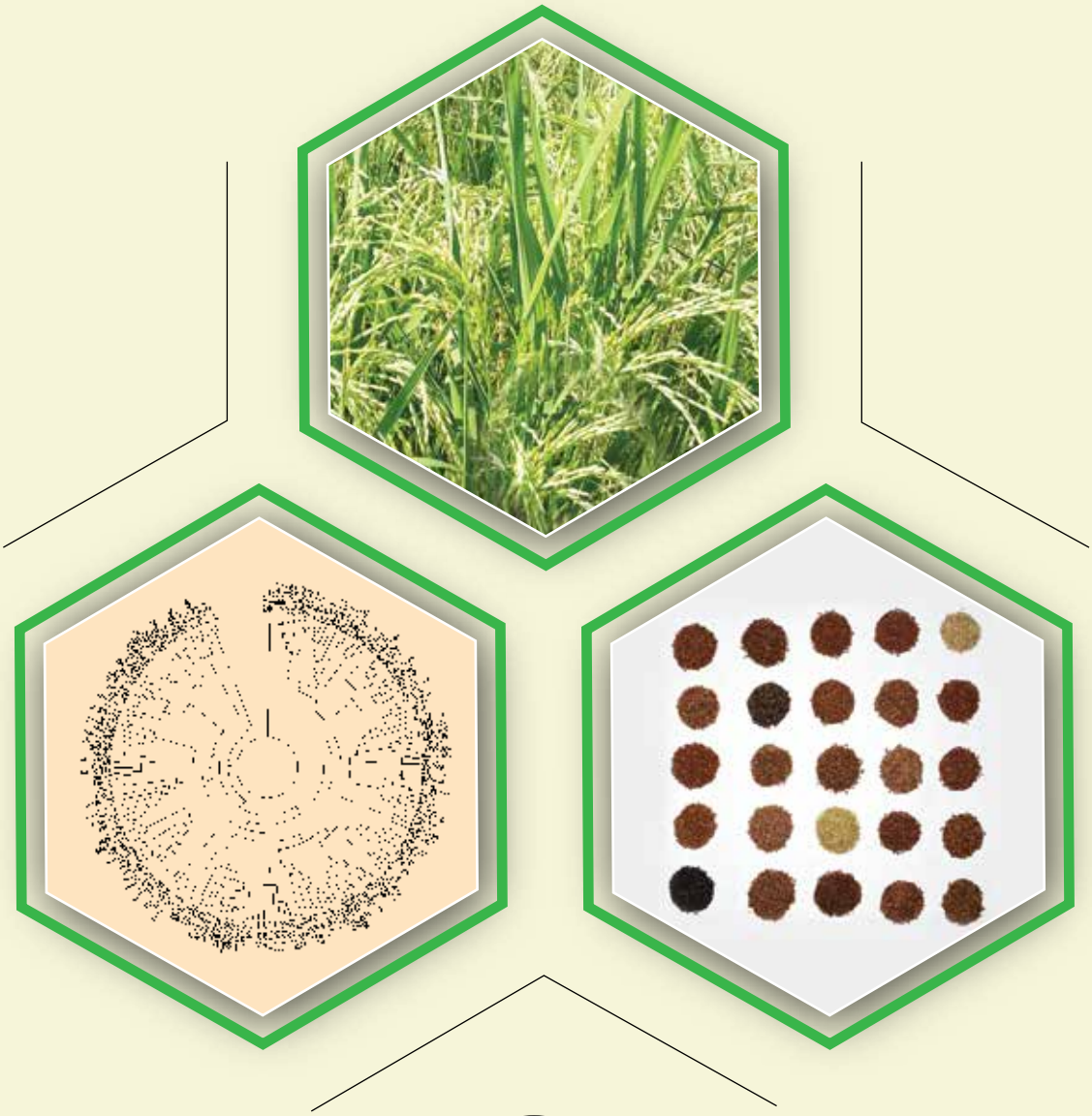
भाकृअनुप
ICAR

ANNUAL REPORT
वार्षिक प्रतिवेदन

2017-18



ICAR - Indian Institute of Agricultural Biotechnology

Garhkhatanga, Ranchi – 834 010, Jharkhand, India

Phone: +91 651 2261125; Fax: +91 651 2261122

Email: iiab.ranchi@gmail.com | Website: https://iiab.icar.gov.in

भाकृअनुप
ICAR

ANNUAL REPORT
वार्षिक प्रतिवेदन

2017-18

ICAR - Indian Institute of Agricultural Biotechnology
Garhkhatanga, Ranchi – 834 010, Jharkhand, India
Phone: +91 651 2261125; Fax: +91 651 2261122
Email: iiab.ranchi@gmail.com | Website: https://iiab.icar.gov.in

Annual Report 2017-18

Published by

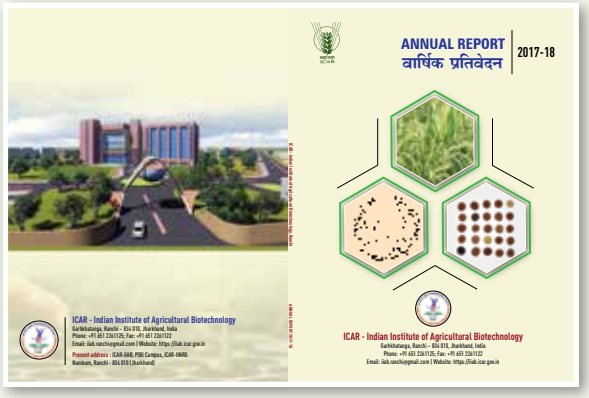
Dr. T.R. Sharma
Director

Correct Citation

Annual Report 2017-18, ICAR - Indian Institute of Agricultural Biotechnology, Garhkhatanga, Ranchi - 834 010, Jharkhand, India.

Printed at

Kailash Paper Conversion Pvt. Ltd.
Ranchi - 834 001



Front Page

Rice crop
Phenogram of rice germplasm
Pigmented rice germplasm

Back Page

Model of ICAR-IIAB

Contents

Preface

Agriculture, the backbone of rural Indian economy, is still the source of livelihood for the majority of the unorganized workforce of rural India. With one out of four of the rural population associated with agriculture, the primary challenge of the farming community is to support their livelihood with the small, shrinking and fragmented land holdings, combating the errant weather as well as rapid deterioration of the quality of natural resources like soil and water. Promotion of new technologies, a paradigm shift in agricultural research agendas and framing of suitable mitigation plans are crucial to addressing the grave problems and hurdles plaguing the primary sector, for overall development and welfare of farming communities of our country. Application of modern scientific tools and techniques in agriculture, is a potential factor and major step towards this goal.

Recent advancements in molecular biology, genomics and bioinformatics can facilitate researchers to understand complex biological traits and processes and demarcate or identify the critical genomic regions underlying the crucial biological processes, relevant to crop/animal improvement, thereby enabling scientists to develop crop cultivars or animal breeds with precision. The ICAR-Indian Institute of Agricultural Biotechnology (IIAB) established at Ranchi envisages the dream and task of meeting the demand for biotechnology products, processes and technologies, as well as building world-class human resources for research in frontier areas and undertaking post-graduate teaching in all domains of agricultural biotechnology. At present, the institute is operating from the Process and Demonstration Unit (PDU) campus of ICAR- Indian Institute of Natural Resins and Gums (IINRG) located at Namkum, Ranchi with fourteen scientists from different disciplines. Although the institute is still in its incipient stage, developmental activities are taken up on a priority basis and research programmes undertaken in significant areas of Genomics and Bioinformatics, Translational Research for Crop Improvement and Fish Health Management, with modest research facilities available at the Institute. Annual report 2017-18 of ICAR-IIAB describes the research activities undertaken and outlines the significant achievements and annual accounts of the financial year 2017-18.

I wish to heartily congratulate all the scientific, administrative and finance staff of ICAR-IIAB and accord my gratefulness to all who contributed to this report. I sincerely express my appreciation to the members of the Editorial Board for their tireless efforts in preparing and publishing this report.

I express my profound sense of gratitude and place on record my thankfulness to Dr. T. Mohapatra, Secretary, DARE, Government of India and Director General, ICAR; Dr. A.K. Singh, Deputy Director General (Crop Science) and Dr. D.K. Yadav, Assistant Director General (Seeds), ICAR for their constant supervision and guidance.

Ranchi
July 2018

T.R. Sharma
Director

About the Institute

A premier national institute working under the aegis of Indian Council of Agricultural Research (ICAR), New Delhi, the ICAR-Indian Institute of Agricultural Biotechnology (IIAB), located at Ranchi, was established with a broader vision of harnessing the potential of biotechnology to accelerate the pace of agricultural growth. The mission of the institute is to strengthen as well as conduct high-quality basic and applied research in plant, animal, fish and microbial biotechnology, in an integrated manner and to develop excellent human resources by undertaking teaching and training programmes at master, doctoral and post-doctoral levels in all the frontier areas of agricultural biotechnology. Basic and strategic research in agricultural biotechnology and development of quality human resources for academic excellence in agricultural biotechnology form the chief mandate of the institute. The focus is to provide a revolutionary impetus to agricultural development in the country, through cutting-edge research in biotechnology and application of modern scientific tools and techniques.

Self-sufficiency in food production and self-reliant farming community with enhanced farm income is the prime goal of agricultural development programmes. ICAR-IIAB has the mandated responsibility to critically assess the stakeholder's needs and to make a need-based paradigm shift in research agendas. ICAR-IIAB aims to achieve its goals through marker-assisted selection (MAS), an integral part all breeding programmes which also supplements them, through the search for or identification of novel genes/alleles and promoters or *cis*-regulatory regions of genes from the vast and diverse biological resources in the country and application of genetic engineering to manipulate biochemical processes for effective stress response, enhanced productivity and input-use efficiency. Development of designer crops suited to the preference of stakeholder is one of the priority research agendas of the institute. Generation of genomic/sequence data in large-scale and strengthening the management as well as analytical capability for such data will be a regular research activity of the institute. Development of molecular diagnostics for precise identification of significant diseases in plants, animals and fish and prophylactic measures for their control, will be another focus area of the institute. Advances in nanotechnology shall be explored and exploited by the institute, to device ultrasensitive detection system for disease as well as pest management and nanodelivery of pesticides, vaccines, nutrients/ hormones, genes etc.

The institute shall serve as a hub for biotechnology research activities undertaken under the National Agricultural Research and Extension System (s) (NARES), by providing technical support and service facility for tools, techniques, protocols, database, sequencing, bioinformatics, safety studies, products and knowledge. With its modest facilities, ICAR-IIAB has already initiated research in the areas of molecular breeding, for guided integration of known QTLs for drought tolerance and phosphorus-uptake in rice and to search for novel QTLs/genes for enhancing phosphorus and zinc uptake as well as utilization efficiency in rice. The drought-responsive genes from wild chickpea (*Cicer microphyllum*) were identified and studies undertaken on genes responsible for heat tolerance in lentil and ideotype breeding in horse gram. Efforts are undertaken for the development of oral vaccines and characterization of genes responsible for immune response in fish. Augmentation of the germplasm resources through exploration and collection of landraces as well as wild species of crops, characterization of germplasm and enhancing the crop gene pool for use in crop improvement, are also among the significant activities taken up by ICAR-IIAB. Recently, the institute has also taken up inter-institutional research projects on the development of genomic resources, in few highly remunerative agri-horticultural crops, prevalent to eastern India. In addition, ICAR- IIAB is also actively involved in undertaking all possible measures to empower the tribal farmers by implementing central schemes for farmer's welfare.

Mandate

- Basic and strategic research in agricultural biotechnology
- Development of quality human resources for academic excellence in agricultural biotechnology and policy support

Cadre Strength

Category of Staff	Sanctioned	Filled	Vacant
Research Management Position (RMP)	8	1	7
Scientific	29	12	17
Technical	01	0	01
Administrative	02	02	Nil
Skilled Supporting	Nil	Nil	Nil
Total	**40**	**15**	**25**

Executive Summary

ICAR - Indian Institute of Agricultural Biotechnology (IIAB) was established in 2012 with the mandate of basic and strategic research in the frontier areas of agricultural biotechnology and development of quality human resources for academic excellence in agricultural biotechnology. The institute is presently functioning from the Process and Demonstration Unit (PDU) campus of ICAR-IINRG, Namkum, Ranchi. With its modest research facilities, the institute is working on three major areas namely, Genomics and Bioinformatics, Translational Research for Crop Improvement and Biotechnological Interventions for Fish Health Management. The progress of work done during the year 2017-18 is summarized below:

Institute-Funded Projects

- Transcriptome profiling of wild chickpea (*Cicer microphyllum*) grown under drought-stress and normal conditions were performed and differentially expressed genes were identified.
- Five Heat Shock Factor (HSF) genes were cloned from lentil. Moreover, the stability of expression of eight housekeeping genes at different developmental stages and under various abiotic stresses were assessed.
- Biological samples were collected and characterization of Major Histocompatibility Complex (MHC) genes of indigenous pig (*Sus scrofa*) was initiated.
- Crosses (using IR-64-*drt-1*, Anjali and Sahbhagi) made in the preceding *kharif* season were advanced through selfing for development of mapping population. These populations will be used for mapping gene(s)/QTLs for Zn homeostasis in rice. Hydroponics protocol for evaluation of Zn uptake and utilization efficiency in rice is being standardized.
- The F_1s made during the preceding *kharif* season using IR-64-*drt-1*, Kasalath, Vandana and Swarna as donors and RNR-15048 as the recipient was backcrossed for developing BC_1F_1 population. Crosses were also attempted to generate fresh F_1s for developing drought-tolerant phosphorus-use efficient varieties of rice.
- The F_1s generated by crossing Vikash and Rasi; known for better phosphorus utilization and RPBIO-226 and IR-64; less efficient regarding phosphorus utilization, were advanced to F_2 generation. A total of 490 SSR markers evenly distributed among all the 12 linkage groups of rice were selected and evaluated for amplification. The SSR markers yielding successful amplification were subjected to polymorphism analysis using the parents involved in the crosses. Also, a total of 1,015 rice germplasm accessions collected from different sources/locations were screened for yield and yield-related traits and grain pigmentation. Hydroponics protocol is being standardized for the screening of a broad set of diverse rice germplasm for identification of novel donors for efficient phosphorus utilization.
- The rice germplasm set available with ICAR-IIAB was screened under the natural epiphytotic conditions for identification of potential rice blast resistance sources. Two germplasm accessions collected from Bihar showed broad-spectrum resistance against rice blast pathogen.
- Two hundred and thirty-five lentil germplasm accessions were procured and morphologically characterized during 2017-18. Germplasm accessions EC 225495, EC 267710, EC 267635 and IC 567315 were identified as early maturing type while IC 240990 and IC 240976 were identified for high biomass and pod yield per plant.
- An extensive breeding programme has been initiated in horse gram (*Macrotyloma uniflorum*). During 2017-18, a total of 252 horse gram germplasm accessions were procured from ICAR-NBPGR, New Delhi and their seeds were multiplied.
- The dietary administration of microbial levan @ 1.25%, in *Aeromonas hydrophila*-infected *Labeo rohita* fingerlings significantly up-regulated m-RNA-mediated pro-inflammatory cytokines *IL-1β*, *TNF-α* and *IL-12p40* and downregulated anti-inflammation regulatory cytokine *IL-10* in the intestine, gill, kidney and liver in a time-dependent manner.

