed the absence of soybean mosaic virus and bean pod mottle virus but the presence of cowpea mild mottle virus under Delhi conditions. The division is progressing at the technology development forefront, and this year, three technologies were identified that are at different stages of development.

The division offers courses for the UG, PG and PhD students selected through the All India Entrance test. This year, 8 MSc and 11 PhD students earned their degrees after successfully completing the respective courses. The students and faculty of the division received several awards and brought laurels to the division. One of the MSc students, Ms Tuhina Ghosh, received the IARI merit medal, and Dr Archana received the Sadhana All India Best Research Award at the doctorate level by the Society for Advancement of Human and Nature, YS Parmar University of Horticulture and Forestry, Solan.

The scientists of the Division published 34 research papers in scientific peer-reviewed journals. In addition, an edited book, training manuals, technical bulletins, and book chapters were also published during 2023. The Division conducts various national and international capacity-building programs for extension and industry personnel. Several training programs were conducted to transfer the technology to the farming community, and huge quantities of seed and planting materials were distributed to needy farmers under the SCSP scheme. The scientific and technical staff of the division also participated in several kisan goshtis, Krishi Vigyan mela, MGMG program and several other extension activities.

DIVISION OF SEED SCIENCE AND TECHNOLOGY: AN INTRODUCTION

Realizing the importance of seed in agriculture, IARI took the lead and established a separate Seed Testing section in the erstwhile Division of Botany in the year 1961. The section of Seed Testing was later upgraded to a full-fledged Division of Seed Technology in 1968 to provide leadership in maintenance breeding, seed production, quality evaluation, storage, physiology, pathology, variety identification, genetic purity evaluation and DUS testing for plant variety protection, development of seed quality assessment procedures and human resource development. The Division was renamed as Division of Seed Science and Technology in 1984. This Division has the following mission.

Mission

- To undertake basic, strategic and applied research on seed production, testing, storage and seed quality enhancement.
- Development of seed production technology for field and vegetable crops.
- To impart postgraduate education and training for human resource development.
- Standardization of seed testing procedures, facilitating implementation of Seeds Act and Plant Variety Protection & Farmers' Rights Act
- Enhancing quality seed availability through farmers' participation.

The Division of Seed Science and Technology has seven major laboratories that conduct research on seed production, testing, storage and quality enhancement.

Seed Physiology laboratory

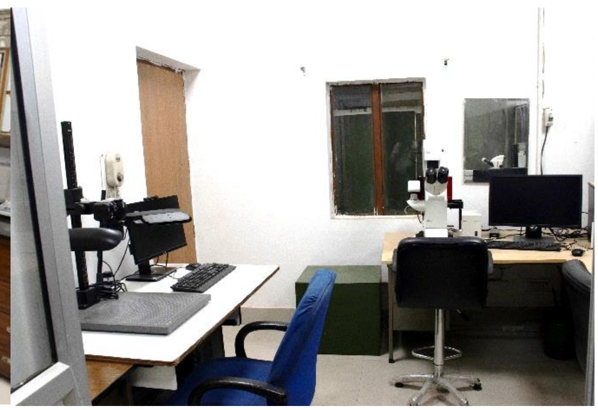
The primary research interests being pursued in the lab are seed storage physiology; seed germination and dormancy mechanisms; seed longevity and its extension methods; seed vigour and its enhancement techniques.

Presently, the research work on the following topics is initiated in the seed physiology lab by the scientists and students

- ♦ Storability studies of quality protein maize
- ♦ Studies on thermotolerance of rice at seed and seedling stages
- ♦ Understanding the genetics of seed dormancy in rice, wheat and mung bean
- ♦ Understanding the genetics of seed longevity in rice, maize and soybean

- Seed vigour and seed quality enhancement studies in pearl millet, maize and rice
- Role of oxygen in seed storage, germination and dormancy mechanisms.



Seed Biochemistry Laboratory

The major areas of research in this lab are identifying biochemical mechanisms underlying the improvement of crop establishment through seed invigoration techniques under various abiotic stresses *viz.,* heat, drought, salinity etc., thereby developing strategies for increasing crop resilience. Further, studies on effect of climate change particularly high temperature, on seedling establishment, plant reproductive development and seed quality in Indian Canola are being carried out in this laboratory.

Seed Molecular Biology Laboratory

In the seed molecular biology laboratory, both basic and applied research in areas like - the development of protein, isozyme and DNA markers for assessment of seed purity; and understanding the molecular mechanism of seed germination, dormancy,

longevity and early seedling vigour are being undertaken. The lab also specializes in the application of chemical formulations for seed quality enhancement..

Seed Pathology Laboratory

The major research activities in the lab include characterization and development of diagnostics for seed borne fungal, bacterial and viral diseases of cereals and vegetable crops. In this laboratory, standard ISTA recommended seed health tests are being carried out along with advanced molecular techniques.

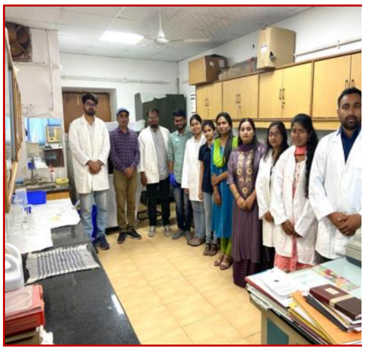
Seed Quality Enhancement Laboratory

In this laboratory, research on different seed priming approaches, including osmopriming, hydropriming, phytohormone-priming, chemical priming, nutrient priming, and redox priming to boost seed vigour are being carried out. The objective is to find a cheaper, more practical and effective approach, leading to fast and uniform seed germination, increasing seedling vigor and crop yield, especially under unfavorable environmental conditions. In addition, nanopriming of tomato seed is also being undertaken for seed quality enhancement.

Post Graduate Laboratory

The Post Graduate Laboratory of the Division has all the basic facilities and equipment that are required to carry out various activities needed for facilitating the research activities of both the students and the faculty. The major research themes in this lab are seed quality assurance, seed quality enhancement, seed biology and seed pathology.






Seed Testing Laboratory

The first seed testing laboratory in India was established at IARI in 1961 with the aid of Rockefeller Foundation. Later, through a Gazette notification, it was notified as the Central Seed Testing Laboratory (CSTL) from 01 Oct 1969 by the Government of India. CSTL played a significant role in strengthening the Indian Seed Sector by providing technical inputs for seed quality assurance. The Central Seed Testing Laboratory was relocated from IARI, New Delhi to the National Seed Research and Training Centre (NSRTC), Varanasi (UP) in 2007. The Seed Testing Laboratory at IARI, New Delhi, is still continuing its service / activities to the seed industry by analyzing commercial seed samples and seed samples of other research organizations apart from the research samples of scientific staff and post-graduate and doctoral students of the Institute.

Services

Seed testing Laboratory is the hub of seed quality control. The Seed Testing Laboratory housed at the DSST, ICAR-IARI, New Delhi caters to the seed testing needs of public and private agencies to gain information regarding the planting value of seed lots. The high quality seeds of improved field and vegetable crop varieties, bred at ICAR-IARI, New Delhi are spread all through-out the country and marketed through brand name called "PUSA BEEJ". Seed quality testing is a mandatory requirement for commercial seed sale as well as in-house quality control mechanism with respect to the seed production programme undertaken at Institute research farms, Seed Production Unit and regional stations by subjecting the seed samples to routine tests at our Seed Testing Laboratory. The Seed Testing Laboratory has significantly contributed in the formulation and standardization of seed testing protocols, developing seed standards for un-investigated crop species and is actively involved in conducting research in solving the practical problems in seed testing. The Seed Testing Laboratory has imparted a number of trainings to seed analysts working in other Seed Testing Laboratories since 1980. Besides, the STL is also generating revenue for the Institute through seed testing of commercial samples and resource generation through seed testing services. A total of 2187 samples were tested during 2023, including 1117 commercial and 1070 service samples, with a total revenue generation of Rs. 4,38,000

Divisional projects

The Division is undertaking all its research activities under the aegis of two research projects. Project 1 is designed for basic seed research, and Project 2 caters to the application part of the seed research.

PROJECT 1
Understanding the mechanisms of seed quality traits expression and development of seed production in field and vegetable crops
Objectives:

1. To study natural genetic variation for seed longevity, dormancy, germination and vigour in rice, maize, mungbean, soybean and onion

2. Development of hybrid seed production technology of gynoecious and parthenocarpic cucumber and tomato

3. Understanding the effect of abiotic stress on seed yield and quality parameters in rice, wheat and Indian mustard

4. Identification, characterization and development of diagnostic protocols for detection of seed borne viruses in soybean

PROJECT 2
Enhancement of planting value through pre and post production interventions in agri-horticultural crops

Objectives:

1. Exploration of the seed treatment interventions including nanotechnology for enhancing and maintaining seed quality in pearl millet, specialty maize, soybean, quality mustard, chickpea, onion, brinjal and tomato

2. Seed storage studies under modified atmosphere for seed quality maintenance in soybean, high volume pulses (chickpea and field pea) and high value vegetable seeds (tomato, brinjal and onion)

3. Development of protocols for testing and seed health standards for important fungal (Fruit rot in chilli, fruit rot in brinjal, bakanae in paddy and flag smut in wheat) and bacterial (bacterial leaf blight in rice and tomato canker) seed borne diseases

4. Optimization of sieve size and type of screen for grading seeds of different crop varieties and hybrids including their parents.

5. Development of seed quality standards in potential (buckwheat and rice bean) and medicinal rtimisia, palmarosa and opium poppy) plants

1. HYBRID SEED PRODUCTION

1.1. Stigma receptivity studies in CMS lines of Indian mustard

New CMS and fertility restoration systems in Indian mustard (*B. juncea* (L) Czern and Coss) have been developed using the cytoplasm of a wild species namely, *Moricandia arvensis*, *Diplotaxis erucoides* and *Diplotaxis berthautii*. To increase the success of hybrid seed production, it is necessary that the female parent plants are at the optimal stage of stigma receptivity and a prolonged stigma receptivity during pollination period. The highest stigma receptivity reached up to two to three days following flower opening. Among the 3 CMS sources; *Diplotaxis berthautii* showed higher stigma receptivity compared to *Moricandia arvensis* and *Diplotaxis erucoides*. Among the nuclear genotypes, Pusa Tarak was the most promising. These findings will aid in the selection of appropriate nucleo-cytoplasmic combinations for use in the *B. juncea* hybrid breeding programme.

1.2. Hybrid seed production technology of gynoecious cucumber

Hybrid seed production technology of Pusa Cucumber Gynoecious Hybrid-18 has been standardized under protected conditions (Fig. 1). Multiple pollination had no effect on enhancing the fruit and seed yield and quality. A row ratio of 3:1 was recommended for hybrid seed production. Application of silver thiosulphate at 0.03 mM twice at 2-3 leaf stage and 7 days after first spray was found optimum for

Fig 1. Seed production under net house.

maintenance of gynoecious lines. Stigma receptivity was highest at time of anthesis, and pollination could be attempted from anthesis to 10 a.m. for higher fruit setting and seed yield. Fruit load of 4 and 3 fruits/vine respectively was found optimum in *Kharif* and Spring-Summer. Seed production in *kharif* yielded higher but the seed quality was better in spring-summer season. A seed yield of 2.0kg/100sqm could be achieved under net house conditions.

2. SEED QUALITY ASSESSMENT

2.1. Seed vigour assessment in rice varieties

Seed vigour determines early, rapid, uniform, germination, emergence, and growth of vigourous seedling in varied environmental conditions. Forty-four rice varieties were assessed for different seed vigour component traits. The estimation of descriptive statistics of 20 quantitative vigour traits indicated existence of variability among the rice varieties. The 44 varieties were grouped into five clusters on the basis of average linkage and dendrogram (Fig. 2). The cluster-I had 21 varieties followed by 8, 6, 3 and 6 varieties in other clusters, respectively. Varieties in Cluster I were considered to possess high vigour traits. Principal component (PC) analysis showed first 5 PCs having Eigen value >1 explaining 77.01% of the total variation with different seed vigour traits. Seed vigour index-I, seed vigour index-II, seed dry weight, shoot length, reserve mobilization, germination percentage, dehydrogenase, mean germination rate, speed of germination, and mean germination time contributed to high variability among the varieties. The positive correlation among these seed vigour contributing traits

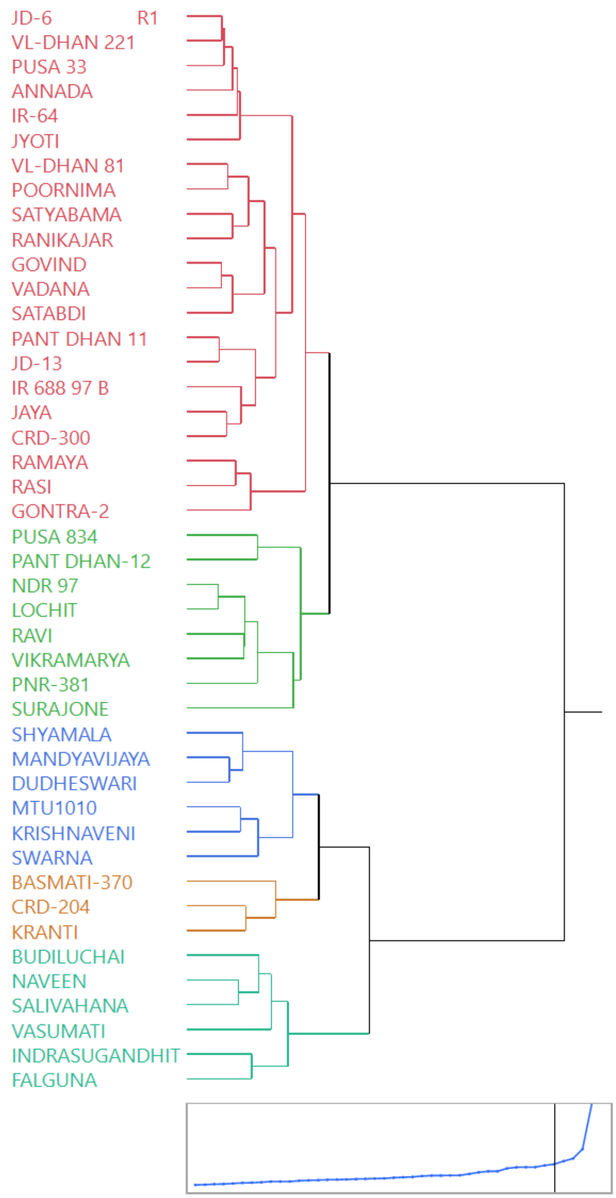


Fig 2. Clustering of rice varieties based on seed vigour traits.

suggested that these characters were important for selection of high seedling vigour and early emergence varieties. The identification of traits and markers namely RM 1353, RM 250 and RM 229 were associated with seed vigour and provides valuable insights for future rice breeding programs, aiming at enhancing the overall quality and productivity.

2.2. Candidate gene/s for the early germination trait in rice

In direct-seeded rice (DSR) cultivation, robust seedling establishment is crucial for crop success under less favourable field conditions. Early seedling vigor (ESV), encompassing lemma rupture (LR), radicle emergence (RE), and coleoptile emergence (CE), significantly influences uniform seedling establishment. Despite its importance, the genetic mechanisms governing ESV in early seed germination

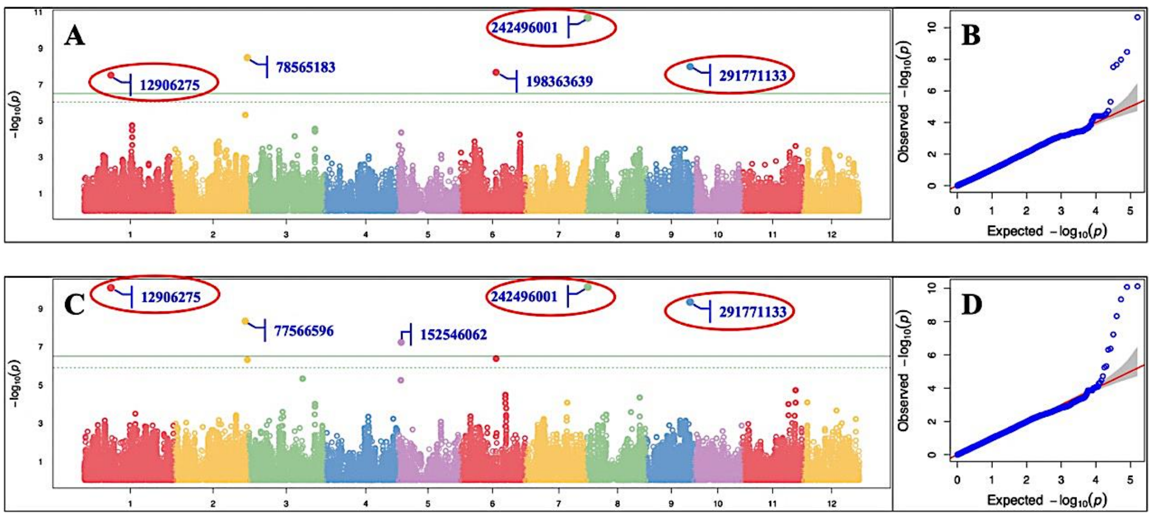


Fig 3. Manhattan plot of BLINK model for TFRE. A: First *Kharif harvest;* B: Q-Q plot of first *Kharif* harvest; C: Second *Kharif* harvest; D: Q-Q plot of second *Kharif* harvest. Green line: Bonferroni threshold (3.13972×10^{-07}) at $-\log_{10}(P)$ value of 6.50. Significant MTAs are named by their SNP IDs MTAs that were consistent across the seasons were circled with red line.

are largely unexplored. A genome-wide association study (GWAS) was conducted using a subset of the rice germplasm from the 3,000 Rice Genomes Project (3KRGP). Germination patterns were observed at four-hour intervals, and specialised software quantified key parameters: Time to First Lemma Rupture (TFLR), Time to First Radicle Emergence (TFRE), and Time to First Coleoptile Emergence (TFCE). Seeds of two hundred and fifty-seven rice accessions belonging to 3KRGPthat were multiplied in two consecutive *Kharif* seasons at IARI, New Delhi were phenotyped for early germination trait 'Time to 50% radicle emergence (TFRE) and GWAS were conducted to identify the candidate gene/s associated with TFRE. In the first season, five significant MTAs (qTFRE1.1, qTFRE2.1, qTFRE6.1, qTFRE8.1 and qTFRE9.1) located on chromosomes 1, 2, 6, 8 and 9were identified. In the second season five MTAs (qTFRE1.1, qTFRE2.2, qTFRE5.1, qTFRE6.1 and qTFRE9.1) on chromosomes 1, 2, 5,6 and 9 in second season crop. Notably, three of these MTAs (qTFRE1.1, qTFRE8.1 and qTFRE9.1) remained consistently significant across both seasons (Fig. 3). qTFRE8.1, which exhibited consistency in both seasons, displayed the highest PVE values of 16.70% in first season and 17.30% in second season. Genes in the vicinity of the identified MTAs that were in the LD block of the respective MTA were retrieved and subjected to Knetminer analysis to get the gene specific Knet Score. Based on the Knet Score, seven candidate genes were identified that could play significant role in TFRE trait expression (Table 1). The study illuminates genetic mechanisms influencing ESV during rice seed germination, emphasising the importance of specific germination-related systems. These insights offer valuable guidance for researchers aiming to enhance crop resilience and productivity in DSR systems traits for crop stand establishment and seedling growth in direct-seeded rice.