- Significant inhibition of growth was observed in fungal pathogens *Ustilaginoidea virens*, *Alternaria tenuissima* and *Erysiphe cichoracearum* by the application of copper nanoparticles. An enhancement in the bio-imaging property of ZnO nanoparticle was observed on its attachment with lac dye. Expression of nanoselenium-delivered pro-inflammatory cytokines (*TNF-α*) was evaluated in rohu (*Labeo rohita*) under metal-stress conditions.

Externally-Funded Projects

- Twenty-six genotypes of lentil were screened for drought tolerance under pot conditions. Based on the preliminary biochemical, physiological and molecular results, the germplasm accession IC248956 was found to be relatively drought-tolerant.
- A novel method was developed for the extraction of proteins from purified plasma membranes of bovine sperm cells. The membrane proteins of the unsorted sperm of indigenous cattle were identified using LC-MS/MS.
- Eleven technical interventions involving a total of 223 farmers were implemented under ICAR-funded Farmer FIRST project. Two hands-on training programmes were organized for skill development of 25 farmers. Also, three exposure visits and one farmer-scientist interphase were organized, that witnessed enthusiastic participation of more than 400 farmers.
- Thirteen technical interventions were implemented under Tribal Sub-Plan, benefitting 70 farm families. Two hands-on training programmes were organized for skill development of tribal farmers.

Inter-Institutional Collaborations

- A total of 247 germplasm accessions of *Artocarpus heterophyllus* (Jackfruit), maintained *ex-situ* at ICAR-NBPGR, RS, Ranchi were analyzed based on ten important quantitative characters. A large number of Illumina NextSeq 500 reads were generated in *Artocarpus heterophyllus* and *Aegle marmelos* (Bael). The clean reads were assembled and characterized through *in-silico* methods. The clean reads were deposited at the NCBI Short Read Archive (SRA) under the BioProject accession numbers SRR7250836 (Jackfruit) and SRR7268533 (Bael). A comprehensive set of genic-SSRs were identified and are being validated in the germplasm available with ICAR-NBPGR, Regional Station, Ranchi.
- Under All India Coordinated Rice Improvement Project (AICRIP), two trials namely AVT-1 E-DS and IVT-E-DS were conducted under rainfed direct-seeded conditions during *kharif* 2017 at ICAR-IIAB Research Farm, Garhkhatanga.
- Based on two consecutive years of testing under preliminary station trials, three Green Super Rice (GSR) entries namely, IABR1-GSR IR1-DQ157-R6-D1, IABR2-GSR IR1-24-D5-Y1-L1-L1 and IABR-3-GSR-IR1-6-D10-Y1-D1-L2 were nominated under different trials (IVT-IME, IVT-E-TP & IVT-IME) of AICRIP systems for multi-location testing. Besides, six other promising entries were also nominated for coordinated state trials to identify stable, promising genotypes under rainfed conditions.
- During *kharif* 2017-18, thirty FLDs were conducted to demonstrate the production potential of marker-assisted selection (MAS) derived drought tolerant rice variety IR-64-*drt-1*. The average yield of the rice variety IR-64-*drt-1* achieved under FLDs was 33.1 q/ha, whereas yield under farmers practice was 29.5 q/ha. During *rabi* 2017-18, twenty FLDs were conducted for high yielding varieties of Indian Mustard namely NRCHB-101 and DRMR-150-35. The average yield achieved by the variety NRCHB-101 was 6.9 q/ha, whereas yield under farmers practice was 6.2 q/ha.
- During 2017-18, three explorations of rice growing as well as forest areas of Ramgarh, Barhi Bundu, Tamar, Chandil, Golmuri-Cum-Jugsalai and Ghatshila blocks of the districts Hazaribagh, Ranchi, Saraikela Kharsawan and East Singhbhum were conducted and seeds of 21 genotypes of wild species of rice were collected.
- The International Rice Research Institute (IRRI) coordinated IURON, SET-II was evaluated at ICAR-IIAB Research Farm at Garhkhatanga under rainfed direct-seeded conditions.

Research Accomplishments

Institute -Funded Projects

Genomics and Bioinformatics

Sustainable agricultural production is the most critical issue of the 21st century. In this context, it is high time to rapidly develop and employ more efficient tools and techniques for crop improvement. The multiple omics platforms coupled with advanced computational methods and modern genetic engineering approaches offer a viable option to improve the yield of crop plants by designing them based on the molecular understanding of gene function, development and growth. ICAR-IIAB has undertaken three research projects under Genomics and Bioinformatics.

IXX12585: Identification and characterization of drought-responsive genes in wild chickpea (*Cicer microphyllum*)

Cicer microphyllum is a wild relative of cultivated chickpea (*Cicer arietinum*). *Cicer microphyllum* grows widely in the cold deserts of Ladakh and Lahaul & Spiti in India. Considering the extraordinary tolerance of *Cicer microphyllum* to cold and drought, ICAR-IIAB has taken up a project to identify drought-responsive genes from this species. In this endeavor, the seeds of *Cicer microphyllum* were germinated on MS medium and seedlings were transferred to pots after 15 d of germination. Plants were allowed to acclimatize in pots for three days after which the drought stress was imposed. Total RNA was isolated from drought-stressed and control plants and RNA-Seq libraries were prepared and sequenced. Raw paired-end reads were quality filtered and clean reads were assembled *de novo* using CLC genomics workbench. The resulting contigs were annotated using GO, EC and KEGG. The enrichment of several stress-associated gene ontology terms in biological processes was observed (Fig 1). Several transcription factor (TF) families were also identified. The top-20 TF families included stress-responsive TF families, namely *Myb*, *ERF*, *NAC*, *RAV*, *bHLH*, *WRKY*, *C2H2* and *bZIP* (Fig 2). Differential expression analysis identified several drought-responsive differentially expressed transcripts.

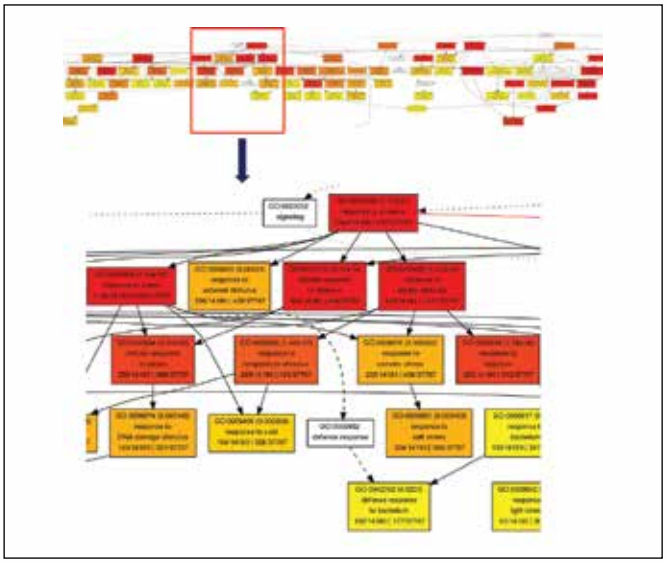


Fig 1: Gene enrichment analysis of biological processes in *Cicer microphyllum*

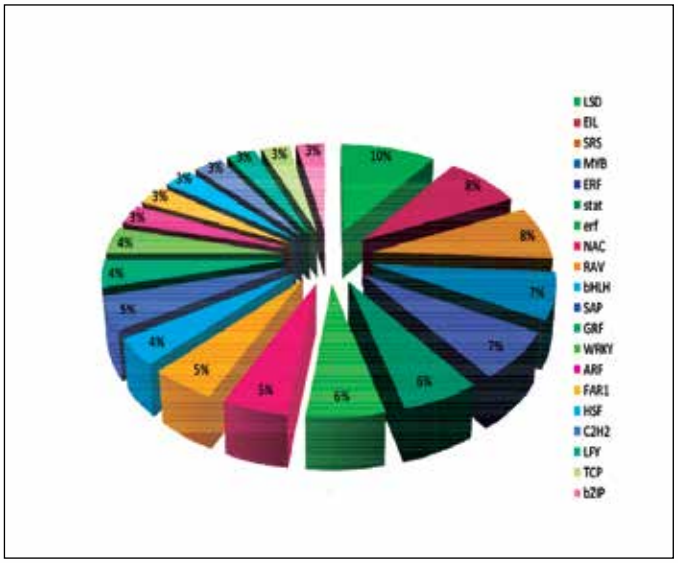


Fig 2: Top-20 transcription factor families identified in the transcriptome dataset

IXX12644: Identification of genes/ QTLs for heat tolerance in lentil

Heat shock factors (HSFs) are ubiquitously found in all organisms and play an important role in adaptation under acute stress. Partial CDS of five heat shock factor (HSF) genes have been amplified from lentil and cloned in TA cloning vector (Fig 3). Their sequence was confirmed through nucleotide sequencing. Full-length CDS amplification through 5' and 3' RACE is in progress.

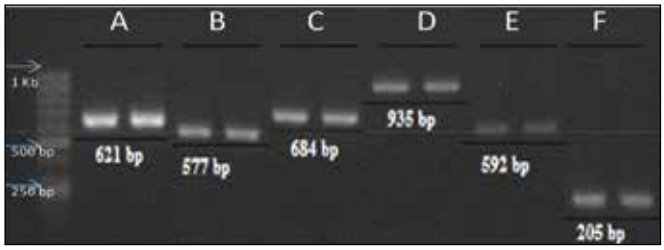


Fig 3: Amplification of partial CDS of HSF genes from lentil

For normalization of the qRT-PCR data, identification of stable expressing housekeeping gene (HKG) is a prerequisite. Thus eight candidate reference genes were screened under various abiotic stresses and at different developmental stages. The genes selected were *18S, GAPDH, EF1α, HSP70, Mat K, Rbcl, Tub,* & *RPL2*. Initially, qRT-PCR parameters (correlation coefficient and PCR efficiency) of these genes were determined. C_t (cycle threshold) values of these genes were then determined through qRT-PCR, under various abiotic stress conditions (abscisic acid, methyl violagen, cold, drought salinity, heat) and at different developmental stages (Fig 4).

The comprehensive ranking of candidate reference genes based on their expression stability was calculated using Bestkeeper, geNorm, Norm-Finder and RefFinder software.

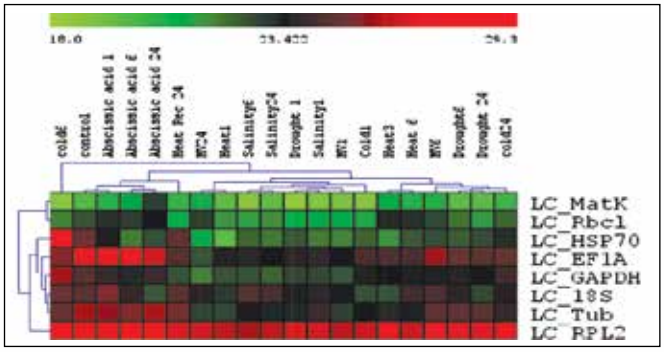


Fig 4: Heat map analysis of differential C_t values of eight candidate genes under various abiotic stress conditions

All the software identified *RPL2* as the top-ranked gene under all the experimental conditions. Hence *RPL2* was used as a reference gene for qRT-PCR analysis.

IXX12950: Molecular characterization of the Major Histocompatibility Complex (MHC) genes of indigenous pig (*Sus scrofa*)

The project aims to characterize the significant constitutively expressed classical MHC genes in native pig (*Sus scrofa*), decipher the allelic architecture of the Swine Leukocyte Antigen (SLA) system and develop a PCR-based assay for following the SLA types.