Generation advancement of RIL population developed for early seedling vigour traits in rice

Four hundred $F_{2:3}$ lines that were having contrasting seed traits (Fig. 4) advanced to F_5 generation.

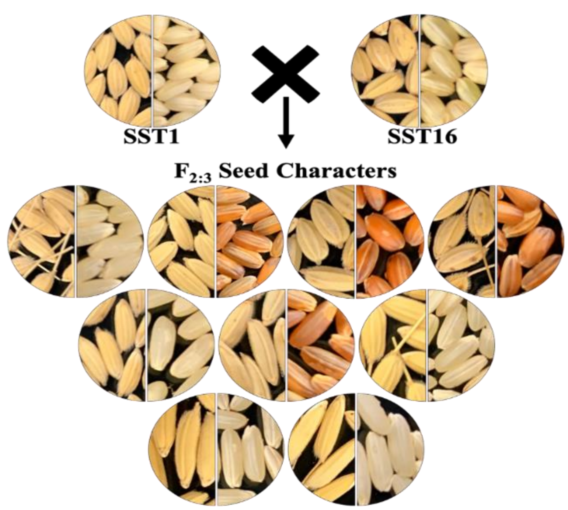


Fig 4. RIL population with contrasting seed traits.

Table 1. List of candidate genes identified for early germination trait TFRE in rice.

Trait	MTA	Potential candidate gene	KnetScore	Distance from MTA / MTA is present in	Functional annotation
TFRE	*qTFRE8.1*	*LOC_Os08g01700*	49.24	50 Kb downstream	Basic helix-loop-helix family protein
		LOC_Os08g01670	15.66	77 Kb downstream	invertase/pectin methylesterase inhibitor family protein
	qTFRE9.1	*LOC_Os09g36910*	134.34	7 Kb downstream	bZIP transcription factor domain containing protein
		LOC_Os09g36900	57.04	22 Kb downstream	WD domain, G-beta repeat domain containing protein
	qTFRE1.1	*LOC_Os01g22920*	141.94	22 Kb downstream	Gibberellin 2-beta-dioxygenase
		LOC_Os01g22954	16.44	7th intronic region of the gene	WD domain, G-beta repeat domain containing protein
	qTFRE2.2	*LOC_Os02g57530*	370.51	43 Kb downstream	Ethylene receptor
	qTFRE2.1	*LOC_Os02g56140*	100.08	57 Kb upwnstream	helix-loop-helix DNA-binding domain containing protein
	qTFRE5.1	*LOC_Os05g03430*	85.94	6 Kb upwnstream	ATSIZ1/SIZ1

2.3. Differentiation of rice seed lots varying for seed vigour by headspace ethanol content

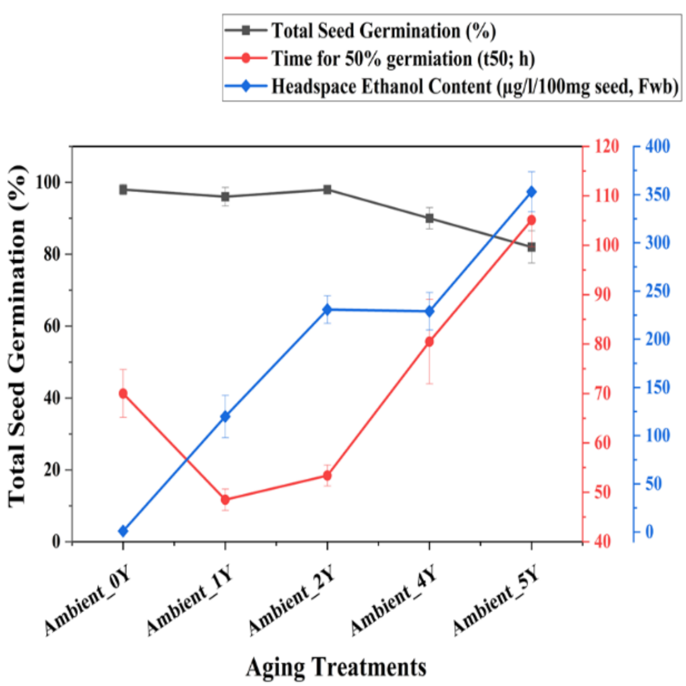


Fig 5. Mean percentage total seed germination, time for 50% germination, and headspace ethanol content of five rice genotypes across different ageing treatments. Fresh seeds (Ambient_0Y) and seeds aged under ambient conditions for different years (Ambient_1Y, Ambient_2Y, Ambient_4Y and Ambient_5Y).

The mean values for percentage total seed germination, time for 50% of total germination, and headspace ethanol content across five different rice genotypes were measured in fresh and aged seed lots (Fig. 5). The time for 50% of total seed germination and headspace ethanol content increased with increase in storage duration clearly indicating a strong positive relation between seed vigor (t_{50}) and headspace ethanol content. We did not see any significant decline in the mean total seed germination with increase in aging time. However, upon ageing seeds took more time to reach 50% of the total seed germination and the seeds accumulated more headspace ethanol content.

2.4. Seed vigor assessment in mustard

A total of 165 lines was evaluated for germination and vigor traits viz. germination (%), seed vigor index-I, Seed vigor index-II, dry weight (mg), total seedling length(cm), speed of germination, mean germination time(days) etc. under normal conditions. The genotypes could be grouped into two groups I (low vigor seeds) and II (high vigor seeds), based on germination and vigour parameters (Fig 6). The group I accounted for 14% of the total accessions while group II accounted for 86% of the total accessions. The high vigor group showed the positive correlation of germination percentage with seed vigour index-I, seed vigour index-II, speed of germination and germination index. The results indicated large natural variation among lines. The lines with high and low vigour were identified and the contrasting lines could be used to breed superior mustard cultivars for vigor traits.

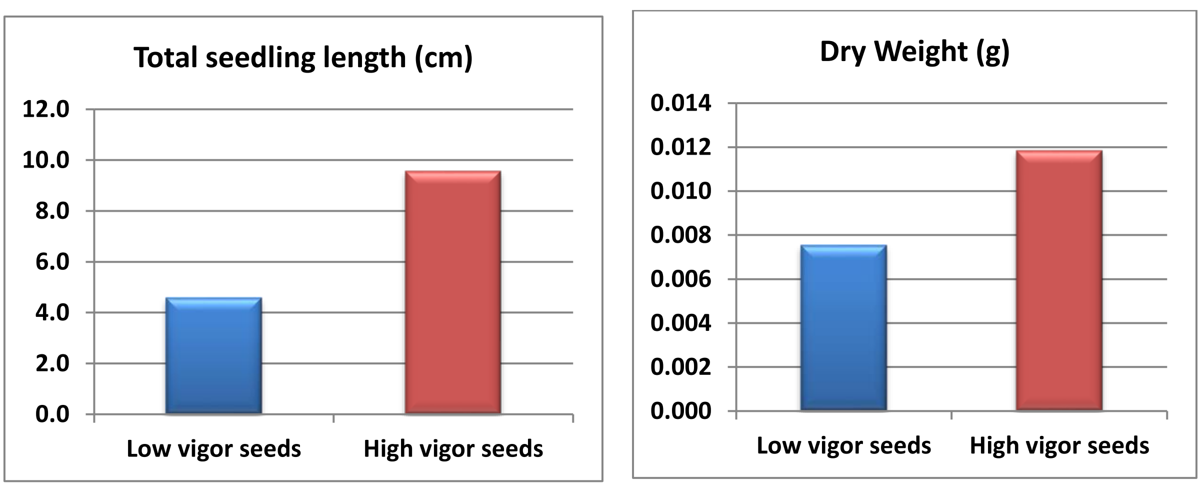


Fig 6. Total seedling length and dry weight in high vigor and low vigor seeds.

3.ABIOTIC STRESS AND SEED PRODUCTION/QUALITY

3.1. Thermotolerance studies in rice

The thermotolerance diversity in rice genotypes was studied at germination and early seedling stages by developing a methodology for basal thermotolerance (BT), short-term acquired (SAT) and long-term acquired thermotolerance (LAT) in 24 h imbibed seed, 1-1.5 cm radicle stage and 7-day old seedling stages using a heat sensitive genotype, IR64. The identified BT of 57°C for 30 minutes for imbibed seed, 48°C for 30 minutes for the radicle emergence (RE) stage and seven-day-old seedlings (Sdl) were validated on four heat-sensitive and four heat-tolerant genotypes (Fig 7). A significant difference in the normal seedling percentage was observed in all three stages between susceptible and tolerant genotypes, with lower values in the sensitive genotypes. At BT, for the imbibed seed stage, the sensitive genotypes produced normal seedlings ranging from 4 to 30% and tolerant genotypes from 60 to 80%. Whereas at the radicle emergence stage in both sensitive and tolerant genotypes, the normal seedlings range from 5 to 20% and 50 to 70%, and at the seedling stage, 10 to 20% and 60 to 70%, respectively. To study the SAT and LAT, the material was subjected to identified acclimation temperatures before heat stress was imposed in all three stages. This enhanced germination in both heat-susceptible and tolerant genotypes, at par with control.

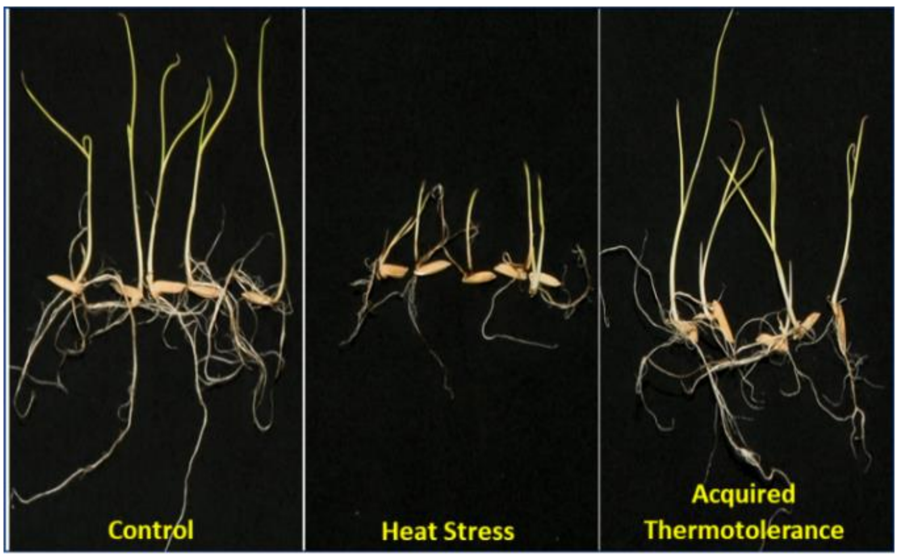


Fig 7. Thermotolerance in radicle stage.

The effect of determined acclimation temperatures was validated in four heat-sensitive and four heat-tolerant genotypes at all three stages for both SAT and LAT. The sensitive and tolerant genotypes produced more than 90% of normal seedlings even after being subjected to heat stress, which was at par with control.

3.2. Salinity stress tolerance and seed quality in wheat The effect of salinity stress was investigated in eleven wheat varieties, comprising one known salt tolerant

Fig 8. Seedling length variation among four wheat species.

genotype viz. KRL 210 as control and ten prominent wheat varieties viz. HDCSW 18, HD 3117, HD3226, HD 3249, HD3271, DBW187, HD3171, HD3118, HD2967, HD 3086. The material was screened at two salinity levels viz. 4ds/m and 6ds/m. A comparative assessment of salinity tolerance was worked out for a total of 16 genotypes belonging to 4 different wheat species viz. four each of *T. aestivum, T. sphaerococcum, T. durum* and *T. dicoccum* along with one known tolerant variety of bread wheat viz. KRL 210 as control. The study was conducted under laboratory conditions at room temperature using top of paper method and the effects of various salinity levels viz. 0, 3, 6 and 9 dS/m on seed quality parameters was assessed. Salinity stress leads to a significant reduction in the root length, shoot length and seedling length (Fig. 8) and dry weight, most prominently at higher salinity stress level at 9 dS/m. The seed quality parameters and their relationship with salt tolerant indices was used for selection of genotypes for salt tolerance; and could classify resistant and susceptible genotypes for each of the wheat species under the present investigation. Based on the correlation studies of all the seed quality parameters with respect to STI, highest correlation was found at 9 dS/m and hence the genotypes with two extreme salt tolerance indices were selected at 9 dS/m for the priming studies for all the wheat species. Seed priming with Ascorbic acid (100 ppm) gave better salinity alleviation response for both bread wheat and *sphaerococcum* genotypes whereas 1.5% KNO_3 gave better response for durum wheat genotypes and 3% KNO_3 for *dicoccum* wheat. Higher amount of catalase, peroxidase and proline were recorded for the salt resistant genotypes than the susceptible genotypes.

4. SEED STORAGE AND LONGEVITY

4.1. Hyperspectral analysis in rice seed longevity

A major challenge to supply quality seed for production depends on seed longevity during its storage. Experiments were carried out to use hyperspectral imaging for estimating seed viability in natural aged rice seed lots of 39 released rice varieties produced in 2017, 2018, 2020, 2021 and 2022 stored under ambient laboratory conditions. Based on the results of seed germination the varieties with good and poor storability were identified. The dehusked grains of those varieties were used to collect reflectance values using hyperspectral imaging system. The spectral reflectance showed that aged seeds had higher spectral reflectance values than that of fresh seeds (Fig. 9). A significant difference in spectral signatures was observed between specific bands (NIR and SWIR) that have high correlation with seed germination. Spectral indices and multivariate technique-based approaches prove to predict seed viability of rice varieties with significant accuracy (RPD >2).

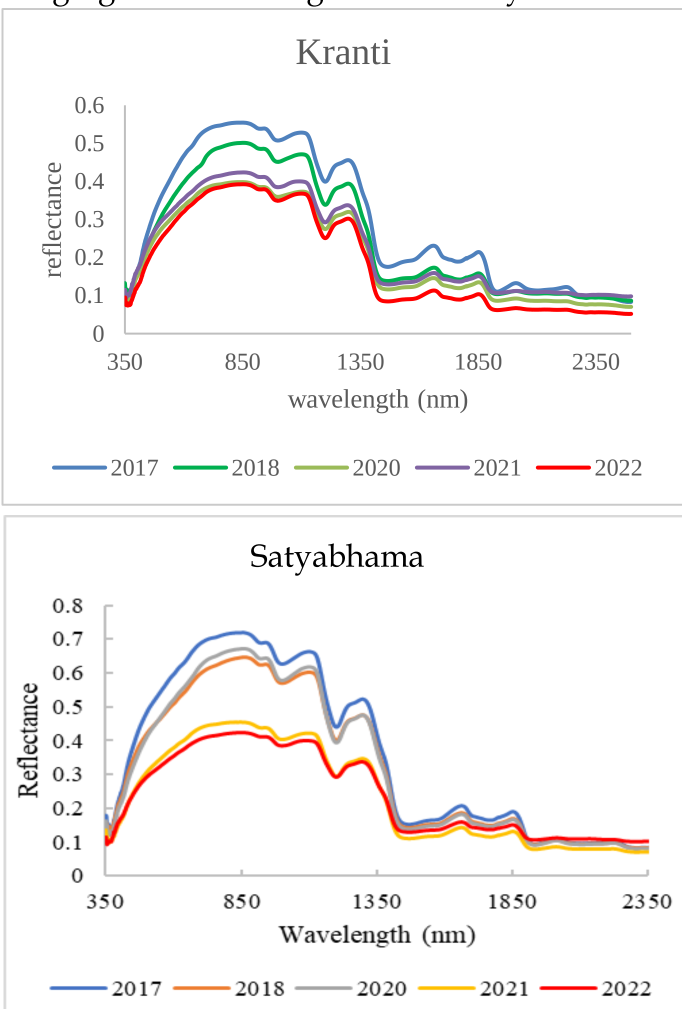


Fig 9. Spectral signatures from seeds harvested in different years subjected to natural ageing in Good (Kranti) and Poor (Satyabhama) storer rice varieties.

Using Multivariate technique, Partial Least Square Regression (PLSR), the most prominent sensitive bands can be identified to predict germination. The information generated using hyperspectral imaging would be useful to determine seed longevity status in each seed lot accurately and rapidly.