During 2017-18, biological samples from indigenous pig breeds were collected and DNA bank was populated. Molecular characterization of the significant constitutively expressed classical MHC genes has also been initiated.

Translational Research for Crop Improvement

During the past decades, the extensive research in genomics and molecular biology has emanated a plethora of available data. However, the translation of the language of genomics and molecular biology to crop improvement is lagging behind. Therefore, it is essential to become involved more aggressively in converting basic knowledge into applications in crops to sustainably support food security and agriculture. At ICAR-IIAB, four research projects aimed at the marker-assisted convergence of known QTLs for drought and phosphorus uptake and identification of novel genes/QTLs for phosphorus-use-efficiency and zinc homeostasis in rice and one project each in horse gram and lentil for earliness and high biomass have been undertaken.

IXX12645: Identification of genes responsible for Zinc homeostasis in rice

Zinc deficiency is a global edaphic problem reported in various parts of the world including India. About 48.1% of the agricultural soils in India are deficient in Zn. In this regard, crosses (using IR-64-*drt-1*, Anjali and Sahbhagi) made in the preceding *kharif* season were advanced through selfing for development of mapping population. These populations will be used for mapping gene(s)/QTLs for Zn homeostasis in rice. Moreover, hydroponics protocol for evaluation of Zn uptake and utilization efficiency in rice is also being standardized for screening of diverse germplasm maintained at the institute.

IXX12649: Introgression of genes/ QTLs for drought tolerance and efficient phosphorus uptake in rice using MAS

Green revolution introduced chemical fertilizers for boosting crop yields and since then their use has increased tremendously. Fertilizers are increasingly becoming expensive year after year. Concurrently, the runoff and leaching of nutrients from farmers' fields are becoming a major cause of water bodies' pollution. Moreover, in problem soils *viz.*, sodic, alkaline and acidic soils, the availability of the majority of nutrients are limited. Consequently, even high yielding crop varieties fail to express their full potential under these constraints. Hence, developing input-use-efficient cultivars will not only save on input cost but also minimize the damage to the environment.

During 2017-18, the F_1s generated by crossing donor genotypes for *Pup1* namely, Vandana, Kasalath, Swarna, DTY 2.2 and DTY 4.1 (IR 64 *drt-1*) were raised along with recipient parents (Fig 5). True F_1s were backcrossed with respective recipient parents for developing BC_1F_1s and seeds of such crosses were harvested. Three hundred SSR markers were screened and a total of 80 SSRs were selected for background selection. To develop mapping populations for mapping new QTLs/genes for drought tolerance, F_1s generated by crossing high-yielding varieties with highly drought-tolerant plants of *Oryza rufipogon* were also backcrossed with their parent varieties to raise BC_1F_1 and the seeds of BC_1F_1 were harvested.

Fig 5: Crossing in rice at ICAR-IIAB polyhouse

IXX12651: Identification and mapping of novel genes/QTLs for phosphorus uptake and use efficiency in rice

The F_1s generated by crossing contrasting parents for phosphorus uptake and utilization efficiency (Vikash and Rasi; known for better phosphorus utilization) and (RPBIO-226 and IR-64; less efficient for phosphorus utilization) were advanced to the F_2 generation. A total of 490 SSR markers evenly distributed among all the 12 linkage groups of rice were selected and evaluated for amplification. The SSR markers yielding successful amplification were subjected to polymorphism analysis using the parents involved in the crosses. Moreover, hydroponics protocol is also being standardized for the screening of a broad set of diverse rice germplasm and the RIL population.

In addition, a total of 1,015 rice germplasm accessions collected from rice-growing and forest areas of Jharkhand, Chattisgarh, Bihar, North Eastern states of India as well as different centers of ICAR and SAUs were evaluated under lowland ecosystem for yield and yield-related traits and grain pigmentation.

Evaluation of rice germplasm for yield and yield-related traits

The germplasm accessions were evaluated under lowland ecosystem for yield and other traits of economic importance (Fig 6). The experiment was laid out in an augmented design comprising 15 blocks with four checks namely, CR Dhan-310, CR Dhan-311, IR 64 *drt -1* and Ciherang. All recommended agronomic practices were followed during the different stages of crop growth. Observations on 12 morphological characters were recorded from five randomly selected plants of each genotype. SPAD (Statistical Package for Augmented Design) developed by ICAR-IASRI, New Delhi was used to calculate the adjusted mean value which was further used for data analysis. Comparison of checks and treatments was done using the CD values calculated by SPAD.

Wide variations were observed in the morphological traits like days to 50% flowering, plant height, number of tillers per plant, panicle length, spikelet fertility, yield per plant, grain length, flag leaf length, flag leaf width, days to maturity and grain yield. Descriptive statistics for various morphological traits are given in Table 1 & Fig 7. Based on grain yield and spikelet fertility SD- 32, SD-106, SD-124, SD-7 and SD-1 were found promising genotypes. RSR-SKY-56, SKB-4/37, IIABR-150, IIABR-434 and IIABR-76 were found promising for developing short duration varieties. Flag leaf width was found to be maximum (4.0 cm) in BL-10. This genotype may be used to develop stress-tolerant rice varieties.

Table 1: Descriptive statistics for various morphological traits

Trait	Minimum	Maximum	Mean	CV
Days to 50% flowering	68.0	105	87.1	3.8
Days to maturity	90.0	138.0	116.4	2.8
Plant height (cm)	44.0	195.0	106.6	5.2
Panicle length (cm)	11.0	39.0	22.2	9.3
Flag leaf length (cm)	11.0	67.5	32.0	14.6
Flag leaf width (cm)	0.5	4.0	1.3	9.7
Number of tillers	2.0	31.0	11.0	19.6
Number of spikelet/panicle	51.0	218.0	129.4	11.0
Number of chaffy grains per panicle	10.0	78.0	32.0	24.3
Total of number of spikelet	86.0	253.0	161.5	11.1
Spikelet fertility (%)	48.6	93.2	79.8	4.5
Grain yield per plant	4.0	27.0	12.5	14.4

Data recorded on each genotype were subjected to ANOVA. The results are indicated in Table 2. For the majority of characters, it was observed that the variance due to treatments, among controls, among tests, test-vs-control were significant at 0.1% significance level.

Table 2: Analysis of variance for morphological traits in rice genotypes

Source	Df	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Flag leaf length (cm)	Flag leaf width (cm)
Block (Adj.)	14	12.28*	8.61	28.59	3.08	15.25	0.01
Treatments (Adj.)	1008	852.56***	47.23***	588.18***	12.52***	54.58***	0.23***
Among-Controls	3	190.46***	212.82***	1665.04***	32.22***	405.34***	0.65***
Among-Tests	1004	855.06***	45.49***	574.97***	12.43***	53.32***	0.23***
Test-vs-Control	1	330.01***	1302.28***	10618.61***	49.27***	263.25***	0.22***
Error	42	10.93	10.90	30.47	4.31	21.77	0.02

Source	Df	Number of tillers	Number of spikelet/ panicle	Number of chaffy grains per panicle	Total of number of spikelets	Spikelet fertility (%)	Grain yield / Plant (g)
Block (Adj.)	14	7.70*	259.73*	16.53	292.70	6.55	1395.10*
Treatments (Adj.)	1008	19.53***	1037.66***	179.70***	1275.73***	36.91***	3.14***
Among-Controls	3	11.22***	1429.05***	232.86***	2517.72***	20.44***	30.76***
Among-Tests	1004	19.58***	1036.35***	179.29***	1270.25***	36.99***	1400.39***
Test-vs-Control	1	0.01	1187.01**	433.33**	3054.73***	5.09	171.92***
Error	42	4.66	203.98	60.75	321.37	13.10	3.22

The standard error of differences and critical differences were also calculated to find out whether the difference between two control treatments, two test treatments (same block), two test treatments (different block) or the difference between a test treatment and a control treatment are significant or not. The values are indicated in Table 3.

Table 3: Standard error of differences and critical differences for various treatments

Traits	Variable	Two control treatments	Two test treatments (same block)	Two test treatments (different blocks)	A test treatment and a control treatment
Days to 50% flowering	SEd	1.21	4.67	5.23	3.77
	CD	2.44	9.45	10.56	7.62
Days to maturity	SEd	1.21	4.67	5.22	3.76
	CD	2.44	9.44	10.55	7.61
Plant height (cm)	SEd	2.02	7.81	8.73	6.29
	CD	4.07	15.78	17.64	12.72
Panicle length (cm)	SEd	0.76	2.94	3.28	2.37
	CD	1.53	5.94	6.64	4.79
Flag leaf length (cm)	SEd	1.70	6.60	7.38	5.32
	CD	3.44	13.34	14.91	10.75
Flag leaf width (cm)	SEd	0.05	0.18	0.21	0.15
	CD	0.10	0.37	0.42	0.30
Number of tillers	SEd	0.79	3.05	3.41	2.46
	CD	1.59	6.17	6.90	4.97
Number of spikelet per panicle	SEd	5.22	20.20	22.58	16.28
	CD	10.54	40.82	45.64	32.91
Number of chaffy grains per panicle	SEd	2.85	11.02	12.32	8.89
	CD	5.75	22.28	24.91	17.96
Total of number of spikelets	SEd	6.55	25.35	28.34	20.44
	CD	13.23	51.24	57.28	41.31
Spikelet fertility (%)	SEd	1.32	5.12	5.72	4.13
	CD	2.67	10.34	11.56	8.34
Grain yield per plant (g)	SEd	0.65	2.54	2.84	2.05
	CD	1.32	5.13	5.73	4.13

Development of core collection and core set for pigmented rice

Data recorded on the entire set of germplasm indicated above was subjected to analysis using PowerCore Software. The analysis led to the development of a core collection of 98 genotypes. The development of the core collection will facilitate more extensive evaluation, easy access and maintenance and effective exploitation of the hidden genetic diversity among the genotypes in crossing programmes. The entire germplasm collection was also used to develop another core set of 67 germplasm accessions of pigmented rice. Finally, both the sets comprising of the total of 165 rice genotypes were subjected to the determination of their seed dimensions and kernel pigmentation.

Fig 6: Rice germplasm accessions growing at ICAR-NBPGR, Regional Station at Garhkhatanga, Ranchi

The paddy samples of the entire germplasm collection were dehulled using the Laboratory Huller. Seed dimensions including length, breadth and thickness were measured using a Digimatic micrometer. The weight of 1,000 dehulled rice samples was determined by manually counting and weighing 1,000 grains. The color intensity was measured in dehulled rice samples using a Hunter Lab colorimeter (Model A-60-1010-615 Colorimeter). The L*, a* and b* color space (also referred to as CIELAB) were used to express the difference in color between the sample and the standard. The L* shows whiteness or brightness/darkness, a* (redness/greenness) and b* (yellowness/blueness). The total color difference (TCD) was calculated from the CIE L*, a*, b* values from the following equation:

$$TCD = \sqrt{(L^*_0 - L^*)^2} + \sqrt{(a^*_0 - L^*)^2} + \sqrt{(b^*_0 - b^*)^2}$$

Where L^*_0, a^*_0, b^*_0 were values of the standards; L*, a*, b* were sample's values. All measurements were done in triplicate.

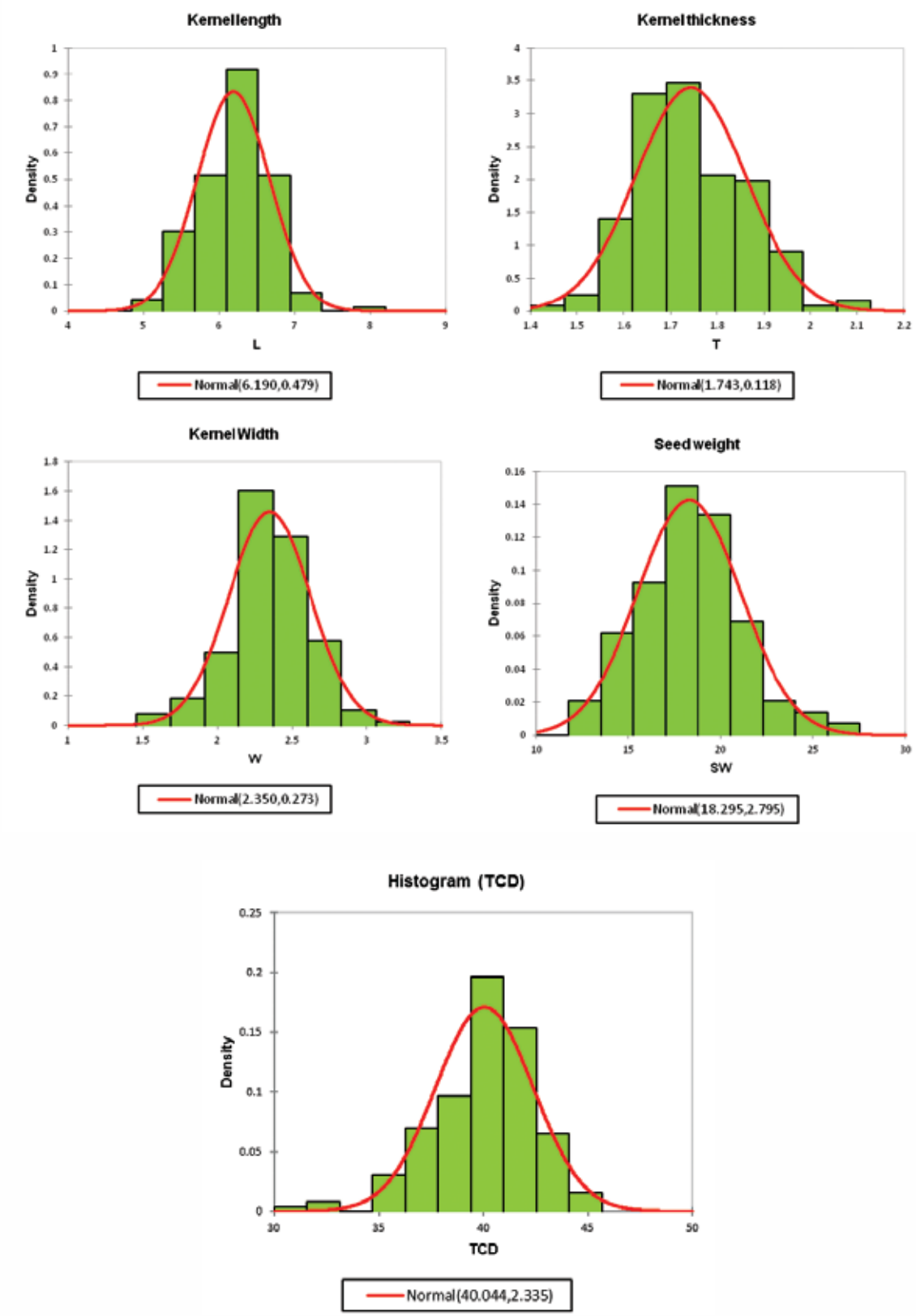


Fig 7: The range of variation for seed dimensions and seed color among 165 pigmented rice germplasm

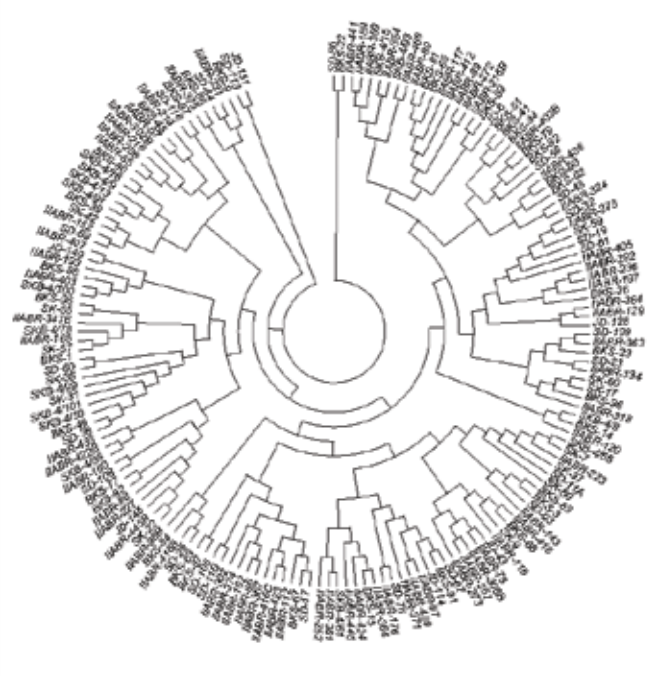


Fig 8: Phenogram of 165 pigmented rice germplasm accessions

A phenogram was developed using seed dimensions and kernel pigmentation (Fig 8). A total of three major clusters were formed. The clustering did not show any correlation with their geographical distribution.

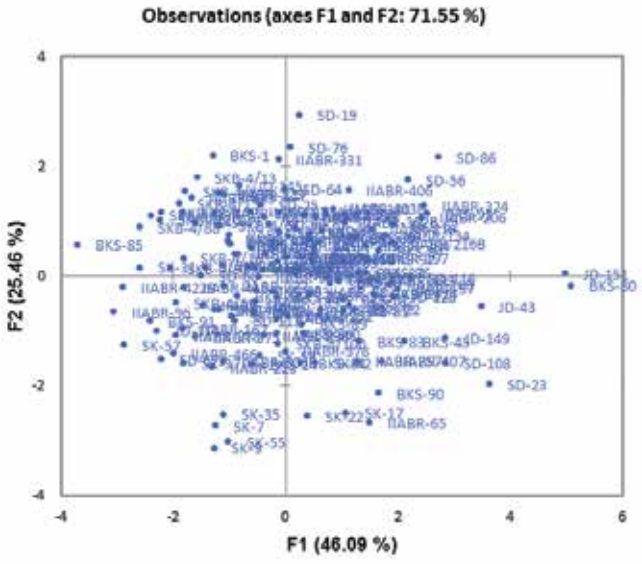


Fig 9: Principal Component Analysis (PCA) indicating the spatial distribution of the rice germplasm

Principal components analysis performed on seed dimensions and kernel pigmentation revealed that the first three most informative components accounted for 89.84% variance (Fig 9). It also presented the characters with greater weightings in each of the three principal component axes. Kernal width, kernel thickness and 1,000 seed weight were the important characters with greater weightings in principal component axis I, while kernel length was the important character with greater weighting in principal component axis II. The PCA, in general, confirmed the groupings obtained through cluster analysis.

Based on seed dimensions and kernel pigmentation, a subset of 38 rice germplasm accessions was drawn using random and non-random method of PowerCore Software. Moreover, 27 accessions with higher TCD values, but not included in the core were also included and thus a total of 65 genotypes were selected for downstream analysis (Fig 10).

Fig 10: Diversity in grain pigmentation in rice germplasm collected by ICAR-IIAB

IXX12951: Understanding host-pathogen interactions and identification of novel blast and false smut resistance gene(s) in rice

Rice blast is one of the most devastating diseases causing substantial yield losses in susceptible cultivars particularly in endemic areas like Jharkhand. The entire set of germplasm (1,015) available at ICAR-IIAB, Ranchi was screened under the natural epiphytotic conditions for

identification of potential rice blast resistance sources. The germplasm showed varied disease responses, suggesting the presence of diverse resistance genes/alleles in the collection. Also, two genotypes collected from Bihar showed broad-spectrum resistance against rice blast pathogen. Besides, these genotypes displayed a high level of resistance against false smut. Currently, these genotypes are being evaluated for resistance to blast under induced epiphytotic conditions. We are also genotyping these lines using previously reported blast-resistance-linked markers to analyze the status of the resistance genes. Together, the genotypes collected with broad-spectrum blast resistance represent the core material for isolation of previously unknown blast resistance genes and/or their allelic variants which we can deploy in rice breeding programs. These genotypes may also serve as resistance source for false smut. A more extensive evaluation of these genotypes is however required to confirm the claim. Resistant genotypes will be reconfirmed in next season and promising ones will be utilized for identification of resistant genes/QTLs by crossing them with contrasting genotypes. Even though observations on false smut was also recorded, due to insufficient inoculum pressure, the data were not considered for analysis. Moreover, standard protocols for false smut screening is yet to be standardized.

IXX13895: Molecular mapping of QTLs for early plant vigour, early maturity and harvest index traits in lentil

Mono-cropping and a low yield of paddy are attributing to low agricultural profitability in eastern India. Thus, the scope of cultivation of pulses, particularly lentil in the rice fallow areas of eastern India is very high. However, for successful cultivation of lentil in the region, there is a need to develop varieties with early vigour, high harvest index and short duration. Mapping of QTLs will be helpful in developing cultivars with these traits through MAS. Given this, a total of 235 lentil germplasm accessions were procured during 2017-18. Seeds of 193 accessions were procured from ICAR-NBPGR, New Delhi and rest was procured from ICAR-RC for NEH region, Meghalaya.

Wide variations for various agronomic traits (Fig 11) like days to 50% flowering, plant height (cm), pods per plant, seeds per pod, days to 80% maturity, 100 seed weight (g) and seed yield per plant (g) were

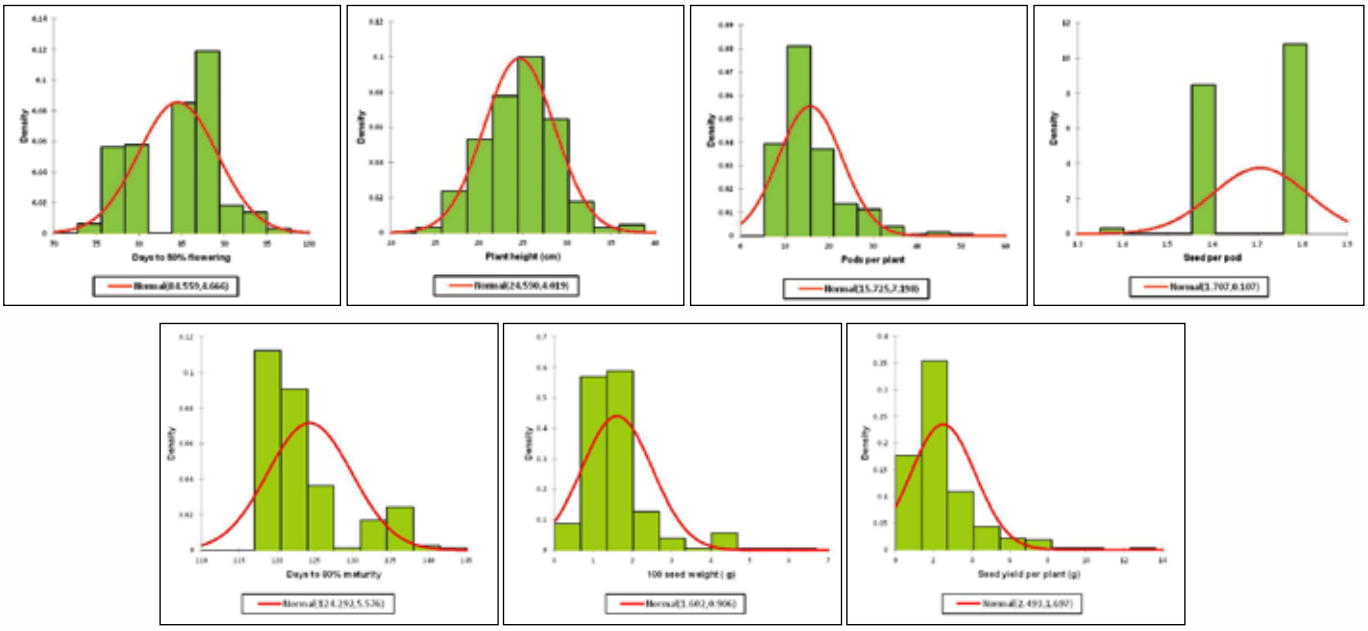


Fig 11: Distribution of agro-morphological characters in lentil germplasm

recorded among the lentil accessions. The accessions namely EC 225495, EC 267710, EC 267635 and IC 567315 were found promising for early-maturing trait. For high biomass with more number of pods, accessions IC 240990 and IC 240976 were found promising. Identified genotypes will be evaluated for one more season and the suitable genotype will be used in crossing programme for developing mapping population.

IXX13896: Ideotype breeding in horse gram for Jharkhand region

Horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.] commonly known as Kulthi or Madras gram is a hardy and drought-tolerant legume crop used as food and fodder in India. Owing to its drought-tolerant nature and ability to grow in problematic soils, there is an ample scope for its cultivation in Jharkhand. However, there is a need to breed varieties possessing traits like early vigor and short duration, for popularization and intensive farming of horse gram in the area. Assessment of variability for these traits in the available germplasm would be helpful in identifying suitable parents for initiating effective breeding programmes. A total of 252 horse gram germplasm accessions were therefore procured from ICAR-NBPGR, New Delhi. These germplasm accessions will be evaluated for different agro-morphological traits in the ensuing crop season. A set of 45 SSRs have also been identified from peer-reviewed publications and have been custom-synthesized for evaluation of genetic diversity in these germplasm accessions.

Biotechnological Interventions for Fish Health Management

XX12206: Identification and characterization of genes responsible for immune responses in *Labeo rohita* fingerlings

The role of prebiotics to boost non-specific defense mechanism, enhanced growth and disease resistance in fishes is well documented. Prebiotics activates the innate immune system by interacting with the pattern recognition receptors (PRRs) in the form of microbe-associated molecular patterns (MAMPs). Levan is an extensively used prebiotic in aquaculture to augment the growth performance and enhanced non-specific immune response. This project aimed to study the pro-inflammatory (*IL-1β*, *TNF-α* and *IL-12p40*) and anti-inflammatory (*IL-10*) cytokines in the intestine, gill, kidney and liver using Real-time PCR at different time intervals in a levan-fed *Aeromonas hydrophila* infected *Labeo rohita*.

Expression analysis of IL-1β

Significant upregulation in the expression of *IL-1β* in the intestine, gill and kidney cells was observed after the dietary feeding of levan in *Aeromonas hydrophila* infected rohu fingerlings. In the intestine, increase in the expression of *IL-1β* began after 3h and reached to the maximum of 1.6-fold at 24h (Fig 12a). A similar pattern was observed in the gill (Fig 12b). Though no significant increase in *IL-1β* expression in the kidney cells was noticed at the early stages, a constant increase was observed from 12 to 96h with the maximum of 2.13-fold (Fig 12c).

Expression analysis of TNF-α

A maximum of 1.6-fold increase was noticed in the expression of *TNF-α,* at 24h in the intestine (Fig 13a). In the kidney cells, significant upregulation was observed at early time points of 3, 6 and 12h (Fig 13c). In the liver cells, significant expression was observed at 6, 12, 24 and 96h post challenge with a minimum of 2.0-fold at 6h and 96h (Fig 13d).