4.2. Seed ageing in rice

Seeds of six different rice varieties equilibrated to low equilibrium relative humidity (ERH) of 33% (SMC=8.3%) showed significant variation in germination after storage for >4.5 years under different oxygen levels and storage temperatures. Among the seed lots, FR 13A is most tolerant to ageing with average seed germination of 70% after 1553 days of storage, and Cypress with 27% average seed viability was observed to be the most sensitive during storage (Fig. 10a). After around 4.6 years of storage, average seed germination of the six seed lots differed across oxygen conditions with 82% at 28°C was significantly different compared to storage at 35°C with only 35% of viable seeds (Fig. 10b). Among the different oxygen levels, seeds of different seed lots exposed to hypoxia for 1553 days showed higher seed germination of 81%. In contrast, seeds under normoxia (21% oxygen) and hyperoxia (99% oxygen) showed significantly lower germination of 53% and

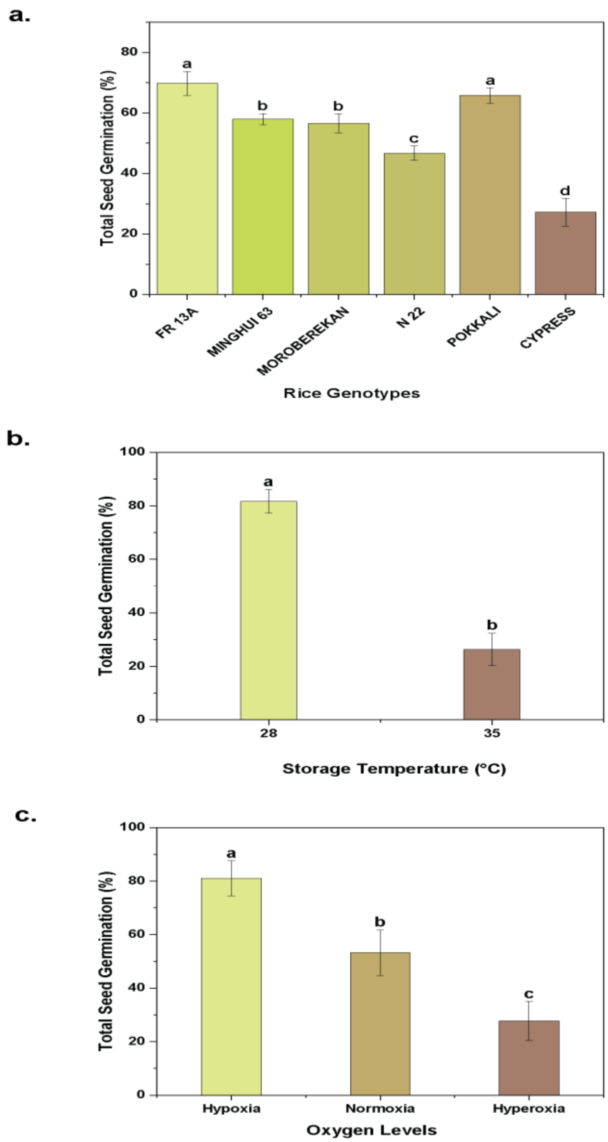


Fig 10. Effect on rice seed germination after storage. Total seed germination (%) as mean for rice genotypes (a), different storage temperature (b), and different oxygen levels (c).

28%, respectively (Fig. 10c).

4.3. Seed longevity of maize inbreds

Seed longevity of the maize inbreds ranges from 6-9 months under ambient storage conditions. The exploitation of natural variation in the inbred seed longevity not only helps in developing good hybrids but also eases foundation seed production and storage. Several screening studies were conducted to identify

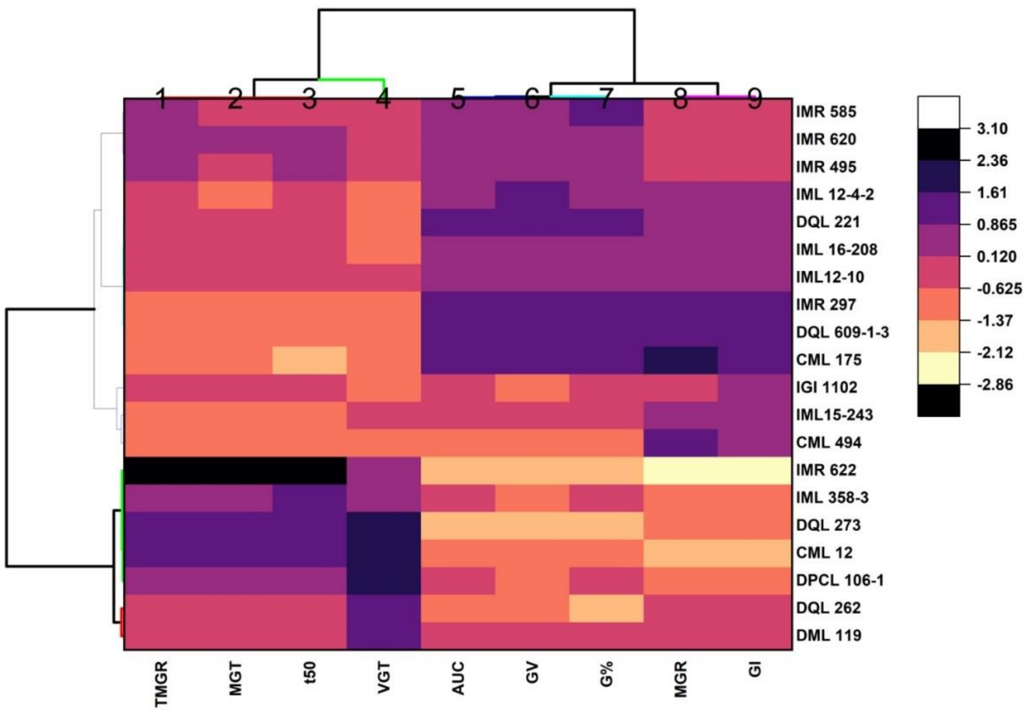


Fig 11. Heatmap with dendogram showing variation with respect to seed vigour among maize genotypes after 15 days of accelerated ageing.

the good storer inbreds. However, these screening methods are restricted mainly to accelerated ageing (100% RH and 42°C), which differs significantly from natural ageing at physiological and biochemical levels. In the present study, freshly harvested seeds of 81 maize inbreds were subjected to ageing for 6, 15 and 22 days of ageing at 75% RH and 42°C. After ageing, seeds were germinated on the top of the paper method. The germination counts were taken at different intervals up to 7 days. By using these germination counts, different germination and vigour parameters were extracted using 4- Parameter Hill Function. The results indicated a considerable variation among 81 maize inbreds for germination over the ageing period. The per cent reduction in mean seed germination was 12% and 58% at 15 and 22 days of ageing, respectively. At 22 days of experimental ageing, the mean seed germination of 81 inbreds was 40%, and the percentage reduction in germination was from 4 to 100% compared to fresh seeds. Significantly different ten good and ten poor storers were selected to construct a heatmap with a dendrogram for germination parameters (Fig. 11). Inbreds *viz.*, DQL 609-1-3, IMR 297, IMR 585 and CML-175 were identified as good storers and inbreds *viz.*, DQL 273, IMR 622 and DQL 262 as poor storers based on Area under germination curve, mean germination rate, germination index, germ value, Time to maximum germination rate, t50, mean germination time and variable germ time.

4.4. Genomic studies of soybean seed ageing

Genetic variation in the selected soybean accessions were studied while subjecting them to dry and wet ageing conditions, mainly to standardize the ageing duration to realize at least 50% drop in total seed germination from initial germination. Seeds of fifteen soybean cultivars were subjected to standard AA test (42° C & ~100% RH) for different storage durations. Soybean varieties showed large variation in their ability to tolerate harsh AA conditions. Aged soybean seeds initially showed reduced vigour with slower germination and loss in total germination (%) over storage time. Cultivar "EC 528623" was highly sensitive and recorded 86 per cent reduction in germination from its initial control at 7 days after ageing (DAA). Seed germination in most of the tested cultivars was reduced to around 50 percent from its initial value in 6 days of accelerated ageing. Similarly, under dry ageing conditions (50% RH and 41°C), we recorded that varieties 'Kalithur' and 'EC 76759' maintained better total germination (>85%) at 116 DAS and varieties 'EC 113770' and 'EC 456620' aged faster and lost > 60% germination at 116 DAS. Based on standardization of storage duration, around 270 soybean germplasm lines were characterized for germination traits under both wet ageing and ambient laboratory bench storage conditions. GWA analysis was carried out to identify casual SNPs across the genome. In seeds subjected to AA conditions, one significant SNP on chromosome 1 (*qSS 9.1*) was identified that regulates seed germination and two significant SNPs on Chromosome 16 and 20 was identified that regulates normal seedlings. Likewise, in seeds stored under ambient conditions, five significant SNPs on chromosomes 16, 12, 13 and 5 were related to seed germination and 3 significant SNPs on chromosomes 13, 12 and 16 were identified that regulate normal seedlings.

4.5. Seed quality and storage potential of Indian quality mustard

The seeds of four quality mustard genotypes were stored in a clothed bag under ambient conditions, and observations were recorded for germination (%), seed vigour index-I and seed vigor index-II at two months intervals for a period of 12 months. The results indicate that variety and storage duration and their interaction have significantly impacted germination percentage. The maximum germination was observed in PM 32 (98%) at 6 months of storage while minimum was seen in PM 33 (75%) after 12 months of storage (Fig. 12). It was observed that all the quality mustard genotypes could be stored for 10 months of storage under ambient conditions.

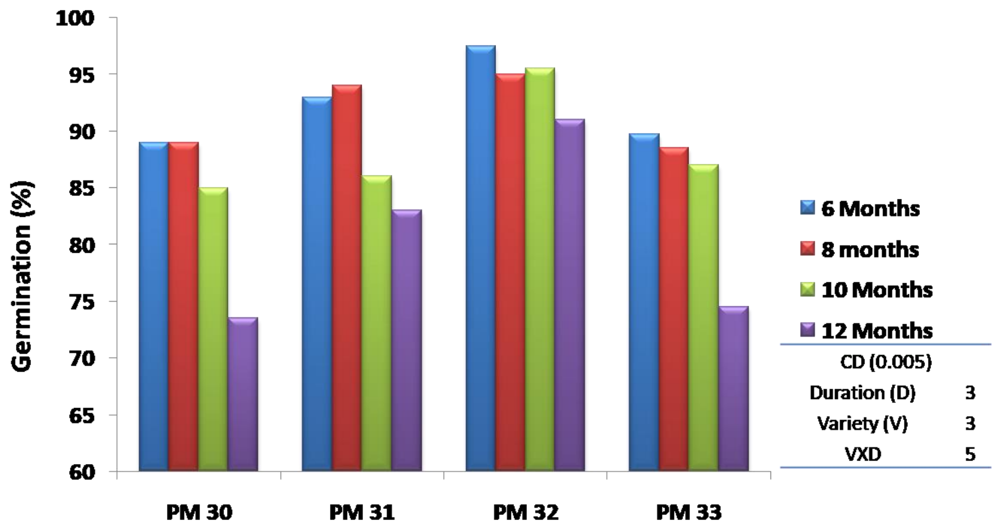


Fig 12. Germination percentage of quality mustard genotypes stored for different durations.

4.6. Seed storability of onion

Two onion varieties, Bhima Safed and Bhima Dark Red, good and poor storers respectively, were aged at 45°C and 100% RH for 0 to 16 days. Aging declined the germination from 81.67 to 0.67%. Increase in H_2O_2, electrolyte leakage, and decreased reactive oxygen species (ROS) scavenging enzymes. A total of 36 different fatty acids (FAs) were detected, several of which were reported for the first time including erucic acid, which is uncommon in onion seeds. Onion seeds were rich in unsaturated fatty acids (96%), with linoleic acid and oleic acid as major constituents. The decline in polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), and an increase in saturated FAs were noticed, indicating the peroxidation of unsaturated FAs. Correlation studies revealed a significant correlation between germination and 12 FAs, notably, FAs such as C18:2(n-6) Linoleic acid, C24:0 Lignoceric acid, and C18:3(n-6)-g-Linolenic acid, which are constituents of the cell membrane or serve as intermediary compounds (Table 2). A particularly intriguing finding was the differential behavior of C22:1n9 Erucic acid, which exhibited a positive correlation with germination in good storer but a negative correlation in poor storer variety (Table 2). In summary, this study establishes a clear connection between oxidative stress, lipid peroxidation, and the loss of viability in accelerated aging onion seeds.

Table 2. Pearson correlation between germination and fatty acids in onion (*Allium cepa* L.) seeds subjected to accelerated aging in Bhima Safed and Bhima Dark Red.

Fatty acids	Bhima Safed	Bhima Dark Red
C18:2(n-6)-Linoleic acid	0.62*#	0.91***
C12:0-Lauric acid	0.041	-0.75**
C24:0-Lignoceric acid	0.64**	0.78***
C23:0-Tricosanoic acid	0.51	-0.81***
C15:1-cis-10-Pentadecenoic acid	-0.43	-0.74**
C22:0-Behenic acid	-0.83***	0.27
C6:0-Caproic acid	0.52*	-0.39
C22:1-Erucic acid	-0.53*	0.82***
C4:0-Butyric acid	0.36	0.58*
C20:1-cis-11-Eicosenoic acid	0.09	-0.71**
C17:1-cis-10-Heptadecenoic acid	0.04	0.58*
C20:3-cis-11,14,17-Eicosatrienoic acid	-0.62*	-0.65**
C21:0-Heneicosanoic acid	0.02	-0.75**
C18:3(n-6)-g-Linolenic acid	-0.87***	-0.80***

5. SEED DORMANCY STUDIES

5.1. Seed dormancy studies in mungbean

A total of 138 mung bean genotypes with available sequencing data were used for dormancy studies. The seed dormancy gradually decreased with an increase in the after-ripening period and almost became zero at 355 days after harvesting. No significant correlation was observed between the decrease in dormancy and the increase in seed vigour in terms of t50 and MGT. The genome-wide association mapping of seed dormancy traits viz., Dormancy Index (DI), Intensity of dormancy (IOD) and Depth of dormancy (DSDS50) was done. Seven significant SNPs were identified for DI @130 days after harvest (DAH) and four marker-trait associations at 175 DAH. A maximum of 12 marker-trait associations were observed for DSDS50 and one significant SNP for IOD on different chromosomes. The identified SNPs needs to be further validated. For breaking the dormancy, infrared and ultrasound treatments were used. Among the different treatments, the infrared treatment with 1000 W for 90 seconds, 1500 W for 60 seconds, 1500 W for 90 seconds and 2000 W for 60 seconds resulted in higher germination and seed vigour in terms of mean germination time and germination uniformity.

5.2. Seed dormancy in common buckwheat

Buckwheat (*Fagopyrum esculentum* Moench) seeds exhibited high dormancy with only 21% of seeds germination in seed lots. Dormancy-breaking protocols through the use of chemicals and phytohormones namely GA_3, KNO_3, and H_2O_2 was developed. Seed treatment with 0.4% KNO_3 enhanced germination to 69% (Fig. 13). Both KNO_3 and H_2O_2 treatments significantly reduced the time to 50% germination (t50) (2.37 – 2.55 days) and mean germination time (MGT) (3.02 – 3.23 days). These treatments also enhanced the dormancy index (DI) (253.56 - 217.86). The seedling length was enhanced by 55% with 200 ppm GA_3. There was an enhancement in seed vigour indices by 305% and 260% in 20 mM H_2O_2 and 0.4% KNO_3 treatments respectively. Compared to the control, all the seed treatments enhanced the α-amylase activity. Both 0.4 % KNO_3 and 20 mM H_2O_2treatments recorded the highest α-amylase activity. The result suggested that KNO_3 and H_2O_2 treatments reduced seed dormancy and improved seed germination and vigour by increasing the mobilization of seed reserves. Application of 0.4% KNO_3 or 20 mM H_2O_2 as a dormancy release mechanism can be incorporated during seed testing and germplasm evaluation of buckwheat seeds with physiological seed dormancy.

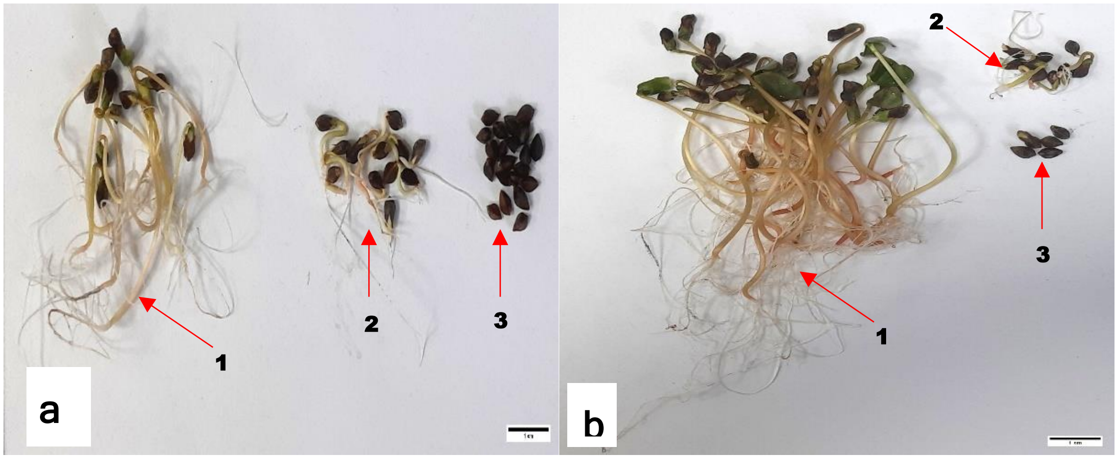


Fig 13 a. Control and b. 0.4% KNO_3-treated buckwheat (*Fagopyrum esculentum* Moench) variety PRB-1 seeds. Arrows indicate (1) normal seedlings, (2) abnormal seedlings, and (3) fresh ungerminated seeds of buckwheat. Scale bar = 1 cm.