Expression analysis of IL-12p40

The intestinal expression of *IL-12p40* exhibited a decreasing trend of fold change over time. A highest upregulation of 3.65-fold was observed as early as 3h followed by a decrease to 2.0 and

1.8-fold at 6 and 12h, respectively (Fig 14a). In the gill, the fold change in expression of *IL-12p40* was remarkably higher at all the time points tested except at 6h. However, at 12h the highest upregulation of 2.0-fold was noticed with the concomitant decrease after that (Fig 14b). A similar trend was observed with the kidney cells and the liver cells at all the time points tested (Fig 14c & 14d).

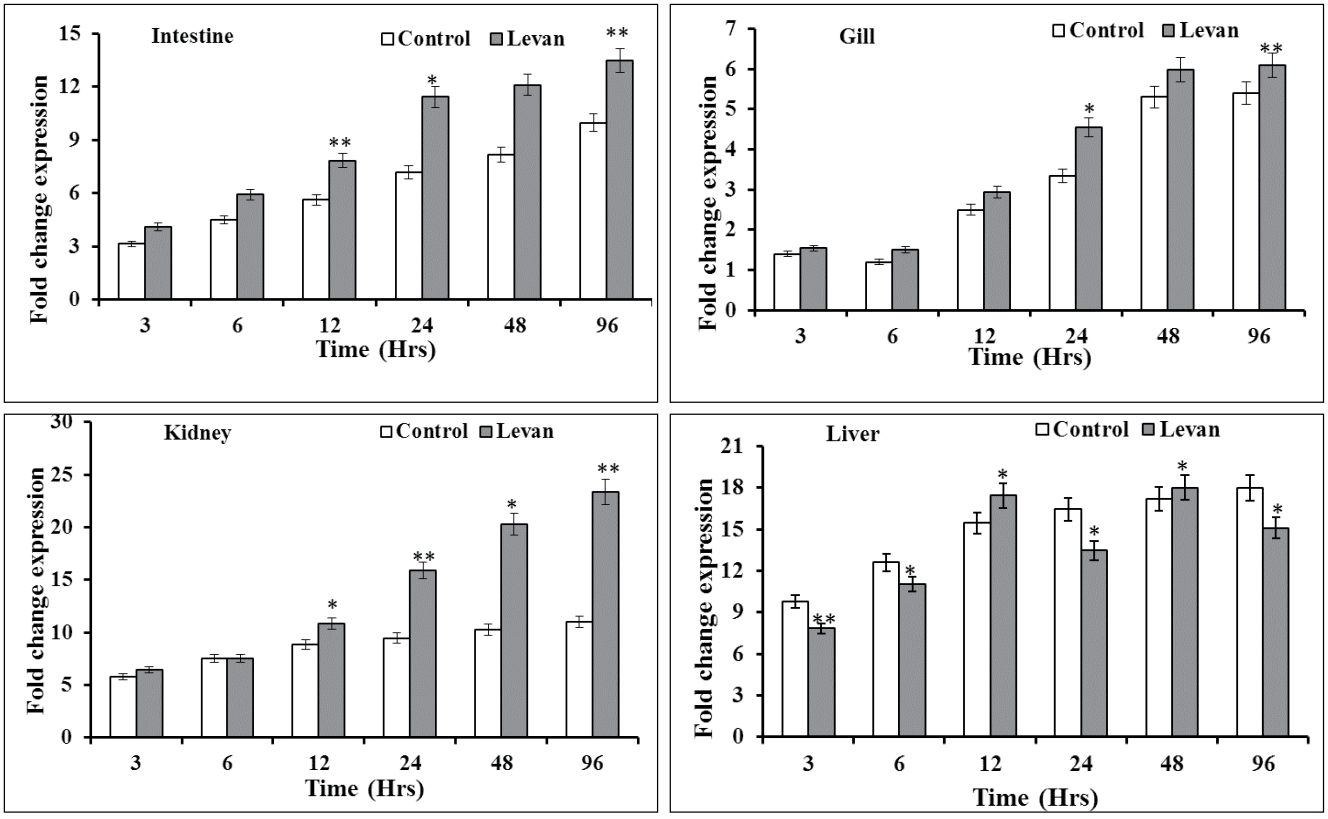
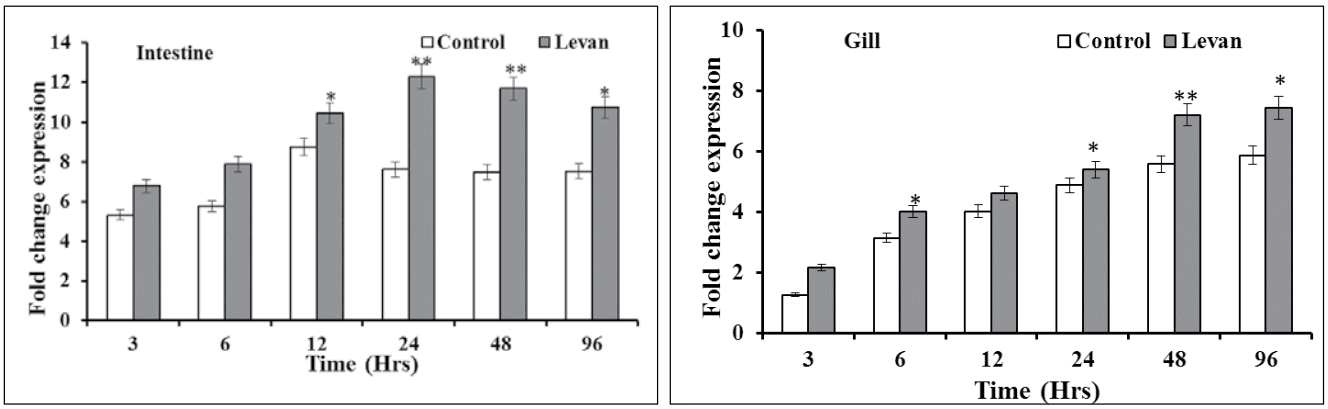


Fig 12: Expression of *IL-1β* mRNA in (a) intestine, (b) gill, (c) kidney and (d) liver relative to *β-actin* after 60d of feeding trial with microbial levan supplemented and levan non-supplemented (control) group at different time points *viz.*, 3h, 6h, 12h, 24h, 48h and 96h post challenge with *Aeromonas hydrophila* in *Labeo rohita* fingerlings. Bars represent mean ± SE of three samples. Statistically significant upregulation and downregulation in the expression of mRNA relative to the levan non-supplemented control group. P value as < 0.05 (denoted as *), P value < 0.001 (denoted as **) and P-value < 0.0001 (denoted as ***)



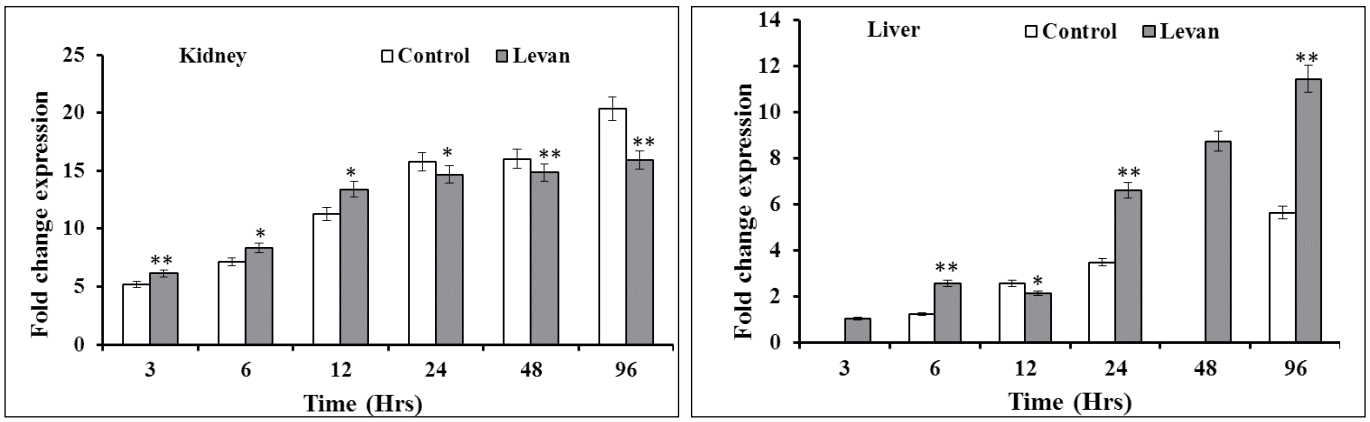


Fig 13: Expression of *TNF-α* m-RNA in (a) intestine, (b) gill, (c) kidney and (d) liver relative to *β-actin* after 60d of feeding trial with microbial levan supplemented and levan non-supplemented (control) group at different time points *viz*., 3h, 6h, 12h, 24h, 48h and 96h post challenge with *Aeromonas hydrophila* in *Labeo rohita* fingerlings. Bars represent the mean ± SE of three samples. Statistically significant upregulation and downregulation in the expression of mRNA relative to the levan non-supplemented control group. P value as < 0.05 (denoted as *), P value < 0.001 (denoted as **) and P-value < 0.0001 (denoted as ***). ND refers to Not detectable.

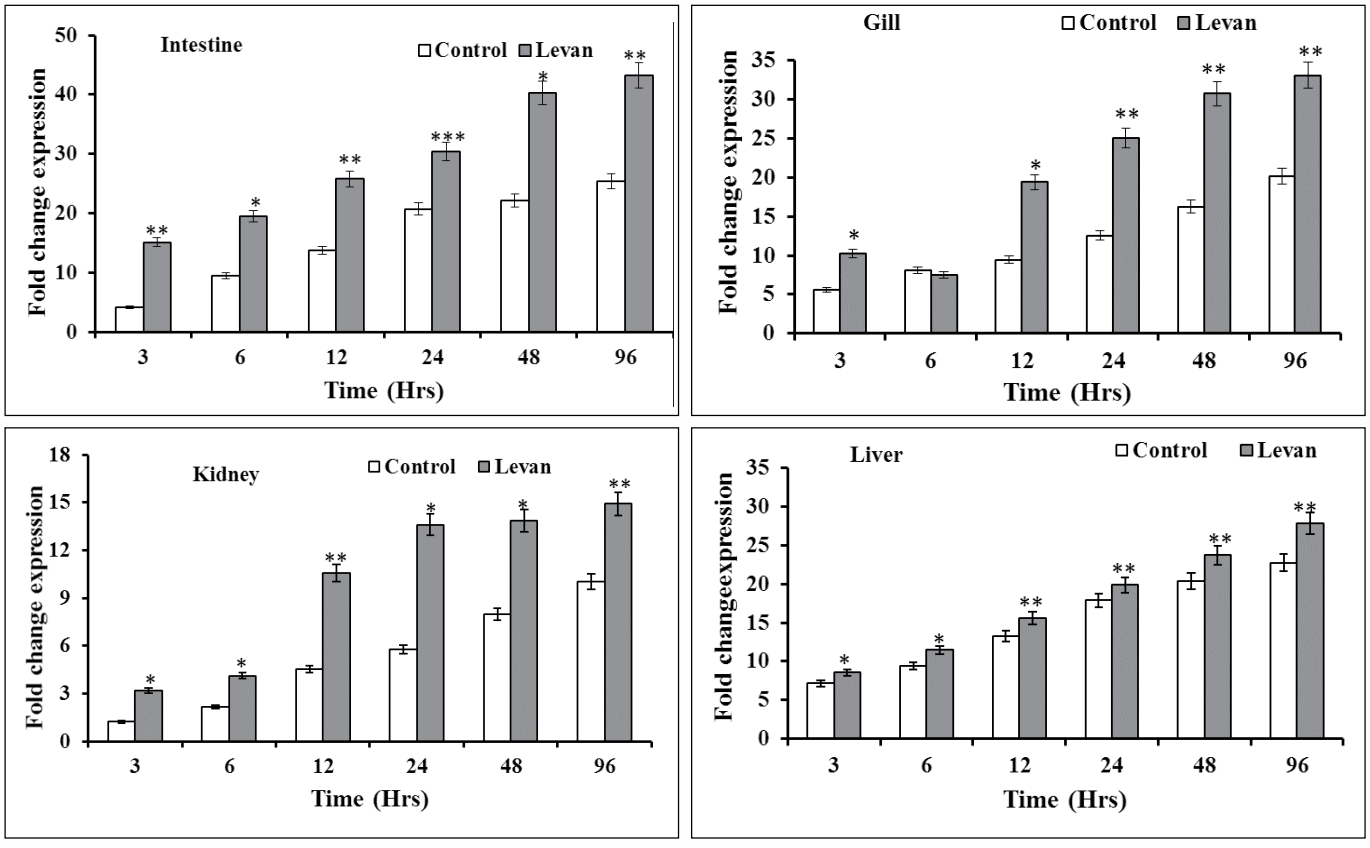


Fig 14: Expression of *IL-12p40* m-RNA in (a) intestine, (b) gill, (c) kidney and (d) liver relative to *β-actin* after 60d of feeding trial with microbial levan supplemented and levan non-supplemented (control) group at different time points *viz*., 3h, 6h, 12h, 24h, 48h and 96h post challenge with *Aeromonas hydrophila* in *Labeo rohita* fingerlings. Bars represent of mean ± SE of three samples. Statistically significant upregulation and downregulation in the expression of mRNA relative to the levan non-supplemented control group. P value as < 0.05 (denoted as *), P value < 0.001 (denoted as **) and P-value < 0.0001 (denoted as ***).