5.3. Seed dormancy behaviour in cucumber

Parthenocarpic, gynoecious and monoecious and exotic lines of cucumber were studied for their seed dormancy behaviour. Genotypic variability was observed for intensity of dormancy, seed size, seed coat thickness, fruit order and post-harvest ripening among genotypes. The dormancy ranged from 0-4 months and was higher in *Kharif* than Spring-summer produce. The traditional monoecious and gynoecious lines had high and moderate dormancy respectively. Hormonal regulations (GA/ABA) were studied in genotypes with high, moderate and low dormancy status. Seed treatment with GA_3 at 1000 ppm, KNO_3 at 1% and dry heat treatment (70°C for 3 days) was effective for mitigation of seed dormancy.

6. SEED QUALITY ENHANCEMENT

6.1. Seed quality improvement through seed processing in paddy

The improvement of paddy seed quality through basic processing machines comprising seed pre-cleaner, seed grader and a specific gravity separator was investigated. The product and rejects of these machines were evaluated for seed quality parameters. There was an enhancement in seed quality parameters after passing through the seed processing machines. The seed germination from reject outlet of processing machines ranged from 27.00% to 54.67%, which increased to 71.67%, whereas unprocessed seeds recorded a germination rate of 64.80% (Fig. 14). There was an improvement by 12.56%, 21.32%, 28.19%, and 27.91% in 1000-seed weight, seedling dry weight, vigour index-I, and vigour index-II, respectively in processed seeds, compared to unprocessed seeds. All the seed quality parameters were significantly lower in reject samples. Principal component analysis (PCA) reveals that all the samples from rejects, except one, grouped into a single cluster. PCA reveal a close relationship between vigour index-II and 1000-seed weight with PC1. The results from the study indicate that seed processing is beneficial in removing low-quality seeds and improving seed quality at various processing stages. The selection of seeds up to specific gravity separator outlet 4 is beneficial for obtaining high-quality seeds in paddy.

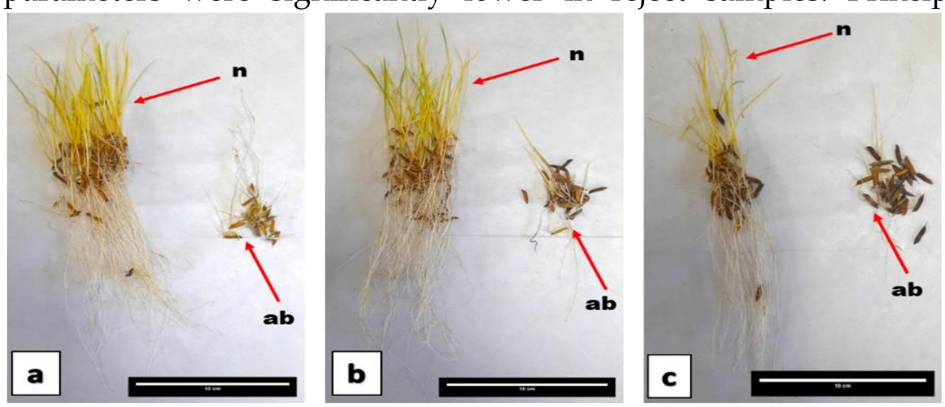
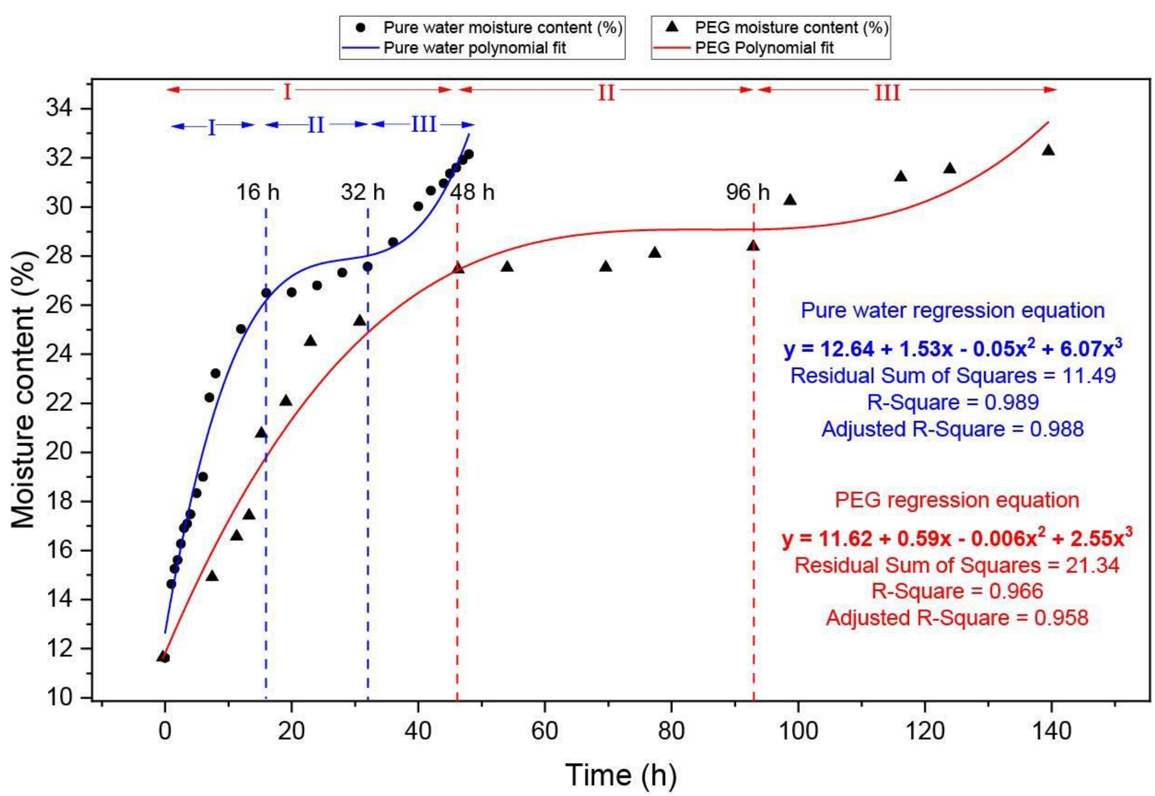


Fig 14. Effect of pre-cleaning on seed germination in paddy variety PBB-1847 a) pre-clean select b) pre-clean reject 1 c) pre-clean reject 2. n- normal seedlings, ab- abnormal and dead seeds. Scale bar = 10 cm.

6.2 Seed priming standardization in rice

Seed priming is a technique to enhance the seed vigour and uniformity of germination by reducing the lag phase and helping infuse beneficial chemicals that aid in metabolism during germination. The priming technique was standardized to know the effect of water availability, imbibition phase and dry back temperature in the IR64 variety. The moisture content curves of 0 and -1.2 MPa water potential were fitted with linear polynomial third-order fitting to identify different imbibition phases. Three different points with equal moisture content were taken from three different imbibition phases to study the effect of drying and imbibition phases on seed priming. The lower drying at 26^{o}C has resulted in better vigour in all three phases. The lag phase has resulted in high vigour with increased seedling growth parameters and germination kinetics among the three phases. The best points in 0 and -1.2 MPa were compared using a t-test to determine the role of water availability during priming. The -1.2 MPa water potential, with lag phase



imbibition and drying back to original moisture at a low temperature of 26^{o}C has the best vigour in terms of seedling growth, time for germination, speed of germination and uniformity of germination

6.3. Seed treatments for mitigating salinity stress in soybean

Studies for evaluation of the effect of salinity stress across various colour groups carried out on 73 soybean genotypes comprising of 26 yellow released varieties and 11 yellow germplasm lines, 25 genotypes with black seed coat colour, 5 genotypes with green seed coat colour and 6 genotypes with brown seed coat colour. All the genotypes were screened for salinity tolerance using standardized Petri plate method at different NaCl solutions with salinity levels of 0, 3, 6 and 9 dS/m. Based on the early seedling vigour and salt tolerance index values, the genotypes were categorized into highly tolerant and susceptible genotypes in each seed coat color (Fig. 15-18). The standard hydropriming duration was selected based on initial moisture uptake by the seeds but was stopped before radicle emergence. Hence, the primed seeds were scanned in Image-scanner and after 14 hrs of hydropriming duration, radicle was emerged in both top of the paper and between paper method. However, in between-paper method, few seeds showed the radicle emergence at 12 hrs of hydropriming. Hence, the best hydropriming duration was selected based on the germination parameters exposed to 0 to 12 hrs of hydropriming (Fig. 19). The physiological and biochemical analysis of selected tolerant and susceptible genotypes in each seed coat based on correlation analysis gave higher antioxidant activity (CAT, POX, APX, and SOD) and proline content with reduced lipid peroxidation and ROS-H_2O_2 content in black seed coat genotypes as compared to others. This suggests that black seed coat genotypes could tolerate higher salinity stress as compared to green, brown and yellow seed coat genotypes. Further, four different priming agents were selected, viz., potassium chloride (50, 100, 250, 500 mM), Paclobutrazol (100, 250, 500, 1000 mM), Salicylic acid (100, 250, 500, 1000 mM), and Jasmonic acid (20, 40, 60, and 80 mM), to select the best doses of seed priming to alleviate the salinity stress. The results revealed that JA (20 µM) had higher mean seed germination (77.5%), mean seedling length (15.85 cm), dry weight (13.62mg), VI-I (1230.00), and VI-II (1058.00) as compared to others. Hence, JA (20 µM)-primed seeds were further evaluated for the effectiveness of seed priming in enhancing the seed quality under hydroponic conditions and compared with hydro-primed and unprimed seeds. The morphological parameters such as leaf area index, leaf perimeter, and root system architecture were enhanced in JA-primed seeds, along with higher K^+ content and reduced Na^+ in the seedlings. Also, JA seed priming enhanced the antioxidant enzyme activity (CAT, POX, APX, and SOD) and proline content in the seedlings with reduced lipid peroxidation and ROS-H_2O_2 content. Hence, the potential use of black seed coat soybeans to germinate better under salinity stress is proven in the current study. Further, JA seed priming effectively alleviated the salinity stress by enhancing the morphological, physiological, and biochemical activity of the germinating soybean seedling.

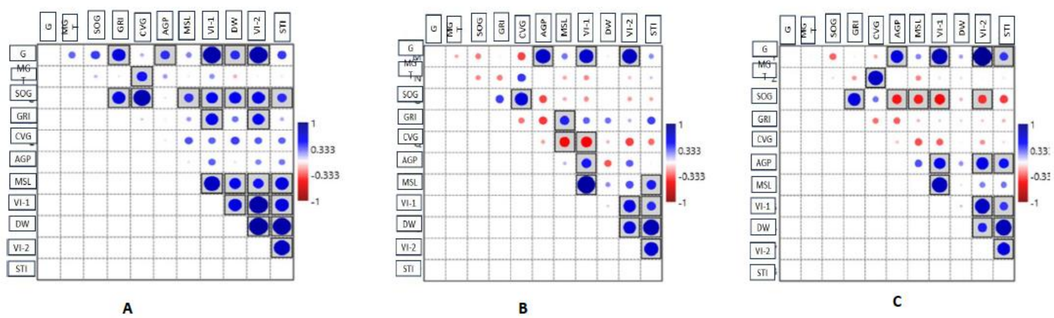


Fig 15. Correlation analysis of black seed coat genotypes (A) 3dS/m (B) 6dS/m (C) 9dS/m.

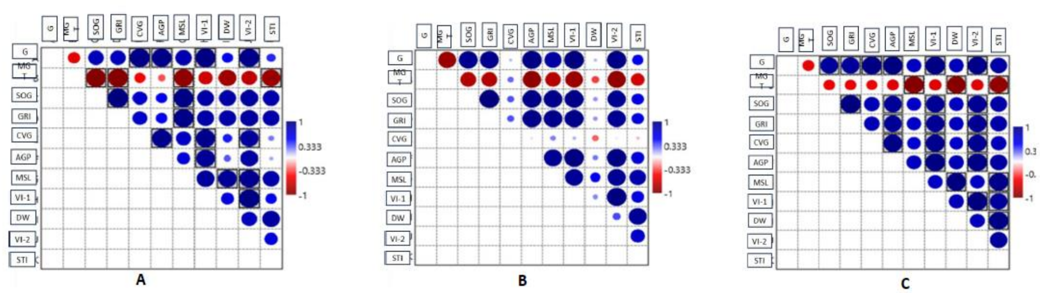


Fig 16. Correlation analysis of green seed coat genotypes (A) 3dS/m (B) 6dS/m (C) 9dS/m.

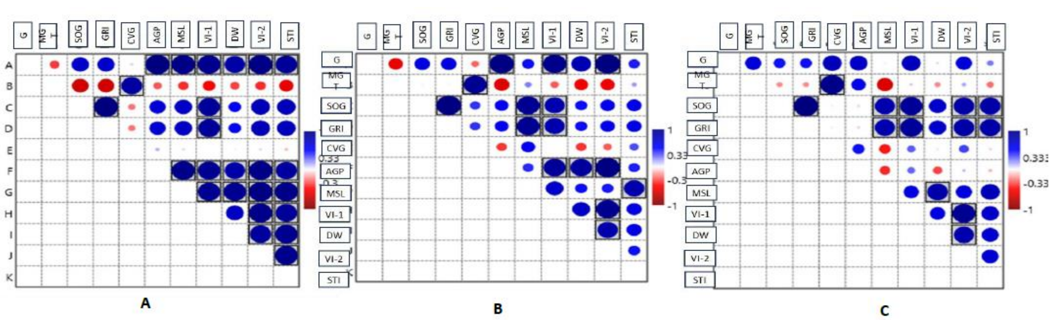


Fig 17. Correlation analysis of brown seed coat genotypes (A) 3dS/m (B) 6dS/m (C) 9dS/m.

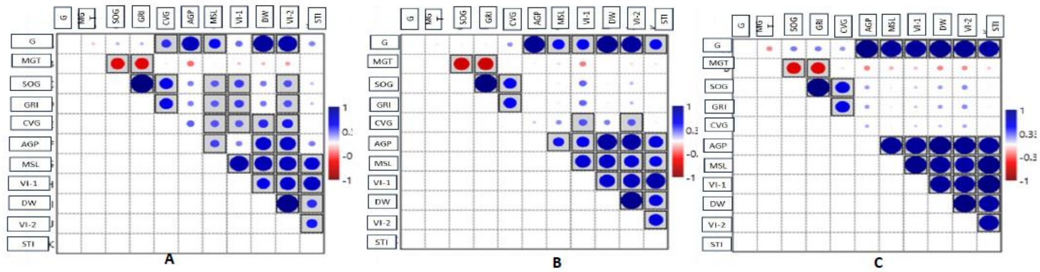


Fig 18. Correlation analysis of yellow seed coat genotypes (A) 3dS/m (B) 6dS/m (C) 9dS/m.

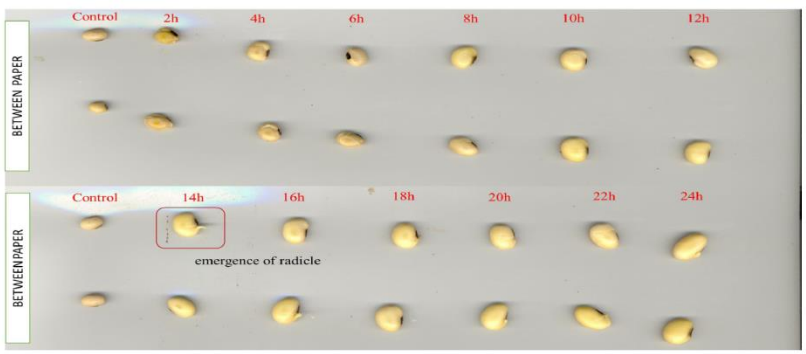


Fig 19. Standardization of hydropriming duration on between-paper method.

6.4. Seed priming for heat tolerance in lentil

To develop suitable strategies for heat tolerance in lentil (*Lens culinaris* Medik.) at germination stage, the humic acid priming seed treatments were evaluated for improving seed quality of lentil under heat stress. Seed priming with humic acid at a concentration of 600 ppm for 18 h increased the germination percentage (20%–23%) (Fig. 20), seedling vigor (29%–34%), membrane stability index (14%–18%), chlorophyll content (32%–68%), proline content, phenolic content, antioxidant activity, enhanced reserve mobilization and reduced the mean germination time, lipid peroxidation under both optimal and adverse conditions, thereby mitigating the deleterious effect of heat stress. Thus, humic acid seed priming is an eco-friendly, sustainable, and user-friendly strategy to improve germination indices and other biophysiological traits under heat stress in lentil.

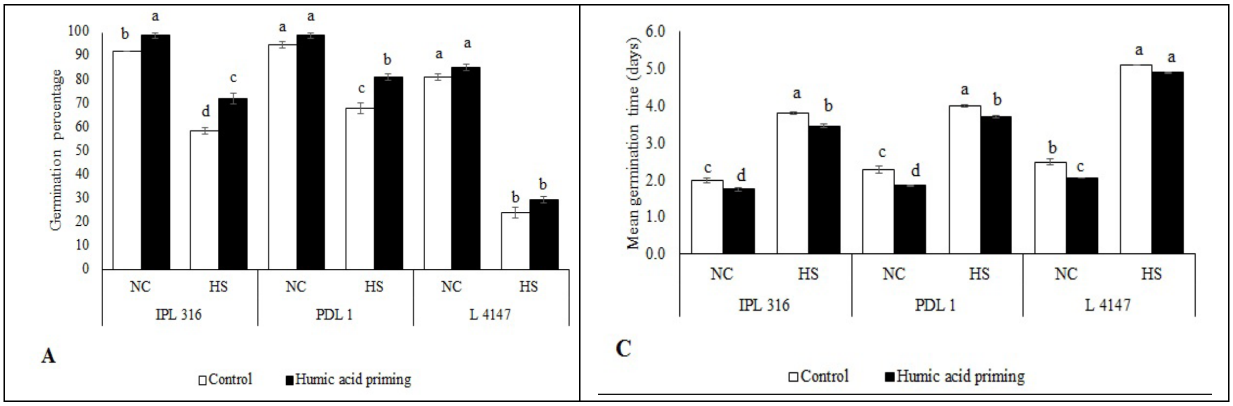


Fig 20. Effect of heat stress and humic acid priming on the seed germination (%) and Mean germination time (days).

6.5. Seed quality enhancement in Chilli

The seed crop encounters sub-optimum temperature during post-transplanting phase which affects seedling growth and crop establishment. Seed enhancement treatments play an important role in ameliorating detrimental effect of sub-optimum temperatures. Chilli genotypes: namely Kashi Anmol (high vigour) and Arka Lohit (low vigour) were given seed enhancement treatments which improved seedling establishment, plant height, total SPAD value, fruit and seed yield and flowered 2 to 3.5 days earlier as compared to untreated plots. Solid matrix priming (vermiculite: 24h/25^{0} C) and magnetic treatment (50mT/ for 30 min) were found most effective for improving seed vigour, root growth, emergence, field performance, stand establishment, fruit and seed yield. The correlation and principal component analysis also showed significant relation of seedling vigour and root growth parameters under sub-optimum and optimum temperature conditions. The seed enhancement treatments improved the membrane integrity, seed water relation, elevated free radical levels in the primed seeds. The invasion priming treatments resulted in formation of free space, micro cracks on seed coat topography as depicted in X ray and SEM studies. The trans-sectional studies showed formation of pits and disintegration of layers in solid matrix and magneto primed seeds, reflecting advancements in metabolic activities in primed seeds. The storage studies indicated that the solid matrix and magneto primed seeds stored better at 10±2°C in aluminium foil packaging as compared to 30±2°C in polythene (700 gauge) packets and could maintain seed germination above seed certification standard ($\geq$60%) for up to 9 months.

6.6. Seed quality enhancement through seed coating with microbial formulations in wheat

An experiment was conducted with four leading wheat varieties, including two timely sown (HD 2967 and HD 3086) as well as two late sown (HD 2851 and WR 544) varieties at the experimental field of DSST, ICAR- IARI, New Delhi. The seeds of different varieties were subjected to seed treatments with Vitavax and thiram as well as different microbial formulations, viz. (Vitavax and Thiram (3 g/ kg seed) + 100% RDN; Vitavax and Thiram (3 g/ kg seed) + 75% RDN; Cyanobacterial Consortium (BF1 – 4) + 75% RDN; Bacterial consortium (PW 1+5+7) + 75% RDN; biofilm (An – Tr) + 75% RDN; biofilm (An - PW5) + 75% RDN). A comparative study was made to assess the efficacy of seed coating with microbial formulations based on field performance, seed quality attributes and storability of coated seeds (Fig 21). The coated seeds exhibited significantly higher values of field emergence, plant stand establishment, dehydrogenase and nitrogenase activity in soil, leaf nitrate reductase and glutamine synthetase activity, available soil nitrogen along with yield and yield contributing attributes. Seed coating with microbial formulations was associated with savings in nitrogen dose up to 25% and the crop yields were at par with the recommended practices. Seed coating with microbial formulations resulted in better germination, seedling vigour and uniformity in germination throughout the storage period. Among all the treatment combinations, Biofilm (An-Tr) and Cyanobacterial Consortium can be recommended for timely sown and late sown varieties respectively, as they were associated with an overall increase in crop growth, seed yield and quality parameters.

Fig 21. Efficacy of coating with microbial formulations for seed quality enhancement in wheat.

6.7. Seed coating with microbial formulations for enhancing seed yield and quality in Chickpea

A study was undertaken with two chickpea varieties (Desi- Pusa 3062, Kabuli- Pusa 3022) and different microbiological formulations (such as *Anabaena torulosa-Mesorhizobiumciceri*; Cyanobacterial consortium BF1-4 comprising *Anabaena torulosa* (BF1), *Nostoc carenum* (BF2), *Nostocpiscinale* (BF3), and *Anabaena doliolum* (BF4); *Anabaena laxa* and An- Tr biofilm: *Anabaena torulosa-Trichoderma viride* biofilm) to assess the efficacy of the microbiological formulations in enhancing

Fig 22. Seed coating with microbial formulations for enhancing seed yield and quality in Chickpea.

seed yield and quality attributes, as well as to explore whether these microorganisms could be used as an alternative to chemical fertilizers in meeting the nitrogen requirements of the crop. The results revealed enhanced field emergence, improved plant stand establishment, plant height, better nodulation as well as enzymatic activity (Fig 22). Furthermore, the coated seeds were associated with improved soil microbial activity, accompanied by enhanced availability of nutrients like nitrogen, phosphorus, potassium, and organic carbon, resulting in improved crop performance as well as growth, including higher numbers of pods per plant and enhanced crop yields. However, there was no significant impact on the percent seed recovery or the seed quality parameters after harvesting. Notably, the application of microbial formulations through seed coatings exhibited a positive impact on seed storability, even after six months of storability. Hence it can be concluded that seed coating with a BF1-4 cyanobacterial consortium and biofilm (An-Rh) had a beneficial impact of on overall plant growth and crop performance along with savings in nitrogen dose.

6.8. Development of Polymer composites for seed treatment against pulse beetle in chickpea

Based on the leads obtained from the published literatures, twenty-four polymer composites were synthesized (Fig. 23) using natural (plant derivatives) and synthetic materials. These polymer composites are envisaged to work as either

Fig. 23 Polymer composites synthesized using natural (plant derivatives) and synthetic materials.

deterrents to pulse beetle oviposition or to larval entry into the seed or leading to insect mortality through asphyxiation and dehydration. Presently, these polymers are being evaluated for seed treatment against pulse beetle in chickpea.

6.9. Enhancing zinc use efficiency in mungbean through seed treatments

Zn-seed priming and coating treatments on short-duration mungbean variety Pusa Vishal were standardized to enhance the early seedling vigor characters. Among the Znprimed seeds at 300 ppm, 450 ppm, 600 ppm and 750 ppm, it was found that priming seeds with 450 ppm Zn2+ 1:1.5 (v/v) solution for 9 hrs at 25 ± 2°C has significantly enhanced the seedling growth. Among the seeds coated with Zn-fertilizers viz; Zn-NCPC (1:4; 1:2), Amino acid chelated Zn and EDTA chelated Zn, Zn-NCPC fertilizer + chalk powder in 1:4 proportion manifested in significantly higher in all seed quality attributes. Moreover, coating seeds with either Amino acid chelated-Zn fertilizer or EDTA chelated-Zn fertilizer did not have any beneficial effects on seed quality attributes as compared to the control.

Secondly, the rate of Zn release from the total Zn loaded on/in the mungbean seeds through selected seed treatments was evaluated using a dialysis membrane and Flame Atomic Absorption Spectrophotometer. Various Zn-seed treatments viz; Zn-Primed, Zn-NCPC, AmZn, EDTA-Zn, were subjected to release kinetics experiment where Zn-NCPC (1:4)- coated seed treatment was found to be the slowest in Zn ion diffusion rate. With this controlled and slow-release property of Zn it would become available gradually to the plant's root zone for different metabolic events for a longer duration thus enhancing the Zn-use efficiency. It has been acknowledged that during storage, mungbean seeds decrease their viability very fast, especially in tropical areas kept without proper packaging thus the third objective was to assess the effect of Zn-treatments on seed longevity. Various Zn-seed treatments were subjected from 0 to 12 months duration at an interval of 3 months. At the end of the 12 months storage period, Zn-NCPC (1:4) fertilizer manifested in significantly superior performance. Hence, hydro-primed and Zn-primed seeds lose their viability at a faster rate and germination drops below IMSCS (70%) within 6 months of storage. In Zn- 1 seed treatments, Zn-toxicity tolerance of the seed decreases with aging which manifests in lower seed quality attributes. On the contrary, abnormal seedling % and dead seed % increase drastically with seed aging in mungbean. Conclusively, Zn-NCPC (1:4) seed coating fertilizer can be considered as significantly superior in terms of seed quality attributes, Zn use efficiency and storability.

7. SEED HEALTH TESTING

7.1. Organic seed treatments for chickpea

The study aimed to evaluate the efficacy of organic compounds—specifically *Beejamrit*, *Jeevamrit*, and *Kunapjal*—in inhibiting mycelial growth of seed-borne fungi in chickpea. Notably, Carbendazim 50% WP displayed over 90% inhibition of mycelial growth, standing out among the tested treatments. Among organic products, *Beejamrit* @ 12% showed maximum mycelial growth inhibition (81.82%) followed by *Beejamrit* @ 9% (72.71%) and *Jeevamrit* @12% (69.34%). Conversely, *Kunapjal* @ 3% exhibited the lowest fungal growth inhibition (41.54%) against *Fusarium oxysporum* f.sp. *ciceri*, *Alternaria alternata*, and *Ascochyta rabiei.* The concentrations (9% and 12%) of *Beejamrit*, *Jeevamrit*, and *Kunapjal* that showed relatively better performance were applied to seeds of 10 varieties, alongside untreated seeds and those treated with the recommended POP (0.2% Carbendazim 50% WP). Seeds treated with *Beejamrit* at 12% demonstrated better performance in terms of seed germination (93%), seedling length (26.66 cm), and dry weight (0.396 g), displaying robust seedling vigour indices compared to the control group. These findings contribute to the development of environmentally friendly approaches for managing seed-borne pathogens in chickpeas through seed treatments and potentially in other leguminous crops.

7.2. Management of stemphylium blight and its integrated disease management for quality seed production in onion

Morpho-molecular characterization of *Stemphylium vesicarium* (Wallr.) for variability among 11 isolates of *S. vesicarium* isolated from different onion cultivars of four states namely, Delhi, Punjab, Karnataka and Maharashtra were done. Variable colony growth was observed as either cottony or velvety and pigmentation was recorded as whitish, light to dark grey to brownish with a filiform margin. The mean colony diameter ranged between 44.53 to 71.64 mm. Molecular detection by PCR assay using ITS1F/ITS4R primer amplified about ~550bp amplicon, whereas β-tubf1 and β-tubr1 primer amplified ~1400bp amplicons. Two onion varieties namely Punjab Naroya (Susceptible) and Pusa Sowmya (moderately resistant) were used to for artificial inoculation of eleven isolates of *S. vesicarium* spore suspension at different conidial concentration to study the seed quality parameters and field emergence. Seed germination and vigour of Punjab Naroya was adversely affected at tested concentration with severe reduction at 5×10^4 conidia per ml. whereas, the seeds of Pusa Sowmya showed no decline in the seed quality parameters up to 4×10^4 conidia per ml and 11-14% reduction in germination at 5×10^5 conidia. In dual culture, *T.harzianum* exhibited better mycelia growth inhibition with 72.11% outperforming other biocontrol agents. A comparison is made between six fungicides (Mancozeb, Metiram + Pyraclostrobin, Difenoconazole, Zineb, Tebuconazole, and Kitazine) and two botanicals (*Lantana camara* and *Pongamia pinnata*) alongside *A. indica*. *In vitro* evaluation revealed superiority of *A. indica* in mycelial growth inhibition, outperforming other plant-based products and most fungicides, except Difenoconazole and Tebuconazole. Field trials demonstrate that three sprays of *A. indica* at 5 ppm reduce disease severity by over 50% and enhance seed yield, comparable to Mancozeb and Zineb. Seeds obtained from *A. indica* sprayed plants exhibit higher seed.

7.3. Viral infection studies in soybean

A total of 150 soybean leaf samples showing crinkling, mosaic and mottling symptoms of various soybean lines (Initial varietal trails) were collected (Fig.24) and subjected to direct antigen coating enzyme linked immunosorbent assay (DAC-ELISA) using soybean mosaic virus (SMV), bean pod mottle virus (BPMV), cowpea mild mottle virus and tobacco ringspot virus polyclonal antibodies. Samples were found negative for SMV and BPMV whereas 30 samples showed positive value in the range of 0.5299 to 1.4742 for CPMMV at OD_{405nm}.

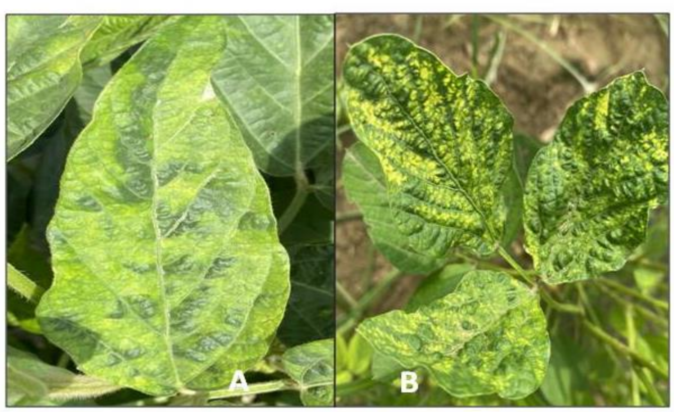
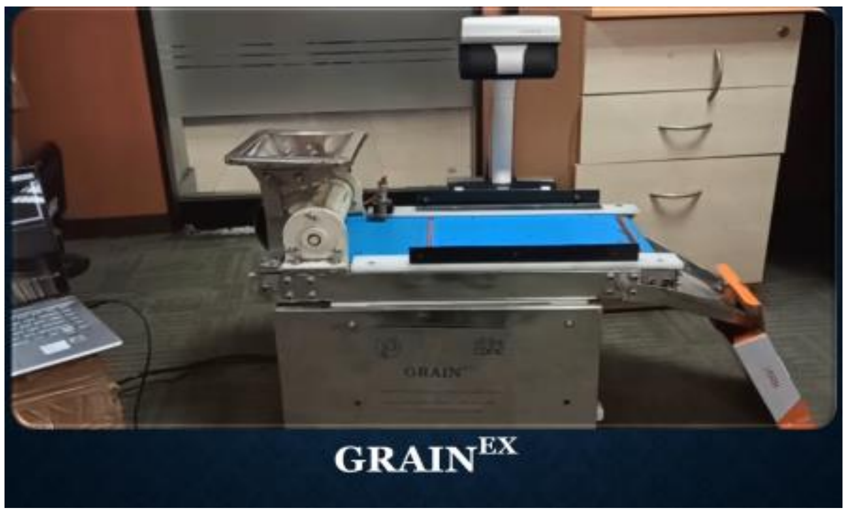


Fig. 24 Soybean plants showing the symptoms of mosaic and mottling.

8. TECHNOLOGY DEVELOPED/ COMMERCIALIZED

8.1. Purity Analysis of Seeds by Machine vision: GrainEx technology

To capture high-resolution images of seeds, an imaging setup has been developed by integrating a specialized image sensor. Proper lighting and positioning of grains is ensured to obtain clear and representative images. Various image processing techniques, including segmentation, morphological operations and colour analysis are employed to extract relevant features from the acquired images. These features serve as inputs for the subsequent



classification stage. The automated purity analysis system is implemented using a combination of hardware and software components. The hardware setup consists of the imaging device, lighting arrangement and necessary interfaces for data transfer. The software component includes image processing libraries, machine learning frameworks and a user-friendly interface for easy operation. This appearance-based detection system GrainEx technology which replaces the manual seed sorting with developed e-Quality assessment protocols through machine vision technology was launched on 10th July 2023 by the Ministry of Electronics and Information Technology, GoI. The product has been developed by the Division of Seed Science and Technology in collaboration with C-DAC, Kolkata under AgriEnIcs program. This system will bring about a transformative change in the e-NAM markets for quality-based pricing and will be helpful for more than 1,200 e-NAM connected markets.

8.2. Thermotolerance induction in rice seedlings

The technology comprises subjecting the germinating seeds (with 1-1.5 cm radicle) and early seedlings (7-day-old seedlings) to mild heat shock called acclimation temperature so that they can tolerate severe heat stress even after two days. The acclimation temperatures are 38°C for 75 minutes and 42°C for 75 minutes for germinated seed and early seedling stages, respectively. The acclimated seeds tolerated severe heat stress equal to 48°C even 2 days after mild shock. The thermotolerance induction was validated in known heat-tolerant and susceptible genotypes.