Nanoselenium grafting for improving the prebiotic efficiency of levan

A solution-phase approach was employed to synthesize the selenium nanoparticles. The process involved the reduction of sodium selenite solution with ascorbic acid, at room temperature. By this process, selenium nanoparticles with a size range of about ~ 20-30 nm with a polydispersity index of 0.89 were synthesized (Fig 15A). The dynamic light scattering technique and scanning electron microscopy were employed to determine the size of the selenium nanoparticles. Grafting of selenium nanoparticles to levan was achieved by mixing and ultra-sonication of selenium nanoparticles with levan. Successful grafting of selenium to the levan matrix was confirmed by analyzing the variation in the – OH region of the freeze-dried precipitate obtained after ultra-sonication (Fig 15B).

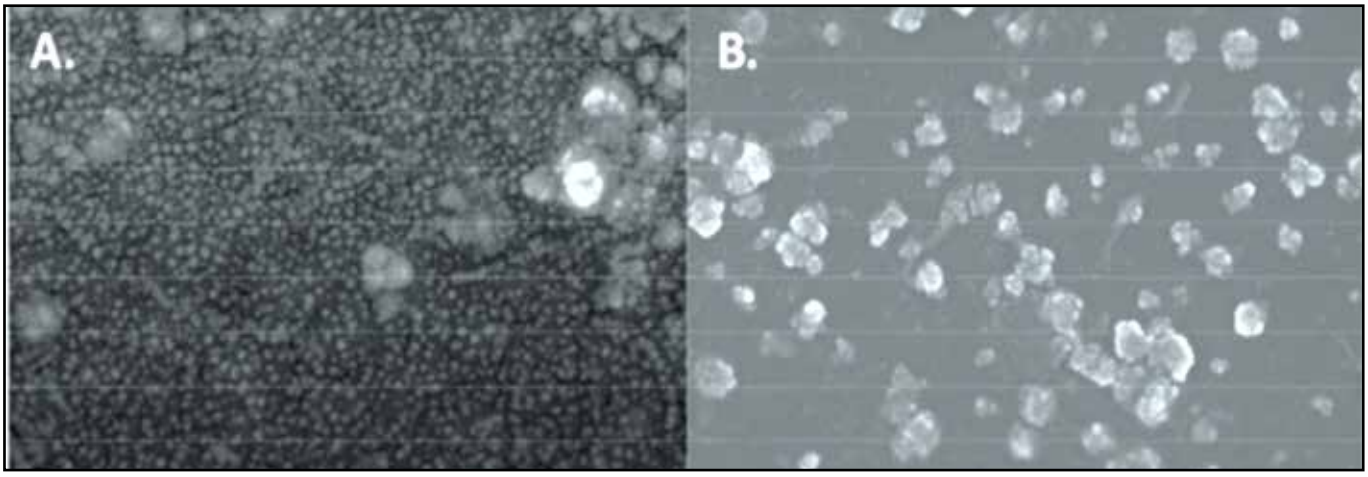


Fig 15: (A) Synthesis of selenium nanoparticles, (B) Grafting of selenium nanoparticles to levan matrix

IXX12919: Development and evaluation of the efficacy of novel nanoparticles for enhancing yield in rice and Indian major carp

Green synthesis of iron oxide nanoparticles

Green synthesis of iron oxide nanoparticles involved the mixing of two gram of Tetley green tea with 100 ml of de-ionized water, followed by incubation at 80°C in a water bath. Further, 0.01 M ferric chloride solution was added to the green tea extract in equal proportion. Immediately, the colour of the solution turned black indicating the formation of iron oxide nanoparticles, which were separated by centrifugation. The iron oxide nanoparticles were characterized by Fourier-Transform Infrared Spectroscopy (FTIR) and Particle Size Analyzer (Fig 16, 17 & 18).

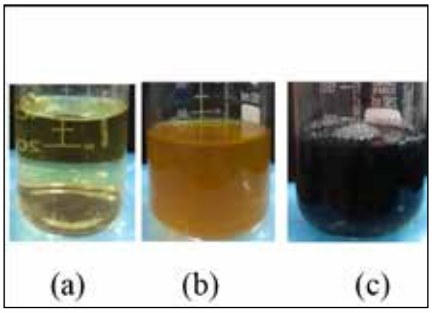


Fig 16: (a) 0.01M ferric chloride soln. (b) Green tea leaves extract (c) Synthesized iron oxide nanoparticles

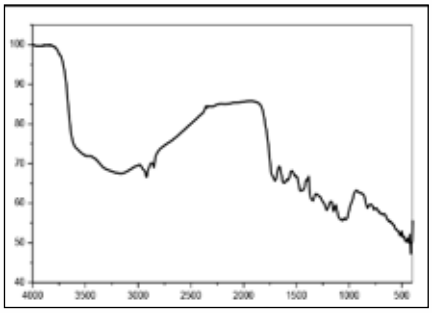


Fig 17: FT-IR spectra of iron oxide nanoparticles

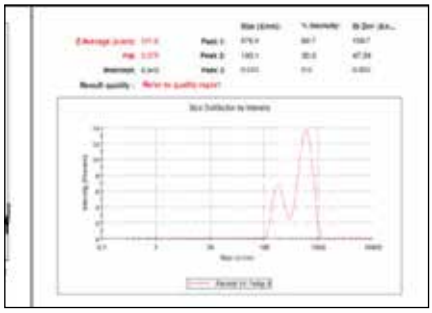


Fig 18: Particle size analysis of iron oxide nanoparticles

Green synthesis of gold nanoparticles

Green synthesis of gold nanoparticles involved the mixing and homogenization of two gram of fish gill tissue with 18 ml of 0.25M sucrose solution. Further, 1mM gold chloride solution was added to the gill tissue extract in 1:2 ratio. The mixture was stirred on a magnetic stirrer for two hours and incubated overnight at room temperature. The gold nanoparticles synthesized by the process were characterized by UV-Visible Spectroscopy and Particle Size Analyzer (Fig 19, 20 & 21).

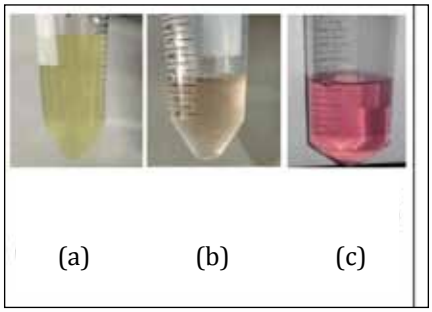


Fig 19: (a) Fish gill extract
(b) Gold chloride solution
(c) Synthesized gold nanoparticle

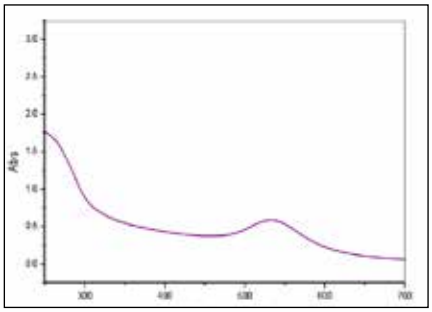


Fig 20: UV-Vis spectra of synthesized gold nanoparticle

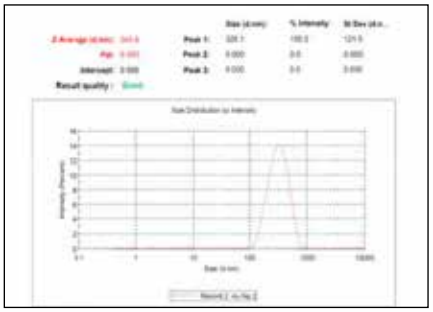


Fig 21: Particle size analysis of gold nanoparticle

Computer vision algorithm based analysis of photocatalytic dye degradation by zinc oxide nanoparticles

The photocatalytic activity of the zinc oxide nanoparticles was tested by degradation of methylene blue solution. The methylene blue solutions were exposed to two different concentrations (0.1 and 0.05gm/40ml dye solution) of zinc oxide nanoparticles. Colour normalization and Circular Hough Transform algorithms were used to segment the dye region in the sample images. The degradation of methylene blue dye was analyzed through UV-Visible spectroscopy (Fig 22 & 23). The observations indicated the possibility of using imaging techniques for evaluating the photocatalytic behavior of different nanoparticles in various dye models.

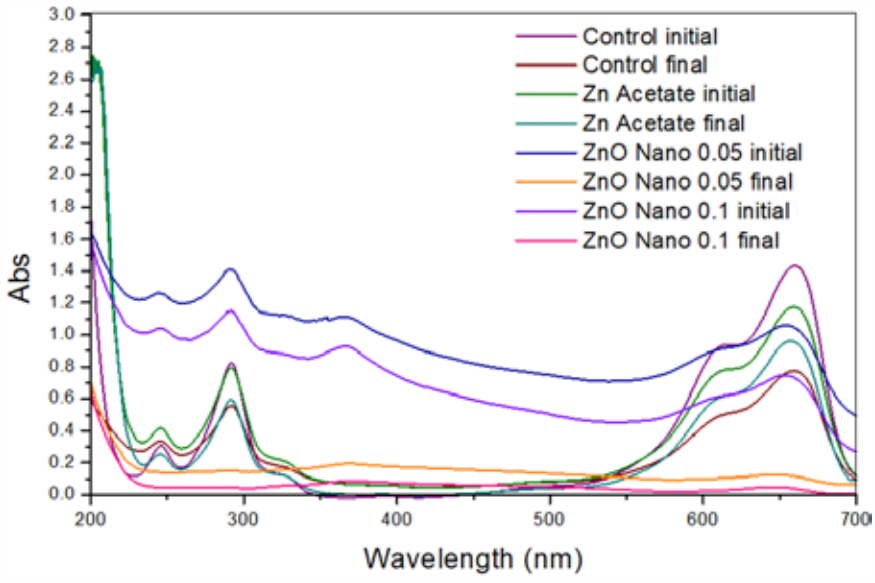


Fig 22: UV-Vis spectra showing the degradation of methylene blue dye at an initial and final levels of experiment

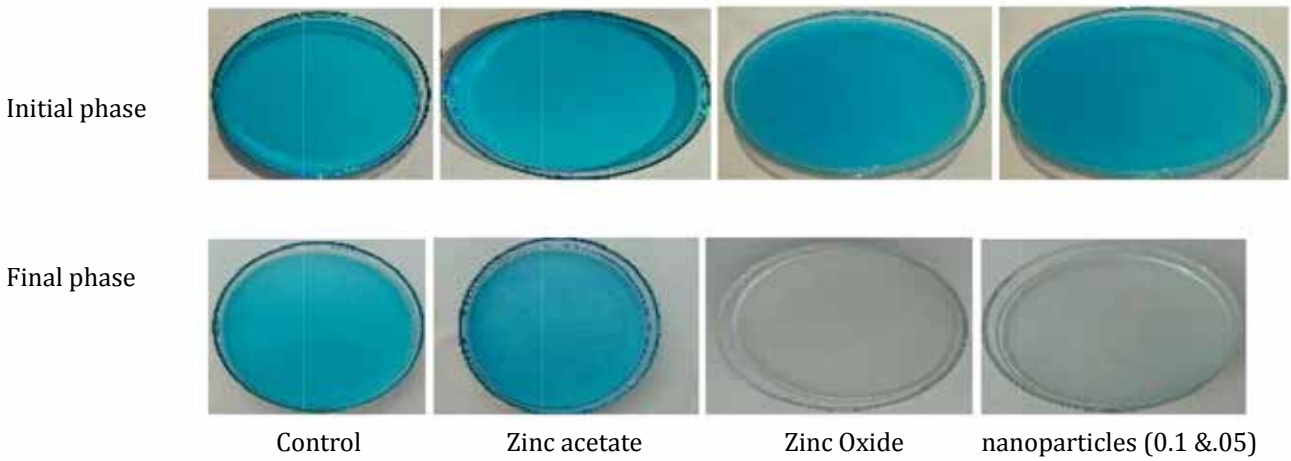


Fig 23: Samples at the initial and final level of the experiment

Inhibitory effect of copper nanoparticles against fungal pathogens

Assessment of the effect of copper nanoparticles on the growth of *Ustilaginoidea virens*

Poisoned Food Technique was used to assess the effect of copper nanoparticles against the fungal pathogen *Ustilaginoidea virens*. For the assay, Potato Dextrose Agar (PDA) media amended with copper nanoparticles in various concentrations (25, 50, 100 and 200 ppm) were used. PDA media without copper nanoparticles was used as a control. *Ustilaginoidea virens* mycelial disc of 8 mm diameter was inoculated aseptically on the PDA plates in triplicate and incubated at 27°C for 14 days. The observations were recorded at 7d intervals. The percent of inhibition by copper nanoparticles was calculated using Vincent's formula. From the experiment, it was concluded that copper nanoparticles at the concentration of 200 ppm significantly inhibits the growth of *Ustilaginoidea virens* (Fig 24).

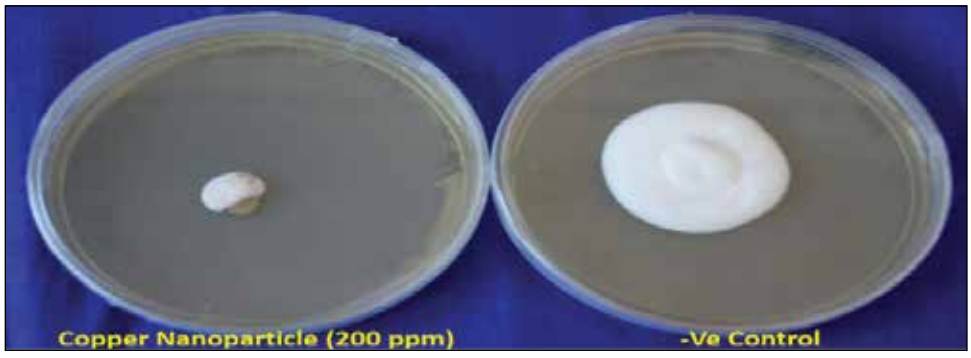


Fig 24: Effect of copper nanoparticles on mycelial growth of *Ustilaginoidea virens*

Effect of copper nanoparticles on the growth of *Alternaria tenuissima* and *Erysiphe cichoracearum*

The effect of copper nanoparticles on the growth of *Alternaria tenuissima* causing leaf spot and fruit rot in *Capsicum* and *Erysiphe cichoracearum* causing powdery mildew in Balsam was assayed *in vitro* using three different test concentrations (1000, 2000 and 3000 µg/ml). The results indicated that the copper nanoparticles at 2000 µg/ml and 3000 µg/ml concentrations completely inhibit the spore germination in both the fungi (Table 4).

Table 4: Antifungal efficacy of copper nanoparticle against *Alternaria tenuissima* and *Erysiphe cichoracearum*

Tested Fungi	Host	Spore germination (%)			
		Concentration (µg/ml) of copper nanoparticles			
		Control	1000	2000	3000
Alternaria tenuissima	*Capsicum annum*	93	15.33	0	0
Erysiphe cichoracearum	*Impatiens balsamina*	42.67	16.33	0	0

Exploration and characterization of the bio-imaging property of zinc oxide nanoparticles conjugated with lac dye

Zinc oxide (ZnO) nanoparticles possess mild auto-fluorescence property. However, to use ZnO nanoparticles as a bio-imaging material, an additional dye/coloring agent is required to enhance its fluorescence property to an optimum range. To assess the feasibility of using lac dye for improving the bio-imaging property of ZnO nanoparticles, aqueous solution of lac dye was added to the dispersion of ZnO nanoparticles with continuous stirring. The lac dye-ZnO nanoparticle mixture was then ultra-sonicated. Consequently, the color of the lac dye changed from orange-red to deep purple. The UV-Vis spectra of ZnO-lac dye complex showed the absorption maxima at 354 nm. The spectrofluorimeter results revealed that the fluorescence intensity of ZnO-lac dye complex was higher than the fluorescence of ZnO nanoparticle or lac dye alone. The results indicated that the lac dye-ZnO nanoparticle complex could find the application in biosensing and cellular imaging (Fig 25 & 26).

Fig 25: The change in color of lac dye-ZnO nanoparticle complex

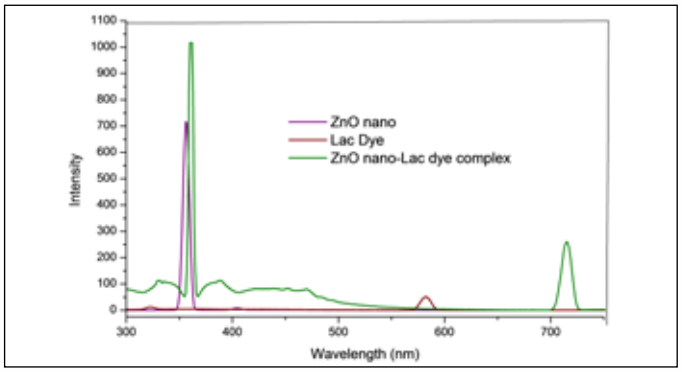


Fig 26: Spectro-fluorometric study of ZnO nanoparticles, lac dye and lac dye-ZnO nanoparticle complex

*Evaluation of the effect of biologically synthesized selenium nanoparticles on TNF-α expression in rohu (*Labeo rohita*) under heavy metal stress condition*

Synthesis of selenium nanoparticles was achieved by mixing sodium selenite pentahydrate solution (Fig 27 A1) with aqueous extract of goat intestinal tissue (Fig 27 A2). After overnight incubation at room temperature, the color of the solution changed to brick red confirming the formation of selenium nanoparticles (Fig 27 A3). The dynamic light scattering study revealed that the size distribution of selenium nanoparticles ranges from 10 to 600 nm (Fig 27 B). The Transmission Electron Microscopy (TEM) further revealed the details of the morphology and size of the selenium

nanoparticles(Fig 27 C). Cytokine expression study was performed using *TNF-α* as a candidate gene to understand the effect of selenium nanoparticles on rohu (*Labeo rohita*) exposed to lead stress. Selenium nanoparticles enriched feed (0.5 mg/kg, 1.0 mg/kg and 1.5 mg/kg) were administered to the fish exposed to lead nitrate stress for 28 days. The level of expression of *TNF-α* in fish gill tissue was determined using the comparative threshold cycle method ($2^{-\Delta\Delta C_T}$) with *β-actin* as control (Fig 28). The results indicated that the selenium nanoparticles enriched feed has the potential to decrease and stabilize the expression of *TNF-α* in gill tissue of rohu exposed to heavy metal like lead.

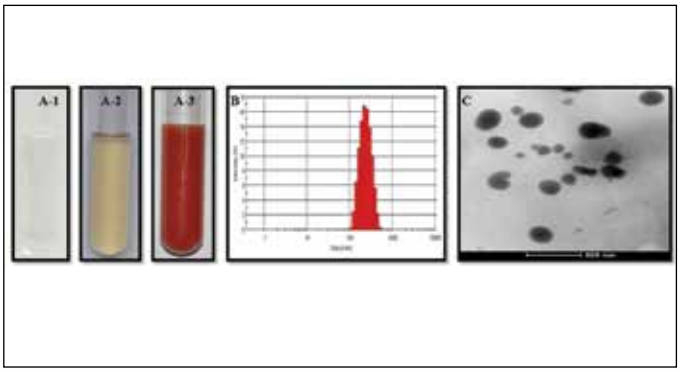


Fig 27: Sodium selenite solution (A-1); Goat Intestine extract (A-2); Synthesized nanoselenium (A-3); DLS analysis (B); TEM micrograph(C)

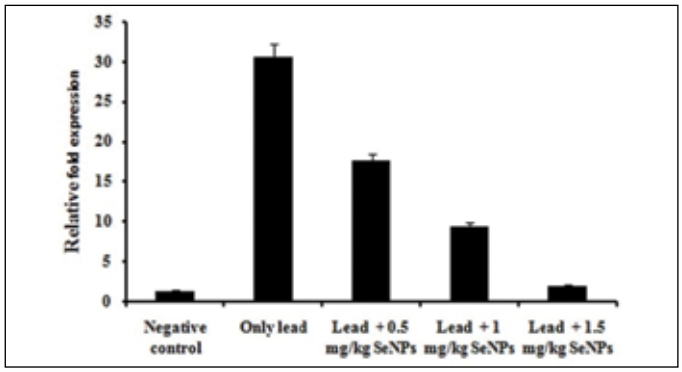


Fig 28: Pro-inflammatory (*TNF-α*) gene expression in gill of rohu (*Labeo rohita*) under dietary delivery of nanoselenium at lead stress condition

Externally-Funded Projects

Screening of various Lentil (*Lens culinaris* L.) genotypes for drought tolerance using physiological and molecular approaches

Lentil (*Lens culinaris*) is a staple pulse crop in northern India. However, the yield of lentil in this region is adversely affected by abiotic factors like heat and drought. Hence, the screening of lentil germplasm for the identification of drought-tolerant genotypes would be crucial for developing drought-tolerant lentil cultivars. During 2017-18, twenty-six genotypes of lentil were screened for drought tolerance under pot conditions. The seeds of these genotypes were germinated in the greenhouse and exposed to PEG 6000 (18%) for 15 days. Eight genotypes (GP3690, LL1136, GP3643, IC248956, KLS218, PL230, NDL908 and L4076) were selected on the basis of their growth performance, and their response to drought stress was assessed through physiological (stomatal density and relative water content) and biochemical (chlorophyll, proline, anthocyanin and total soluble sugar content) analysis (Fig 29 & 30).

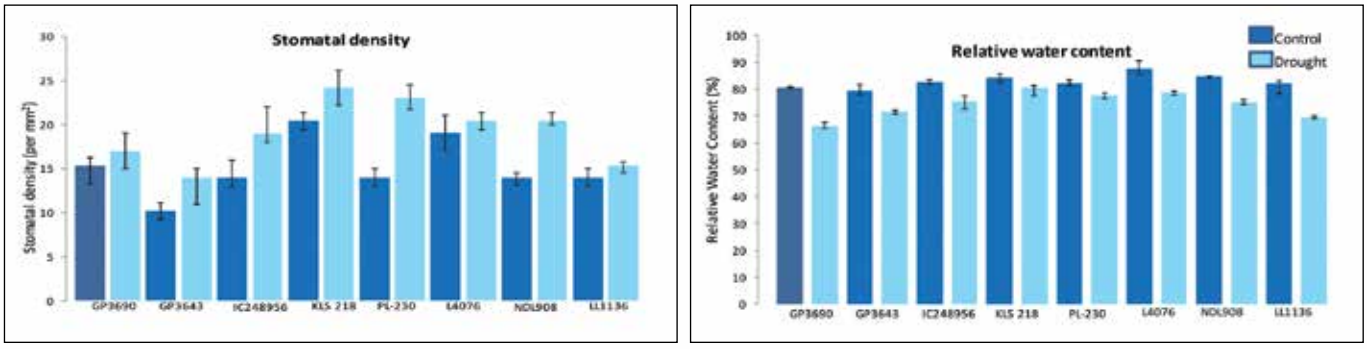


Fig 29: Physiological parameters observed after 15 d of drought stress in various lentil genotypes.

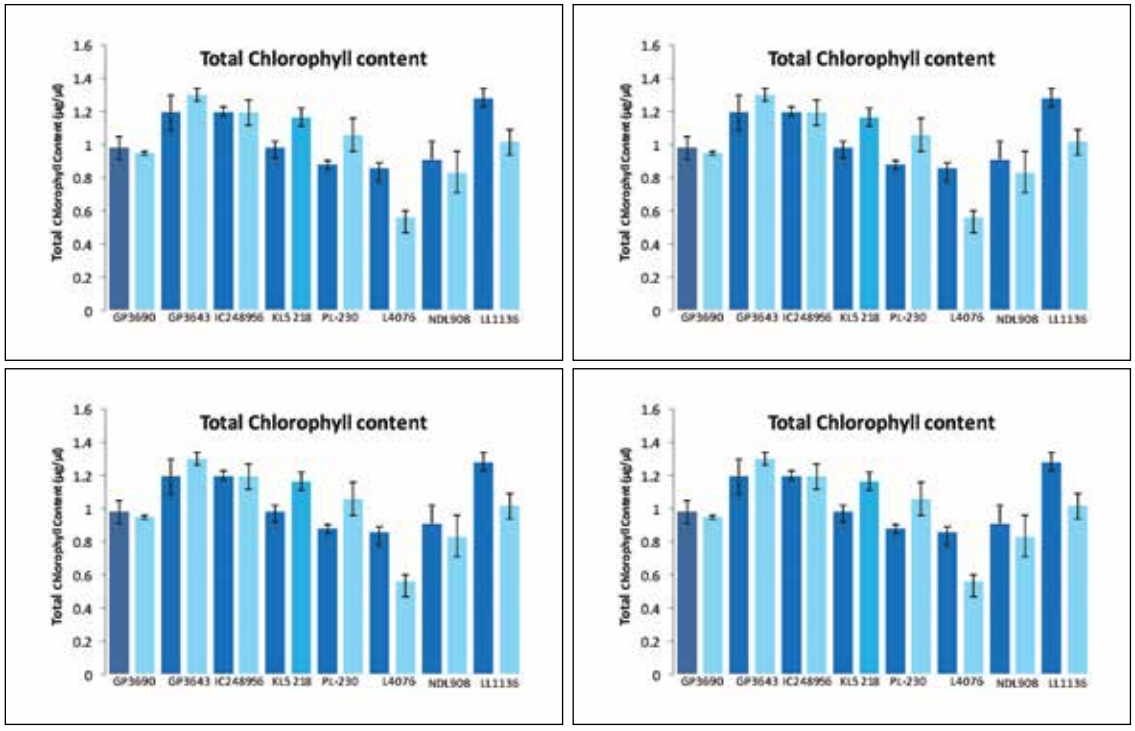


Fig 30: Biochemical parameters observed after 15 d of drought stress in various lentil genotypes.

Five out of eight genotypes (GP3690, LL1136, GP3643, IC248956 and KLS218) exhibited significant differences when compared to the control. To determine the drought-tolerance efficiency, the relative expression analysis of drought marker genes (*DREBs* and *RDs*) was performed on these genotypes using qRT-PCR (Fig 31).