8.3. Identification of QPM inbred with high vigour and longevity

Quality Protein Maize inbreds have poor storability and low seed vigour. After screening 28 QPM inbreds, two better storable inbreds, MGU-QPM-16 and MGU-QPM-20 were identified. They have more than 90% germination after 12 months of ambient storage and > 60% after 18 months. They also possess high vigour, with more than 70% of normal seedlings after seven days of accelerated ageing

9. GRADUATE SCHOOL ACTIVITY

9.1. Courses offered in the I Semester of academic session 2023

S. No.	Course code	Name of the course	Credits	Instructors
1	SST 501*	Seed Developmental Biology	2 (1+1)	Dr. Monika A. Joshi Dr. Sangita Yadav Dr. Nagamani S
2	SST 502	Seed Dormancy and Germination	2 (1+1)	Dr. D. Vijay Dr. Vijayakumar H.P
3	SST 503*	Seed Production Principles and and Techniques in Field Crop	3 (2+1)	Dr. Monika A. Joshi Dr. Sudipta Basu Dr. Vijayakumar H.P Dr. R.N. Yadav[1] Dr. K.K. singh[2]
4	SST 504*	Seed Production Principles and and Techniques in Vegetable Crops	3 (2+1)	Dr. Sudipta Basu Dr. Vishwanath Yalamalle Dr. B.S. Tomar[3] Dr. Shrawan Singh[3]
5	SST 505	Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops	3 (2+1)	Mr.Manjunath Prasad Dr. Namita Banyal[4]
6	SST 506	Seed Production Techniques in Forage, Pasture and Green Manure Crops	2 (1+1)	Dr. D. Vijay Dr. Vijayakumar H.P Dr. K.K. Singh[2]
7	SST 510	Seed Technology of Tree Species	2 (1+1)	Dr. Nagamani S Dr. K.K. Singh[2]
8	SST 601*	Hybrid Seed Production Technology	3 (2+1)	Dr. S.K. Chakrabarty Dr. Sudipta Basu

				Dr. Priya Ranjan[5] Dr. Vijayakumar H.P.
9	SST 602	Organic Seed Production	2 (1+1)	Dr. Sandeep K. Lal Dr. Atul Kumar Dr. P. Nallathambi[6]
10	SST 604*	Genetic Purity and DUS Testing	3 (2+1)	Dr. Arun Kumar M.B Dr. S.K. Chakrabarty Dr. S.K. Yadav Dr. Monika A. Joshi Dr. Nagamani S
11	SST 608	Germplasm Conservation Techniques	2 (1+1)	Dr. Sushil Pandey[7] Dr. Badal Singh[7]
12	SST 610	Seed Planning, Trade and Marketing	2 (1+1)	Mr. Manjunath Prasad Dr. Sandeep K. Lal Dr. Vishwanath Yalamalle
13	SST 591	Master's Seminar	1 (1+0)	Dr. Vijayakumar H.P Dr. Nagamani Sandra Dr. Vishwanath Yalamalle Mr.Manjunath Prasad Dr. D. Vijay
14	SST691/ SST 692	Doctoral Seminar I and II	1 (1+0)	Dr. D. Vijay Dr. Vishwanath Yalamalle Mr.Manjunath Prasad Dr. Nagamani Sandra Dr. Vijayakumar H.P

*** Core Course for M.Sc. and Ph.D.**

1: IARI Regional Station, Karnal, 2: IARI Regional Station, Pusa, Bihar, 3: Division of Veg. Sci, ICAR-IARI ICAR-NBPGR, 4: Division of Floriculture, ICAR-IARI, New Delhi; 5: IARI Jharkand;6: IARI Regional Station, Wellington

9.2. Courses offered in the II Semester of academic session 2023

S. No.	Course No.	Title	Credit	Faculty Members
1.	USST 101	Principles of Seed Technology	3 (1+2)	Dr. Monika A Joshi Dr. Gyan P. Mishra Dr. Sangita Yadav Dr. Vishwanath Yalamalle
2.	SST 507*	Seed Legislation and Certification	3 (2+1)	Dr. S. K. Yadav Dr. Sandeep K. Lal Dr. Sudipta Basu
3.	SST 508*	Post Harvest Handling and Storage of Seeds	3 (2+1)	Mr. Manjunath Prasad Dr. D Vijay Dr. Vijayakumar H.P. Dr. Ashwini Kumar*1
4.	SST 509*	Seed Quality Testing and Enhancement	2 (1+1)	Dr. Sandeep Lal Dr. Sudipta Basu Dr. S. K. Yadav Mr. Manjunath Prasad Dr. P. Nallathambi*4
5.	SST 511	Seed Industry and Marketing Management	2 (1+1)	Mr. Manjunath Prasad Dr. Sandeep K. Lal Dr. D Vijay
6.	SST 512	Seed Health Testing and Management	2 (1+1)	Dr. Nagamani Sandra Dr. Atul Kumar Dr. Jameel Akhtar*2 Dr. Kavita Gupta*2

7.	SST 603	Physiology and Biochemistry of Seeds	2 (1+1)	Dr. Sangita Yadav Dr. D Vijay Mr. Manjunath Prasad
8.	SST 605	Seed Vigour and Crop Productivity	2 (1+1)	Dr. D Vijay Dr. Sangita Yadav Dr. Vijayakumar H.P.
9.	SST 606*	Advances in Seed Science	2 (2+0)	Dr. Nagamani Sandra Dr. Arun Kumar MB Dr. D Vijay
10.	SST 607	Advances in Seed Quality Enhancement	2 (1+1)	Dr. Sudipta BasuDr. S. K. Yadav Dr. Sandeep K. Lal Dr. P. Nallathambi*4
11.	SST 608	Germplasm Conservation Techniques	2 (1+1)	Dr. Chitra Pandey*3 Dr. Susheel Pandey*3 Dr. Viswanath R.Y.
12.	SST 609	Seed Ecology	2 (1+1)	Dr. S.K. Chakrabarty Dr. Viswanath R.Y.
13.	SST 591	Seminar	1 (0+1)	Dr. Vijayakumar H.P. Mr. Manjunath Prasad, Dr. D. Vijay Dr. Viswanath Yalamalle Dr. Nagamani Sandra

14.	SST 691	Seminar -I	1 (0+1)	Dr. Viswanath Yalamalle Dr. Vijayakumar H.P. Mr. Manjunath Prasad, Dr. D. Vijay Dr. Nagamani Sandra
15.	SST 692	Seminar -II	1 (0+1)	Dr. Viswanath Yalamalle Dr. Vijayakumar H.P. Mr. Manjunath Prasad, Dr. D. Vijay Dr. Nagamani Sandra

* Core courses for M.Sc and Ph.D.

*1 IARI RS, Karnal; *2 Div. of Plant Quarantine, NBPGR; *3 Div. of Germplasm Conservation, NBPGR; *4: IARI RS- Wellington, Tamil Nadu

9.3. List of degree recipient students and chairpersons of their advisory committee

S. No.	Name of the Student & Roll No.	MSc/ PhD	Title of the thesis	Chairperson	Institute
1.	Nan Khiang Khiang Soe (21378)	M.Sc.	Evaluation of seed physiological parameters of diverse rice genotypes under different experimental seed ageing methods	Mr. Manjunath Prasad	ICAR-IARI, New Delhi

2.	Sandeep (21707)	M.Sc.	Evaluation of organic seed treatments on seed quality and seed health status of chickpea (*Cicer arietinum* L.)	Dr. Atul Kumar	ICAR-IARI, New Delhi
3.	Tanya Singh (21708)	M.Sc.	Studies on seed longevity in rice seed lots using hyperspectral imaging and metabolomics	Dr. S. K. Chakrabarty	ICAR-IARI, New Delhi
4.	Shreya Patil (21709)	M.Sc.	Studies on effect of salinity stress on seed quality parameters and its alleviation through seed priming in wheat species	Dr. Monika A. Joshi	ICAR-IARI, New Delhi
5.	Tuhina Ghosh (21710)	M.Sc.	Effect of ZnO nano-particle based priming on seed quality enhancement in tomato (*Solanum lycopersicum* L.) under salt stress	Dr. Shiv K. Yadav	ICAR-IARI, New Delhi
6.	Yallavva Madar (21711)	M.Sc.	Physiological and biochemical basis of seed deterioration in rice	Mr. Manjunath Prasad	ICAR-IARI, New Delhi
7.	Mujtahida Khatun (60115)	M.Sc.	Evaluation of seed coating with microbial formulations for enhancing seed yield and quality in chickpea (*Cicer arietinum* L)	Dr. Priya Ranjan Kumar	ICAR-IARI, Jharkhand

8.	Sayan Makur (60116)	M.Sc.	Assessing the efficacy of seed coating with microbial formulations for quality enhancement in wheat (*Triticum aestivum* L.)	Dr. Priya Ranjan Kumar	ICAR-IARI, Jharkhand
9.	Mrinali Manohar Mandape (10670)	Ph.D.	Enhancing zinc use efficiency in mungbean (*Vigna radiata* L. Wilczek) through seed treatments	Dr. K.K. Singh	ICAR-IARI, New Delhi
10.	Niranjan Prasad H.P. (11328)	Ph.D.	Studies on stemphylium blight caused by *Stemphylium vesicarium* (Wallr.) on seed quality parameters in onion and its integrated disease management for quality seed production	Dr. Atul Kumar	ICAR-IARI, New Delhi
11.	Dilshad Ahmad (11332)	Ph.D.	Seed storability studies in quality protein maize genotypes	Dr. Vijay Dunna	ICAR-IARI, New Delhi
12.	Jayasri S. (11333)	Ph.D.	Seed enhancement technology for quality seed production of chilli (C*apsicum annum* l.)	Dr. Sudipta Basu	ICAR-IARI, New Delhi
13.	Preeti Sagar Negi (11334)	Ph.D.	GWAS to identify marker trait associations for early seedling vigour in rice	Dr. Arun Kumar M.B.	ICAR-IARI, New Delhi

14.	Archana H.R. (11598)	Ph.D.	Studies on thermotolerance and its induction during seed germination and seedling growth in rice	Dr. Vijay Dunna	ICAR-IARI, New Delhi
15.	Ramappa S. (11600)	Ph.D.	Mapping of seedling vigour related traits for moisture deficit stress tolerance in wheat (*Triticum aestivum* L.)	Dr. Monika A. Joshi	ICAR-IARI, New Delhi
16.	Shobharani M. (11601)	Ph.D.	Effect of sowing dates and planting seasons on the seed yield and quality attributes with special reference to Mungbean yellow mosaic India virus (MYMIV)	Dr. S.K. Lal	ICAR-IARI, New Delhi
17.	Shruti Kumari (11602)	Ph.D.	Studies on seed vigour traits in relation to flowering, harvest maturity, storage period and validation of QTL associated with seed vigour in rice (*Oryza sativa* L.)	Dr. S. K. Chakrabarty	ICAR-IARI, New Delhi
18.	Shahil Kumar (11860)	Ph.D.	Genetic and molecular basis of protogyny, CMS and self-incompatibility system in Indian Mustard [*Brassica juncea* (L.) Czern. & Coss.]	Dr. S. K. Chakrabarty	ICAR-IARI, New Delhi

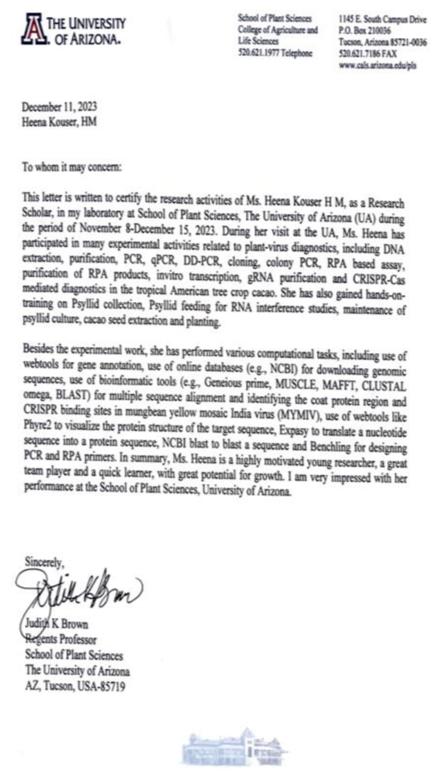
19.	Deepak Rao (11865)	Ph.D.	Effect of chemical priming for improving early seedling vigour under salinity stress in lentil	Dr. Sangita Yadav	ICAR-IARI, New Delhi

9.4. Honours/Awards/Placement

S.No.	Name of the Student & Roll No.	Award/placement	Particulars
1.	Tuhina Ghosh (21710)	IARI merit medal	• IARI merit medal under post graduate category in 2023.
2.	Archana H.R. (Roll No. 11598)	Sadhana All India Best Research Award at Doctorate Level 2023	• Award given by the Society for advancement of human and nature, YS Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.
3.	Archana H.R. (Roll No. 11598)	Best oral presentation award	• 12th National Seed Congress, Aurangabad, 11-13 December 2023 • 6th International conferences on Advances in Agricultural Technology and Allied Sciences, ICAATAS, 2023, Loyola Academy, Secunderabad, Telangana • International conference on Agricultural and Biological Science, VDGOOD Professional Association, 28 October 2023
4.	Alok Kumar (Roll No. 11655)	Best oral presentation award	• National Seminar on Agri innovations for food security and sustainable Rural livelihoods, AFSSR-2023 held during 15-16

			Dec 2023 at Naira Agricultural College, ANGRAU, Andhra Pradesh.
5.	Mr Sayan Makur (Roll No. 60116)	Appointment	• Appointed as quality inspector, Food Corporation of India, cadre quality control, divisional office Bilaspur, Chhattisgarh

9.5 NAHEP-CAAST International Training in the area of Genomics



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December 11, 2023
Heena Kouser, HM

To whom it may concern:

This letter is written to certify the research activities of Ms. Heena Kouser H M, as a Research Scholar, in my laboratory at School of Plant Sciences, The University of Arizona (UA) during the period of November 8-December 15, 2023. During her visit at the UA, Ms. Heena has participated in many experimental activities related to plant-virus diagnostics, including DNA extraction, purification, PCR, qPCR, DD-PCR, cloning, colony PCR, RPA based assay, purification of RPA products, invitro transcription, gRNA purification and CRISPR-Cas mediated diagnostics in the tropical American tree crop cacao. She has also gained hands-on-training on Psyllid collection, Psyllid feeding for RNA interference studies, maintenance of psyllid culture, cacao seed extraction and planting.

Besides the experimental work, she has performed various computational tasks, including use of webtools for gene annotation, use of online databases (e.g., NCBI) for downloading genomic sequences, use of bioinformatic tools (e.g., Geneious prime, MUSCLE, MAFFT, CLUSTAL omega, BLAST) for multiple sequence alignment and identifying the coat protein region and CRISPR binding sites in mungbean yellow mosaic India virus (MYMIV), use of webtools like Phyre2 to visualize the protein structure of the target sequence, Expasy to translate a nucleotide sequence into a protein sequence, NCBI blast to blast a sequence and Benchling for designing PCR and RPA primers. In summary, Ms. Heena is a highly motivated young researcher, a great team player and a quick learner, with great potential for growth. I am very impressed with her performance at the School of Plant Sciences, University of Arizona.

Sincerely,

Judith K Brown
Regents Professor
School of Plant Sciences
The University of Arizona
AZ, Tucson, USA-85719

Ms Heena Kouser, PhD 3rd year at The University of Arizona

Degree recepients of 62nd Convocation

Ms Tuhina Ghosh winner of Merit Medal

Freshers welcome (Jan 12, 2024)

10. OFFICIAL LANGUAGE (RAJ BHASHA) IMPLEMENTATION

(क) जारी कागजात की कुल संख्या : 89

(ख) द्विभाषी रूप में जारी कागजात की संख्या : 89

हिंदी में प्राप्त पत्र (राजभाषा नियम 5) जिनके उत्तर अनिवार्यत : हिंदी में दिए जाने हैं :

(क) हिंदी में प्राप्त कुल पत्रों की संख्या : 146

(ख) इनमे से कितनो के उत्तर हिंदी में दिए गए : 52

(घ) इनमे से कितनो के उत्तर दिए जाने अपेक्षित नहीं थे : 94

अंग्रेज़ी में प्राप्त पत्रों के उत्तर हिंदी में दिए जाने की स्थिति (केवल 'क' एवं 'ख' क्षेत्र मे स्थित कार्यालयों के लिए) :

	अंग्रेज़ी में प्राप्त पत्रों की संख्या	इनमे से कितनो के उत्तर हिंदी में दिए गए	इनमे से कितनो के उत्तर अंग्रेज़ी में दिए गए	इनमे से कितनो के उत्तर दिए जाने अपेक्षित नहीं थे
	1	2	3	4
'क' क्षेत्र के लिए	117	25	कोई नहीं	92

भेजे गए मूल पत्रों का ब्यौरा :

	हिंदी /द्विभाषी	केवल अंग्रेज़ी में	भेजे गए पत्रों की कुल संख्या	हिंदी /द्विभाषी में भेजे गए पत्रों का प्रतिशत
	1	2	3	4
'क' क्षेत्र के लिए	53	कोई नहीं	53	100 प्रतिशत

तिमाही के दौरान फ़ाइलो /दस्तावेजों पर हिंदी में लिखी गई टिप्पणियों का ब्यौरा:

(क) हिंदी में लिखी गई टिप्पणियों के पृष्ठो की संख्या : 51

(ग) कुल टिप्पणियों के पृष्ठो की संख्या : 51

हिंदी में प्रकाशित प्रसार साहित्य (पैम्फलेट आदि): 3

संभागीय राजभाषा कार्यान्वन समिति की आयोजित बैठक दिंनाक 03.02.2023 को अपराह्न 12.30 बजे

संभागीय राजभाषा कार्यान्वन समिति की आयोजित बैठक दिंनाक 03.02.2023 को अपराह्न 3.**00** बजे

संभागीय राजभाषा कार्यान्वन समिति की आयोजित बैठक दिंनाक 03.02.2023 को पूर्वाह्न 9.30 बजे

संभागीय राजभाषा कार्यान्वन समिति की आयोजित बैठक दिंनाक 03.02.2023 को अपराह्न 9.30 बजे

राजभाषा समिति द्वारा आयोजित बैठके

दिंनाक **29.03.2023** को ऑनलाइन आयोजित

दिंनाक **30.06.2023** को ऑनलाइन आयोजित

दिंनाक **27.09.2023** को ऑनलाइन आयोजित

दिंनाक **28.12.2023** को ऑनलाइन आयोजित

बीज विज्ञान एवं प्रौधोगिकी संभाग में हिंदी दिवस का आयोजन

प्रतिवर्ष की भांति इस वर्ष भी बीज विज्ञान एवं प्रौधोगिकी संभाग में हिंदी दिवस का आयोजन किया गया। संभाग में हिंदी के प्रचार-प्रसार एवं हिंदी में अधिक से अधिक सरकारी कार्य करने के लिए सुलेख ,श्रुतलेख एवं प्रश्नोत्तरी प्रतियोगिताओ का आयोजन दिंनाक 25 सितम्बर 2023 किया गया । इसमे संभाग के वैज्ञानिक, तकनीकी अधिकारी, छात्र, एवं अनुबंध पर अनुसन्धान कार्य करनेवाले (वाई. पी-1,जे आर एफ, फील्ड वर्कर इत्यादि) ने भाग लिया और विभिन्न पुरस्कार प्राप्त किए। संभाग में पुरस्कार वितरण समारोह का आयोजन 27 सितम्बर 2023 को किया गया,जिसमें भारतीय कृषि अनुसंधान परिषद से डॉ. डी.के. यादव सहायक

महानिदेशक बीज मुख्य अतिथि, संभागीय राजभाषा समिति एवं बीज विज्ञान एव प्रोधौगिकी संभाग के अध्यक्ष डॉ ज्ञान प्रकाश मिश्र ,प्रोफेसर मोनिका ए .जोशी एवं राजभाषा नोडल अधिकारी श्री धर्मपाल सिंह के द्वारा, तीनों प्रतियोगिताओं में प्रथम ,द्वितीय ,तृतीय एवं सांत्वना विजेताओ को स्मृति चिन्ह एवं प्रमाण –पत्र प्रदान कर सम्मानित किया गया। मुख्य अथिति एवं अध्यक्ष ने हिंदी राजभाषा को बढावा देने के लिए इस प्रकार के आयोजन की प्रशंसा की और भविष्य मे कुछ और प्रतियोगिताओ को कराने के लिए प्रेरित किया।

विभिन्न प्रतियोगिता के विजेता

11. PUBLICATIONS

Research Papers:

1. Aniruddha Maity, Debashis Paul, Amrit Lamichaney, Abhradip Sarkar, Nidhi Babbar, Nandita Mandal, Suman Dutta, Pragati Pramanik Maity and Shyamal Kumar Chakrabarty. 2023. Climate change impacts on seed production and quality: current knowledge, implications and mitigation strategies. *Seed Science and Technology*, 51, 1, 65-96. https://doi.org/10.15258/sst.2023.51.1.07 (NAAS Rating: 6.8)
2. Archana H R., Vijay D*., Manjunath Prasad C.T., Ahmad D., Arunkumar M.B., Bhowmick P.K., Sinha S.K., Sharma D.K. and Sushmitha L.C. (2023). Influence of spermidine priming on rice (*Oryza sativa*) seed germinability and vigour under heat stress. *Indian Journal of Agricultural Sciences*, 93(12):1284-1290 https://doi.org/10.56093/ijas.v93i12.141044 (NAAS rating: 6.40)
3. Chaithanya, G., Kumar, A., Vijay, D., Sudipta Basu (2023). : Efficacy of nanoparticles against purple blotch (Alternaria porri) of onion Indian Phytopathology, 76, 845–852. https://doi.org/10.1007/s42360-023-00632-x (NAAS rating:5.99)
4. Dutta H. K., M. S, Aski MS, Mishra GP, Sinha SK, Vijay D, C. T. Manjunath Prasad, Das S, Pawar PA-M, Mishra DC, Singh AK, Kumar A, Tripathi K, Kumar RR, Gupta S, Kumar S and Dikshit HK (2023) Morpho-biochemical characterization of a RIL population for seed parameters and identification of candidate genes regulating seed size trait in lentil (*Lens culinaris* Medik.). *Frontiers in Plant Science* 14: 1091432 https://doi.org/10.3389/fpls.2023.1091432 (NAAS Rating: 11.60)
5. Jadhav S, A Kumar*, SK Lal, J Akhtar, M Aski, GP Mishra, AK Singh and S Javeria (2023) Effect of *Fusarium oxysporum* f. sp. *lentis* on seed quality parameters in lentil. *Indian J. Plant Genet. Resour* 36(1): 1-4 (NAAS rating 5.54)
6. Jawaharjothi, G., Sharma, D. K., Kovilpillai, B., Bhatia, A., Kumar, S., Prasad, M., Suroshe, S. S., Kumar, R. R., Dunna, V. and Kumar, S. N. (2023). Impacts of elevated ozone and CO2 on growth and yield of double zero mustard (*Brassica juncea*). *The Indian Journal of Agricultural Sciences*, 93(7): 743–749. https://doi.org/10.56093/ijas.v93i7.137155 (NAAS: Rating 6.40)
7. Jayasri Sundarraj, Sudipta Basu, Sandeep Kumar Lal, Anjali Anand and Mohammed Athar (2023): Seed enhancement treatments for improved performance in chilli (*Capsicum annuum* L.); *Biological Forum – An International Journal* 15(8): 42-46 (NAAS rating: 5.11).

8. Kohli M, Bansal H, Mishra GP*,Dikshit HK, Reddappa SB, Roy A, Sinha SK, Shivaprasad KM, Kumari N, Kumar A, Kumar RR, Nair RM, Aski M. 2024. Genome-wide association studies for earliness, MYMIV resistance, and other associated traits in mungbean (*Vigna radiata* L. Wilczek) using genotyping by sequencing approach. *PeerJ* 12:e16653. https://doi.org/10.7717/peerj.16653 (NAAS rating 8.70)
9. Kumar, Sahil, Chakrabarty, S. K., Singh, N., Kumar, A., Manjunath Prasad, C. T. and Basu, S. (2023). Nuclear-cytoplasmic interaction for stigma receptivity in Indian mustard (*Brassica juncea*) hybrid development. *The Indian Journal of Agricultural Sciences*, 93(9): 972–977. https://doi.org/10.56093/ijas.v93i9.136772 (NAAS Rating: 6.40)
10. Kumar, Sushma Mudlupura; Yadav, Shiv; Yadav, Sangita; Choudhary, Ravish; Lal, Sandeep; Bharadwaj, Chellapilla; Hussain, Zakir; and Kumar, Priya Ranjan (2023). Preliminary studies on the effect of nano particle seed treatments on seed quality attributes and yield in chickpea, *Turkish Journal of Agriculture and Forestry*, 47(1):100-115.Article. https://doi.org/10.55730/1300-011X.3067. (NAAS rating - 8.67)
11. Manisha Saini, Raju R. Yadav, Subhash Chandra, Ashish Kumar, Rahul Kumar, Seema Sheoran, Nenavath K. K. Rathod, Manu Yadav, Meniari Taku, Sudipta Basu, Ambika Rajendran, S. K. Lal and Akshay Talukdar (2023): Accelerated aging test reveals quantitative nature of inheritance of seed viability in soybean [*Glycine max* (L.) Merr.] *Indian Journal of Genetics and Plant Breeding*, 83(1): 69-76, doi: 10.31742/ISGPB.83.1.9; 1.339 (NAAS Rating: 7.34)
12. Manjunath Prasad, Kodde, J., Angenent, G.C., Hay, F.R., McNally, K.L. and Groot, S.P.C. (2023). Identification of the rice *Rc* gene as a main regulator of seed survival under dry storage conditions. *Plant, Cell & Environment*, 46(6): 1962-1980. https://doi.org/10.1111/pce.14581 (NAAS rating: 13.95)
13. Monika A Joshi, Amitava Akuli, Kunal Pandey, Dharmpal Singh, Abhra Pal, Tamal Dey, Gopinath Bej, Subrata Sarkar, Satanu Kamilya and Alokesh Ghosh (2023) Revolutionizing agricultural quality assessment with e-quality enhancing efficiency and transparency in e-NAM In: Conference Proceedings of ACN Network International Conference on Environment, Agriculture and Biotechnology, Vol 11(2): 1-30-35 (Impact Factor: 3.15)
14. Monika A. Joshi, Kunal Pandey, Amitava Akuli, Dharmpal Singh, Abhra Pal, Alokesh Ghosh and Gyan P. Mishra (2023) Transforming the Indian Agricultural Market through Advanced Technologies: A Comprehensive

Automated Physical Purity Analysis for Agricultural Crops. In: *Proceedings of ICSTA 2023; Kolkata, India;* under printing

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16. Narender Pal, Sudipta Basu*, Firoz Hossain1, Monika A. Joshi, and Mohammad Athar (2023); Genetic variability for early seed vigor traits for enhanced performance under sub-optimum temperatures in sweet corn (*Zea mays* convar. *saccharata* L.) *Indian Journal of Genetics and Plant Breeding*, 83(3): 380-388 https://doi.org/10.31742/ISGPB.83.3.10 (NAAS Rating: 7.34)
17. Patra, K., Parihar, C.M., Nayak, H.S., Rana, B., Sena, D.R., Anand, A., Reddy, K.S., Chowdhury, M., Pandey, R., Kumar, A. and Singh, L.K., (2023). Appraisal of complementarity of subsurface drip fertigation and conservation agriculture for physiological performance and water economy of maize. *Agricultural Water Management*, *283*, p.108308. (NAAS rating 12.70)
18. Prasad N, A Kumar*, V Dunna, JK Ranjan, J Akhtar, GP Mishra, AB Sharma and S Javeria (2024) Cultural, morphological and molecular characterization of *Stemphylium vesicarium* isolates causing onion blight. *Indian Phytopathology* 76(4): pp -1-9 (NAAS rating:5.96)
19. Preeti S. Negi, Chandu Singh, RK Ellur, Manjunath Prasad, Gopalakrishnan S., Vinod K.K., Viswanath C., Monika A. Joshi and Arun Kumar MB (2023) Early germination traits – a comprehension of the relations with other early seedling vigour traits in rice. *Ecology, Environment and Conservation,* 30 (1) *: 18-25* (NAAS rating: 5.05)
20. Rakesh K. Bairwa, M.C. Yadav, Gopala K. Subbaiyan, Amar K. Kushwaha and Monika A. Joshi (2023) Morphological and molecular analyses of grain traits in aromatic rice landrace accessions from Indo-Gangetic plain region of India. *Indian Journal of Plant Genetic Resources*; https://doi.org/10.5958/0976-1926.2023.00036.2.11 (NAAS rating: 5.17)
21. Ramappa S, Monika A. Joshi, Vijay Dunna, Hari Krishna, Neelu Jain, Rohini Sreevathsa, Narayana Bhat Devate (2023). Exploring genetic influences on seed morphological traits in wheat: a genome-wide association study under moisture deficit stress and well-watered conditions. *Agricultural Mechanization in Asia, Africa and Latin America* 54(10): 15851-15862 (NAAS rating: 6.30)
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wheat for seedling vigour-related traits and root traits using genome-wide association study. *Genes*, 14, 1902. https://doi.org/10.3390/genes14101902 (NAAS rating: 9.50)

23. Rao, D.; Yadav, S.; Choudhary, R.; Singh, D.; Bhardwaj,R.; Barthakur, S.; Yadav, S.K. Silicic and Humic Acid Priming Improves Micro- and Macronutrient Uptake, Salinity Stress Tolerance, Seed Quality, and Physio-Biochemical Parameters in Lentil (*Lens culinaris* spp. *culinaris*). *Plants* 2023, 12, 3539. https://doi.org/10.3390/plants12203539 (NAAS rating: 10.5)
24. Sakpal A., Sangita Yadav*, Ravish Choudhary, Navinder Saini, Sujata Vasudev, Devendra Kumar Yadava, Sezai Ercisli, Romina Alina Marc, Shiv Kumar Yadav (2023). Heat stress induced changes in physio-biochemical parameters of mustard genotypes and their role in its tolerance at the seedling stage. *Plants* 12, 1400:1-21. (NAAS rating: 10.5)
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28. Shiv Yadav, Tuhina Ghosh, Ravish Choudhary, Deepak Rao, Sushma MK, Abhishek Mandal, Zakir Hussain, Sangita Yadav, Tatiana Minkina, Vishnu Rajput. (2023). Effect of Zinc Oxide nano-particle based seed priming for enhancing seed vigour and physio-biochemical quality of tomato seedlings under salinity stress. Accepted in *Russian Journal of Plant Physiology* (NAAS rating 7.40).
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30. Shruti Kumari, S. K. Chakrabarty, Debashis Paul, Y. Singh, P. K. Bhowmick and A. S. Hari Prasad. (2023). Variability and heterosis of seed vigour traits in hybrid rice (*Oryza sativa* L.). *Indian Journal of Genetics and Plant Breeding,* 83(2): 168-175. (NAAS Rating: 7.34)

31. Sunil Jadhav, Atul Kumar, Sandeep K Lal, Jameel Akhtar, Muralidhar Aski, Gyan P Mishra, Amit K Singh, Shaily Javeria (2023). Effect of *Fusarium oxysporum* f. sp. *lentis* on seed quality parameters in Lentil. *Indian Journal of Plant Genetic Resources* 36 (1): 70-76(NAAS rating: 5.17)
32. Sunil Kumar, Sudipta Basu, J Aravind, Anjali Anand (2023): Assessment of Storage Potential of Onion Varieties Using Variables Extracted from a Mathematical Model 4-Parameter Hill Function (4-PHF). *Seeds*, 2(2), 195-207; https://doi.org/10.3390/seeds2020015
33. Yalamalle, V R., Dunna V., Chawla, G. Mishra, G P., Vijayakumar H P., Ahmad, D., Lal S K., Joshi, D C. and Meena, R P. (2023). Overcoming physiological dormancy in common buckwheat (*Fagopyrum esculentum* Moench). *Genetic resources and crop evolution*. https://doi.org/10.1007/s10722-023-01729-y (NAAS rating: 8.00)
34. Yalamalle, V. R., Singh, C., and Chakrabarty, S. K. (2023). Quality improvement in paddy seeds during seed processing. *Journal of Agri Search*, 10(4), 266-269. (NAAS rating: 4.95)

Books:

1. Ghosh, P.K., Anup Das, Raka Saxena, Kaushik Banerjee, Gauranga Kar, D. Vijay. 2023.Trajectory of 75 years of Indian Agriculture after Independence. Springer Nature, Singapore. P.852. ISBN:9789811979965

Book Chapters:

1. Vijay D., Vijayakumar H.P., Manjunath Prasad C.T., Choudhury P.R. 2023. Indian Seed Sector. In: Ghosh P. K., Das A., Saxena R., Banerjee K., Kar G., Vijay D. (Eds). Trajectory of 75 years of Indian Agriculture after Independence. Springer Nature, Singapore. pp.79-111. ISBN: 9789811979965

Training manual/technical bulletin/instruction materials

1. Vishwanath Yalamalle, Vijayakumar H P, Sandeep Kumar Lal, Shyamal Kumar Chakrabarty, Shiv Kumar Yadav. 2023. Training Manual: Capacity Building Training Programme on "Seed Production and Quality Evaluation" for the officials of AARDO member countries. February 12 -23, 2023, Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute New Delhi – 110 012, India. TB-ICN No.: 293/2023
2. Nagamani Sandra, Shiv K. Yadav, Sandeep K. Lal, Akriti Sharma. 2023. A Training Manual on "Seed Production, Testing and Storage in Field and Vegetable Crops", March 13-17, 2023, Division of Seed Science and

Technology and ZTM & BPD Unit, ICAR-Indian Agricultural Research Institute, New Delhi - 110012, India. TB-ICN No.: 300/2023

3. Sandeep Kumar Lal, Vishwanath Yalamalle, Gyan P Mishra. 2023. Training Manual: Training Programme on "Seed Production and Certification of Field Crops" for the officials of Department of Agriculture, Govt. of Assam. August 2 - 4, 2023, Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute New Delhi – 110012, India. TB-ICN No.: 304/2023
4. Vishwanath Yalamalle, Vijayakumar H P, Sandeep Kumar Lal, Atul Kumar and Gyan Prakash Mishra. 2023. Training Manual: "Advanced Post-Harvest Technologies for Seed Quality Improvement". November 28 - December 01, 2023, Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi – 110012, India. TB-ICN No.:312/2023
5. Dinesh Kumar, Sandeep Kumar Lal, Alka Joshi and Anamika Thakur (2023). Training Manual: *Krishi upaj ka prasanskaran evam mulya sanvardhan*. March 14-15, 2024, Division of Post Harvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi - 110012, India pp. 44 (Published under SCSP scheme).

6. Kamil D, Das, A, Gurjar M S, Sharma SS, Lal SK, Saharan, MS (2024). Technical Bulletin: Mushroom production technology, ICAR-Indian Agricultural Research Institute (IARI), New Delhi. pp. 1-44. ICH: H-214/2024 (Published under SCSP scheme).
7. Dinesh Kumar, Sandeep Kumar Lal, Alka Joshi and Anamika Thakur (2023). Customised Instruction Material: *Millets ke flakes.* Division of Post Harvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi - 110012, India pp. 4 (Published under SCSP scheme).
8. Dinesh Kumar, Sandeep Kumar Lal, Alka Joshi and Anamika Thakur (2023). Customised Instruction Material: *Phalon evamsabziyon se nirmitposhak candy*. Division of Post Harvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi - 110012, India pp. 4 (Published under SCSP scheme).

12. AWARD, HONOURS AND RECOGNITION

S.No	Name of the recipient	Award	Event/organization
1	Dr Gyan P. Mishra, Head	NAAS Fellow- 2024 in Crop Science	National Academy of Agricultural Sciences
2	Dr. S. K. Chakrabarty, PS	Scientist of Eminence Award for the year 2022-2023	Indian Society of Seed Technology
2	Dr. Nagmani Sandra, Scientist (SS)	Young Scientist Award for the year 2022-2023	Indian Society of Seed Technology
3	Dr. S. K. Yadav	Outstanding Achievement Award, "Distinguished Researcher in Seed Science and Technology"	Venus International Foundation, Chennai
4	Dr. D. Vijay	Regional Representative, India	International Society for Seed Science (ISSS), U.K.
5	Dr. D. Vijay	Best oral presentation award	12th National Seed Congress, Aurangabad, 11-13 December 2023
6	Dr. Vishwanath Yalamalle	Best oral presentation award	3rd "National Symposium on Edible Alliums" during 11-14 February 2023, Jain Hills, Jalgaon
7	Dr. Monika A Joshi	Best poster award	Grain-Ex Technology, International Conference on Systems and Technologies for Smart Agriculture (ICSTA 2023), C-DAC, Kolkata, 19- 20 December, 2023


KM BUJARBARUAH
HIMANSHU PATHAK


12 National Seed Congress-2023
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI, MAHARASHTRA


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TO


12 National Seed Congress-2023
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI, MAHARASHTRA
WELCOMES YOU!
TO

13. EXTENSION ACTIVITIES

1. **Revenue generated**: The seed of improved varieties of field and vegetable crops worth Rs. 6.5 crore was procured from ICAR-IARI under SCSP scheme.
2. **Seeds and planting materials distributed among farmers**: 4500 q of seed was distributed among 50,000 SC farmers under SCSP scheme.
3. **Farm machineries distributed among farmers**: Distribution of small farm implements like spade, bill hook, sickle, rose can, bucket, sprayer, umbrella, torch and *tirpal*. Besides, installation of 10 net houses in the SCSP villages in Rajasthan and Uttar Pradesh.
4. **Technology assessed and refined**: Field demonstrations of IARI-bred improved varieties of field and vegetable crops were organised under SCSP scheme.
5. **Trainings organized**: several training programmes were organized under SCSP. Besides, four sponsored training programmes were organized by DSST, ICAR-IARI, New Delhi for the officials from public/private sector.
6. **Lectures delivered in training for farmers/extension professionals**:
   - 16 lectures delivered by Nodal Officer, SCSP in different farmers' training programmes.
   - Besides, the DSST scientists acted as resource persons in divisional training programmes.
7. **Participation in Krishi Vigyan Mela**: DSST actively participated and disseminated technologies during Krishi Vigyan Mela 2023.
8. **Participation in *Mera Gaon Mera Gaurav* Programme***:* The seed of field crops (wheat, paddy, mustard, vegetable crops etc.) was distributed to the farmers in MGMG villages for field demonstration of improved varieties.
9. **Participation in Demonstrations of technologies organised on-farm trials and among farmers:** Field demonstrations of improved varieties was undertaken in SCSP villages.
10. **Extension Lectures delivered by Scientists**:
    - Dr. D. Vijay, PS, DSST delivered 2 lectures: Members of Primary Agriculture Cooperative Credit Societies Ltd through KVK-Gurugram

of IARI on 18 Sep 2023 and to extension and industry personnel on forage seed production at IGFRI Jhansi on 08 Feb 2024

- Dr. S. K. Lal, PS, delivered a lecture on Seed Production in Paddy in training programme- Good Agricultural Practices for Basmati Production organised for the farmers and entrepreneurs of UP, sponsored by Riz Horizon Pvt. Ltd., New Delhi

11. **Display of varieties and technologies in various extension programmes/ exhibitions**: The display of varieties and technologies was done at Krishi Vigyan Mela 2023.
12. **Organization/Participation in *Kisan Gosthis*:** Various kisan *gosthis* were organized under the SCSP scheme, wherein scientists from different disciplines participated.
13. **Publications** (Popular articles/technical bulletins/Extension Folders) Training manuals- 2, Technical bulletins-3, Customized Instruction Material - 2, Popular articles- 3
14. **Mobile based advisories**: Advisory to MGMG/ SCSP farmers through WA
15. **Agro-advisories**: Agro-advisory to farmers through training programmes/ personal basis
16. **Number of Custom Hire Centers/Information centres created in village**: Custom hiring centres are being developed in villages for allotment of farm equipment like power tiller, happy seeder etc.
17. **Trainings organized**

	Training	**Date**	**Agency**	**No. of participants**
1.	International Training Programme on “Seed production and quality evaluation”	February 12-23, 2023	MoRD, GOI and AARDO for the 10 officials of AARDO member countries.	10
2.	Seed production testing and storage in field and vegetable crops (Self sponsored)	March 13-17, 2023	ZTM & BPD unit	25

3	Seed production and certification of field crops	Aug 2-4, 2023	Assam Agribusiness and rural transformation project (AAPART). Govt. of Assam	20
4.	International Masters Trainers' Training Programme on "Post-Harvest Technologies for Seed Quality Improvement"	November 28 - December 01, 2023	German government and Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture, Govt. of India	20

Seed Production & Certification of Field Crops at IARI, New Delhi (Assam, 2-4 Aug, 2023)

Advanced Post-Harvest Technologies for Seed Quality Improvement at IARI, New Delhi (Nov 28- Dec, 1, 2023; ADT)

OECD Seed certification at RARI, Durgapura (21-23 Feb 2023; ADT)

Field Visit on Nov 30, 2023 (ADT workshop)

Advanced Seed Production Technologies at IARI-RS, Karnal (12-15 March, 2024)

18. Trainings organized under SCSP programme:

S. No.	Training	Date	Place
1	'Orientation cum Training Programme' of Gram Pradhan/Contact Farmers	1st May 2023	IARI, New Delhi
2	'Improved cultivation of paddy– Farmers' training and Seed distribution programme'	17th May 2023	Village Lalgadhi, Block Khair, Aligarh
3	Farmers' training and Seed distribution programme: Improved cultivation of paddy	24th May 2023	Muradnagar, District Ghaziabad, Uttar Pradesh
4	'Farmers' training on Improved cultivation of paddy' and Seed distribution programme	3rd June 2023	Village Rajpur, Block Khair, Aligarh (UP)
5	Farmers' training programme - Improved cultivation of paddy	14th June 2023	Block Pilana, District - Baghpat, Uttar Pradesh
6	Field Day cum Training Programme	12-13 August, 2023	Panchayat Jatwada, Teh. Mandawar, District Dausa, Rajasthan
7	*Krishi Aay Ki Varidhi Mein Mahilaon Ke Yogdaan Ko Badhane Hetu Parsikshan*	12-13 August, 2023	Vill. Balawas&Kaledi, Teh. Nangal Rajavatan, District Dausa, Rajasthan
8	Exposure visit	20th September 2023	IARI, New Delhi

9	Field Day cum Training Programme	22th September 2023	Balahera and Jhoonthahera, Teh. Baijupara, District Dausa, Rajasthan
10	Promotion of Improved Varieties and technologies for agri-horticultural crops	8th October 2023	Sakoti, Distt. Meerut
11	Promotion of Improved Varieties and technologies for agri-horticultural crops	9th October 2023	Shahpur, Distt. Muzaffarnagar
12	Farmers' training on Improved cultivation of Rabi crops and Seed distribution	4th November 2023	Village Mansoorpur, (Spring Dale), Block Khatauli, Muzaffarnagar (UP)
13	Farmers' training on Improved cultivation of Rabi crops and Seed distribution	6th November 2023	Village Charthawal, Block Charthawal, Muzaffarnagar (UP)
14	Agricultural residue management for income generation	12th November 2023	Village Sarawa, Hapur, UP
15	Field Day cum Training Programme	16th November 2023	Rajpura village, Aligarh, U.P.

19.Mera Gaon Mera Gaurav Programme

Training Programmes under SCSP programme

Orientation cum training Programme for *gram pradhan*/contact farmers on 1 May 2023

Improved cultivation of paddy– Farmers' training and seed distribution programme (17 May 2023)

Farmers' training and Seed distribution programme: improved cultivation of paddy (24 May 2023)

Farmers' training on improved cultivation of paddy and seed distribution programme (3 June 2023)

Farmers' training programme - improved cultivation of paddy during (14 June 2023)

Farmers' training on improved cultivation of *rabi* crops and seed distribution (4 November 2023)

Farmers' training on improved cultivation of *rabi* crops and seed distribution (11 November 2023)

14. BUDGET

The Division of Seed Science and Technology received a budget allocation of 39.75 lakh rupees for the fiscal year 2023-24. Additionally, PG grant No. TGS-II/84-01/2023-24/PG Strengthening, dated 20.03.2024, included a first instalment under the Head: Grant-in-Aid General (Revenue) of 1.50 lakhs (Contingency grant) + 1.0 lakh for an Educational Tour. Furthermore, grant No. TGS-II/84-01/2023-24/PG Strengthening, dated 27.03.2024, included a third instalment under the Head: Grant-in-Aid General (Revenue) of 1.50 lakhs (Contingency grant).

14.1 Plan and non-plan budget for the year 2023-24

Particulars	Expenditure (INR in lakhs) Bill paid till 31 March 2024
Research & Operational	
Research	19,96,959
Operational (including Labour & contractual expenditure)	7,83,173
Administrative	-
Communication	-
Repair & maintenance	5,86,866
Others	9,15,649
Miscellaneous	
TA	1,25,214
HRD	52,000
Grand Total	**44,59,861**

14.2 External Grants (2023-2024)

S. No.	Name of of the PI/ CCPI	Title of the projects	Funding Agency	Total Period of the project (mention date)	Sanctioned Budget (In lakhs)
1	Dr. Gyan Prakash Mishra	Unravelling the candidate genomic regions regulating multi-flowering in cultivated lentil (*Lens culinaris* L.) through RNA-Seq and QTL-Seq approaches using a RIL population	SERB	2024-27	49.94
	Dr. Gyan Prakash Mishra	Unravelling the candidate genomic regions regulating MYMIV resistance and extra-earliness traits in mungbean using RNA-Seq and Genotyping-by-sequencing approaches	SERB	2020-23	39.45 (Aug 6th 2023)
	Dr. Gyan Prakash Mishra	*Capacity Building Training Programme for Master Trainers*	ADT, Germany; DAC N Delhi; ICAR, N Delhi	2023-24	118.0
	Dr. Gyan Prakash Mishra	*Identification of candidate genes regulating total protein and carbohydrates in lentil*	ICARDA, India	2023-25	20000 USD
	Dr. Gyan Prakash Mishra	Consortium research project (CRP) on Agrobiodiversity	ICAR, N Delhi	2021-2026	20.00

2.	Dr. Monika Joshi	Electronic Quality Assessment Solution for agricultural commodities for National Agricultural Market (e-NAM)	MeitY CDAC, Kolkata	2022-24	54.39
3.	Dr. Atul Kumar	AICRP (Seed Pathology)	ICAR	2019-Contd	--
4.	Dr. SK Lal	AICRP (Seed Production and certification)	ICAR	2019-Contd	-
5.	Dr. Sangita Yadav	Molecular approaches for mapping of novel gene(s)/ QTL(s) for resistance/ tolerance to different stresses in Rice, Wheat, Chickpea and Indian Mustard including sheath blight complex genomics and resistance mechanisms (ICAR)	Gov. of India	-	-
	Dr. Sangita Yadav	Standardization, Performance Evaluation and Field Demonstrations of Plasma-izedWater™ (PW) Treatments for Enhanced Planting Value in Wheat, Mustard, Lentil, and Tomato Crops against Heat Stress & Normal Conditions.	Plasma water solutions India Pvt. Ltd	2023-25	32.35
6.	Dr. Sudipta Basu	Popularisation of biofortified maize hybrids in Himalayan states and central India	DBT	2021-24)	35.83

		with special reference to North Eastern Region for sustainable nutritional security			
	Dr. Sudipta Basu	Enhancing Abiotic Stress Tolerance in Wheat and Millets: Insights from Integrated Genetic, Epigenetic, Molecular and Physiological Interventions	NASF, ICAR	2024-27	124.11
7.	Dr. Nagamani Sandra	Unraveling the etiology, characterization and seed transmission studies of new viruses associated with vein necrosis disease of soybean”	DBT	2024-27	55.00

15.CADRE STRENGTH

Table 15.1 Cadre strength

Staff	**Cadre strength**	**Current Position**
HoD	1	01
Principal Scientist	02	10
Senior Scientist	07	02
Scientist	10	03
Total Scientists	20	14+1*
Total Number of students M.Sc. and Ph.D.	-	MSc-14 (8)[!] PhD-37 (11)[!]
Technical Officers	10	8
Administrative Staff	04	2.5
Supporting Staff	08	03
Total Number of YPII/JRF/SRF/RAs	-	04 (YPI)
Total number of skilled staff / field assistant in externally funded projects	-	02

Table 15.2 List of Staff Seed Science and Technology Division

S. no.	Name	Designation
1	Gyan Prakash Mishra	Head
2	Monika Atul Joshi	Professor
3	S.K. Chakrabarty	Pr. Scientist
4	Sangita Yadav	Pr. Scientist
5	Kumar Kant Singh	Pr. Scientist
6	Sudipta Basu	Pr. Scientist
7	Sandeep Kumar Lal	Pr. Scientist
8	Arun Kumar MB	Pr. Scientist
9	Atul Kumar	Pr. Scientist
10	Dunna Vijay	Pr. Scientist
11	Vijay Kumar H P	Sr. Scientist
12	Vishwanath Rohidas Yalamalle	Sr. Scientist
13	Nagamani Sandra	Sr. Scientist
14	Manjunath Prasad CT	Scientist
15	Usha Rani Pedireddi	Scientist
16	Smt Seema Khattar	P.S
17	Raj kishor choudhary	U.D.C
18	Nav Bahar Singh	Asstt.
19	Manisha Saini	T-5
20	Mohd. Athar	T-5
21	Ravish Choudhary	T-5

22	Dharmpal Singh	T-4
23	Iqbal Ahmed	T-3
24	Anuj Kumar	T-2
25	Gaurav Kumar	T-1
26	Jitendra	T-1
27	Devender Singh	MTS
28	Sunil kumar	MTS
29	Ramesh Rai	MTS

16. POSTING/SUPERANNUATION

Posting		
	Dr. Gyan Prakash Mishra	Head Division of Seed Science and Technology, ICAR-IARI, New Delhi
	Dr. Shiv Kumar Yadav	Head Regional Station, ICAR-IARI, Karnal
Superannuation		
	Sh. Amarnath Thakur	Asst. Admin Officer

17. MISCELLANY

17.1. Visit of dignitaries in the Division (2023)

NAAC TEAM VISIT

QRT TEAM VISIT

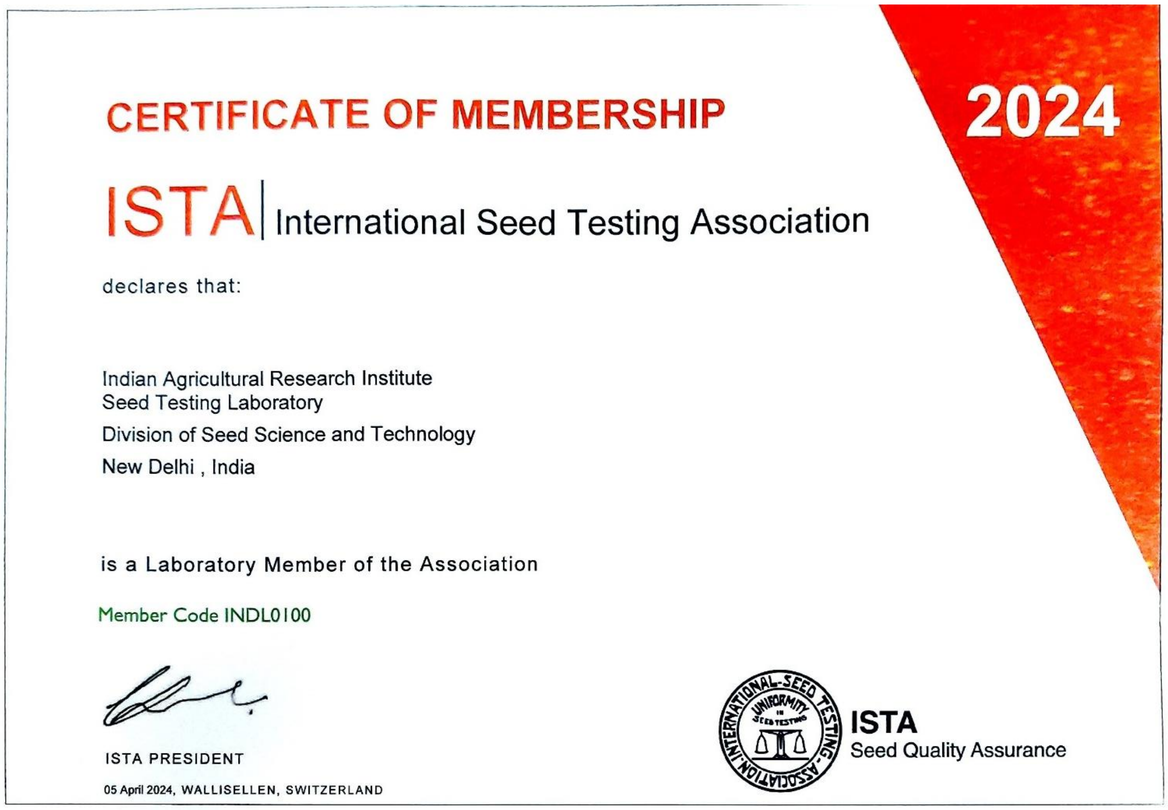
Dr. Steven Groot, Sr. Researcher
PRI Wageningen UR, The Netherlands

17.2. Exposure Visit

TGMS hybrid seed production plot of Savannah Seeds Company station at Panipat on 5th October 2023 by Dr. Arun Kumar M.B. and Mr. Ram Vilas.

17.3. AICRP monitoring team

17.4 ISTA Accreditation



CERTIFICATE OF MEMBERSHIP

2024

ISTA | International Seed Testing Association

declares that:

Indian Agricultural Research Institute
Seed Testing Laboratory
Division of Seed Science and Technology
New Delhi , India

is a Laboratory Member of the Association

Member Code INDL0100

ISTA PRESIDENT

05 April 2024, WALLISELLEN, SWITZERLAND

ISTA
Seed Quality Assurance

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