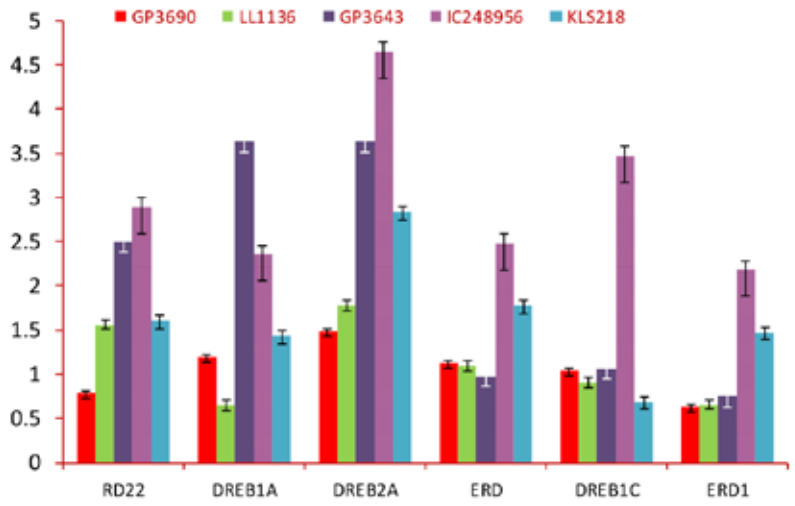


Fig 31: Relative fold change of drought stress marker genes (*RD22*, *DREB1A*, *DREB2A*, *ERD*, *DREB1C* and *ERd1*) on five lentil genotypes after 15 d drought with respect to their control counterparts

Compared to the control, the genotype GP3690 exhibited insignificant expression of the drought marker genes, whereas, the expression of these genes was significantly higher in IC248956 (Fig 31). Moreover, the expression profile of drought marker genes showed a correlation with the phenotypic response of the selected genotypes (Fig 32). When compared to GP3690, the seedlings of IC248956 were observed to be taller and the roots were more developed indicating that IC248956 is a relatively drought-tolerant genotype.

IC248956 GP3690 IC248956 GP3690

Fig 32: Contrasting genotypes IC248956 and GP3690 after 15 days of drought stress.

Characterization of molecular marker(s) associated with X- and/or Y-chromosome bearing spermatozoa in cattle

Sperm sexing offers a favorable breeding strategy which may help meet increased requirement of food production. Moreover, the predetermination of sex, more in favor of profitably milk producing female calves, is essential in consideration of current mechanized agriculture, to reduce the number of stray cattle and to avoid destruction and slaughter of undesired male calves as per the norms of Govt. of India. Majority of the methods used for sperm sexing suffer from lower accuracy, poor repeatability and render low fertility.

The currently available method that is in commercial use is flow-cytometry, which is quantitative and based on measurement of DNA content of individual sperm (approx. 4% more DNA noted in the X-chromosome bearing sperm than that of the Y-chromosome bearing sperm). The commercially viable United States-based patented process of sperm sexing is reported to be 80–90% accurate, but complicated, expensive, having a low sorting rate and accumulates mutagenic effects. Hence, research on the development of the indigenous and innovative technology that increases the frequency and purity of sperm sorting without affecting its viability is crucial.

To date, there is a lack of comprehensive understanding of the cell-surface proteins that may help in sex-sorting of sperm. To provide better insight into the differential proteomics of X and Y chromosome-bearing spermatozoa of cattle. Total protein extraction was carried out from unsorted semen, sourced from BAIF, Pune. Frozen-thawed spermatozoa were washed with phosphate buffered saline (PBS) and the total proteins were extracted using Triton X-100 with protease inhibitor cocktail, which allowed the extraction of proteins from the plasma membrane, the cytosolic fraction and the acrosomal and mitochondrial matrices, as well as from the remaining cytoplasmic droplet. The proteins present in the supernatant were quantified, precipitated with ice-cold acetone, pelleted by centrifugation and re-suspended in sample buffer and one-dimensional electrophoresis of the proteins was carried out.

Further, membrane protein extraction was also carried out on unsorted semen. Sperm cells were washed in PBS and homogenized in the buffer containing Sucrose, Tris and Magnesium Chloride along with a protease inhibitor cocktail. The plasma membrane fraction was collected from the post-nuclear supernatant using Percoll gradient in Sucrose Tris buffer with protease inhibitor cocktail and high-speed centrifugation. Membrane proteins were extracted by suspending the plasma membrane fraction in PBS containing Triton x-100 with protease inhibitor cocktail and centrifuged after that at high speed. The proteins present in the supernatant were quantified, precipitated with ice-cold acetone, pelleted by centrifugation and re-suspended in sample buffer and one-dimensional electrophoresis of the proteins was carried out.

The extracted total soluble proteins and membrane-associated proteins from unsorted bovine sperm cells were studied by the electrophoretic profiling. SDS-PAGE of total soluble proteins (Fig 33) indicated the presence of protein bands with broad range of molecular weight (6.5 kb–200 kb) while only few protein bands of high molecular weight (45 kb–200 kb) were noted in the gel of membrane proteins (Fig 34) of bovine sperm. The solubility of membrane proteins was very less which limited their compatibility with direct SDS-PAGE.

Hence, the solubilized protein samples were analyzed using in-solution digestion and LC-MS/MS. Trypsin in-solution digestion of the membrane protein samples of unsorted bovine sperm was carried out and prepared for nano-LC-MS/MS. MS data have been analyzed to identify the membrane proteins of the unsorted bovine sperm (data not shown).

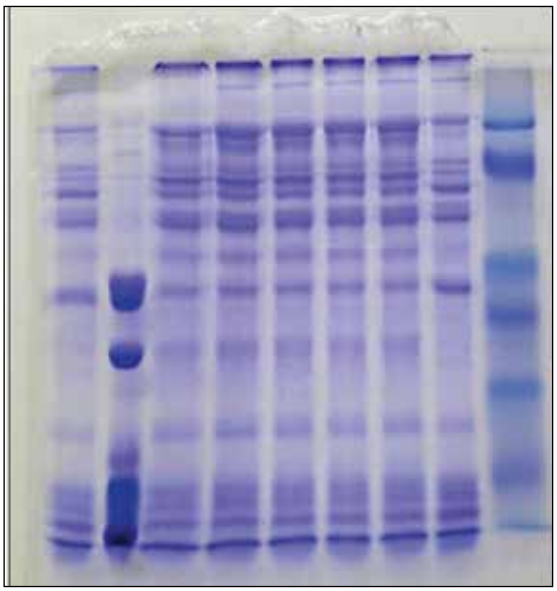


Fig 33: Electrophoretic profile of total soluble proteins of bovine sperm

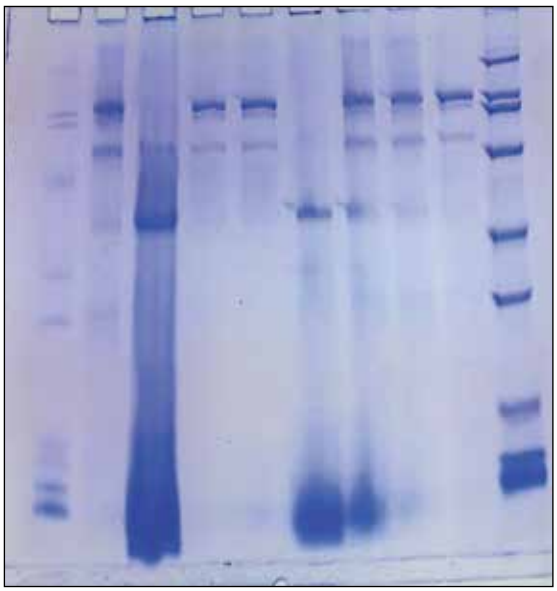


Fig 34: Electrophoretic profile of membrane proteins of bovine sperm

To summarize, a novel method was developed for the extraction and identification of proteins from purified plasma membranes of bovine sperm cells. Further, these experiments shall be carried out in sorted bovine semen to understand the differential proteomics of X and Y chromosome-bearing spermatozoa. The study would furnish data that might help in the development of indigenous technology for sex-sorting of semen, a high priority for the livestock sector of the country.

Enhancing food, nutritional and livelihood security of marginal and small farmers in Jharkhand through need-based agricultural technologies

The project sanctioned on Jan 30, 2017, has been implemented by ICAR-IIAB as a lead center and ICAR-RCER, RC, ICAR-IINRG and BAU at Ranchi as cooperating centers. The project has been implemented in Kutiyatu, Malti, Pindarkom and Tetri villages, under Kutiyatu Panchayat of Namkum block of Ranchi.

During 2017-18, eleven technical interventions, namely paddy (IR64-*drt-1* and Sahbhagi), maize (HQPM5) and gram (Pusa 0547) under crop-based module; papaya (Pusa Dwarf), banana (Grand Nain) and Integrated Pest Management (IPM) in brinjal (Swarna Shyamali) and tomato (Swarna Lalima) cultivation under horticulture-based module; upgraded mixed carp culture under livestock and fish-based module; vegetable seed production, namely french bean (HAFB-2) and field pea (Arkel), oyster mushroom production and lac cultivation under enterprise-based module; and integrated farming system module were implemented, involving a total of 223 farmers. Performance of technical interventions namely paddy, gram, IPM in brinjal and tomato, carp culture, vegetable seed production and oyster mushroom production, was very impressive. Notably, the yield of rice increased by a quarter and there was an increase of harvest by 40 percent in upgraded mixed carp culture, giving a good profit to the farmers.

Two hands-on training programme on mushroom production and improved lac production and processing technologies were organized for skill development of 25 farmers. Three exposure visits to ICAR institutes and state line departments including kisan mela and one farmers-scientist interphase through the involvement of multi-stakeholders were organized that witnessed enthusiastic participation of more than 350 farmers. The project helped in building partnership and establishment of strong institutional linkages (Fig 35).

Institute Advisory Committee Meeting

Site Plan Implementation Group Meeting

Harvest of paddy
(IR64 *drt-1*and Sahbhagi)

Introduction of Quality Protein Maize hybrids (HQPM-5)

Assessment of high yielding, wilt-resistant and drought tolerant variety of Gram (Pusa 0547)

Scientific cultivation of Grand Nain variety of Banana

IPM in brinjal and tomato cultivation

Vegetable Seed Production
(french bean HAFB-2)

Vegetable seed production (Field Pea Arkel)

Oyster mushroom production

Kusumi lac cultivation on kusum and ber

Integrated farming (Horticulture + olericulture + fishery)

Reproductive management of dairy animals at farmer's herd

Upgraded Mixed Carp Culture

Exposure visit of farmers to Kisan Mela-cum-Agricultural Machinery Exhibition

Exposure visit of farmers to Fish Farmer Training Centre, Shalimar, Ranchi

Hands-on training on mushroom production

Hands-on training on lac production and processing technologies

Farmers-Scientist Interphase

Sh. Raghubar Das, Hon'ble Chief Minister of Jharkhand, visiting FFP Exhibition Stall in Kisan Mela

Fig 35: Glimpses of technical interventions, training programmes and other outreach activities under FFP

Tribal Sub-Plan

During 2017-18, activities under Tribal Sub-Plan (TSP) was undertaken at Kharsidag, Kochbang, Lalkhatanga and Tetri villages under Namkum block of Ranchi. Different technical interventions, namely rice (IR64 *drt-1*, Sahbhagi, Ciherang, Sukha Dhan, DRR Dhan 44 and CD Sugandha Dhan), maize (HQPM-5), wheat (VL 0892 and VL 0738), banana (Grand Nain), brinjal (Swarna Shyamali), water melon (Arka Manik), bottle gourd (Swarna Sneha), bitter gourd (Swarna Yamini), gram (Pusa 0547), upgraded mixed carp culture (improved Rohu, Catla, Mrigal etc.) with other required inputs, vegetable seed production (french bean HAFB-2), oyster mushroom and Kusumi lac cultivation on kusum and ber, were implemented under demonstration programme(s) in tribal farmers' fields along with impart of technical know-how of the respective intervention(s). An encouraging response was obtained and the majority of the interventions were successful. Farmers were particularly happy with rice, brinjal, gram, upgraded mixed carp culture, vegetable seed production and oyster mushroom production because of increased yield and better quality of the produce.

Also, two hands-on training programme on mushroom production and lac cultivation and one exposure visit to Fish Farmer Training Centre, Shalimar were organized for skill development of farmers.

A total of 70 tribal farm families were benefitted under Tribal Sub-Plan (Fig 36).

Paddy seed distribution

Rice (IR64 *drt-1*) in stakeholder's field

Distribution of maize seed

Distribution of wheat seed

Distribution of fish fingerlings

Distribution of fish feed

Hands-on training on lac cultivation

Hands-on training on mushroom production

Exposure visit to Fish Farmer Training Centre, Shalimar, Ranchi

Fig 36: Glimpses of technical interventions and training programmes under TSP

Inter-Institutional Collaborations

Development of genome/transcriptome-based resources

Morphological characterization of a germplasm collection of *Artocarpus heterophyllus* (Jackfruit)

Jack (*Artocarpus heterophyllus* Lam.) is the economically most important and widespread tree of the genus *Artocarpus* belonging to the family Moraceae. It is native to the rainforests of Malaysia and the Western Ghats of India. Jack is often referred to as a wonder tree as every part of the tree are used for different purposes. Fruit, however, is the primary economic part. Jackfruit provides huge opportunity for livelihood as well as nutritional and food security of the rural communities of India. Eastern India has a tremendous diversity in the jack germplasm. This diversity is by and large undocumented. Therefore, it is imperative to undertake morphology- and molecular- based quantization of genetic diversity and population structure analysis for effective and efficient utilization of this diversity. Moreover, it would also help to select the promising genotypes for breeding purposes. During 2017-18, a total of 247 germplasm accessions of jack collected from the eastern and northeastern states of India namely Jharkhand, Odisha, Bihar, West Bengal, Meghalaya and Assam were analyzed based on ten important quantitative characters. The analysis of quantitative data is in progress (Fig 37). The germplasm accessions were collected and maintained by the ICAR-NBPGR, Regional Station, Ranchi and the work is being carried out jointly with its active collaboration.

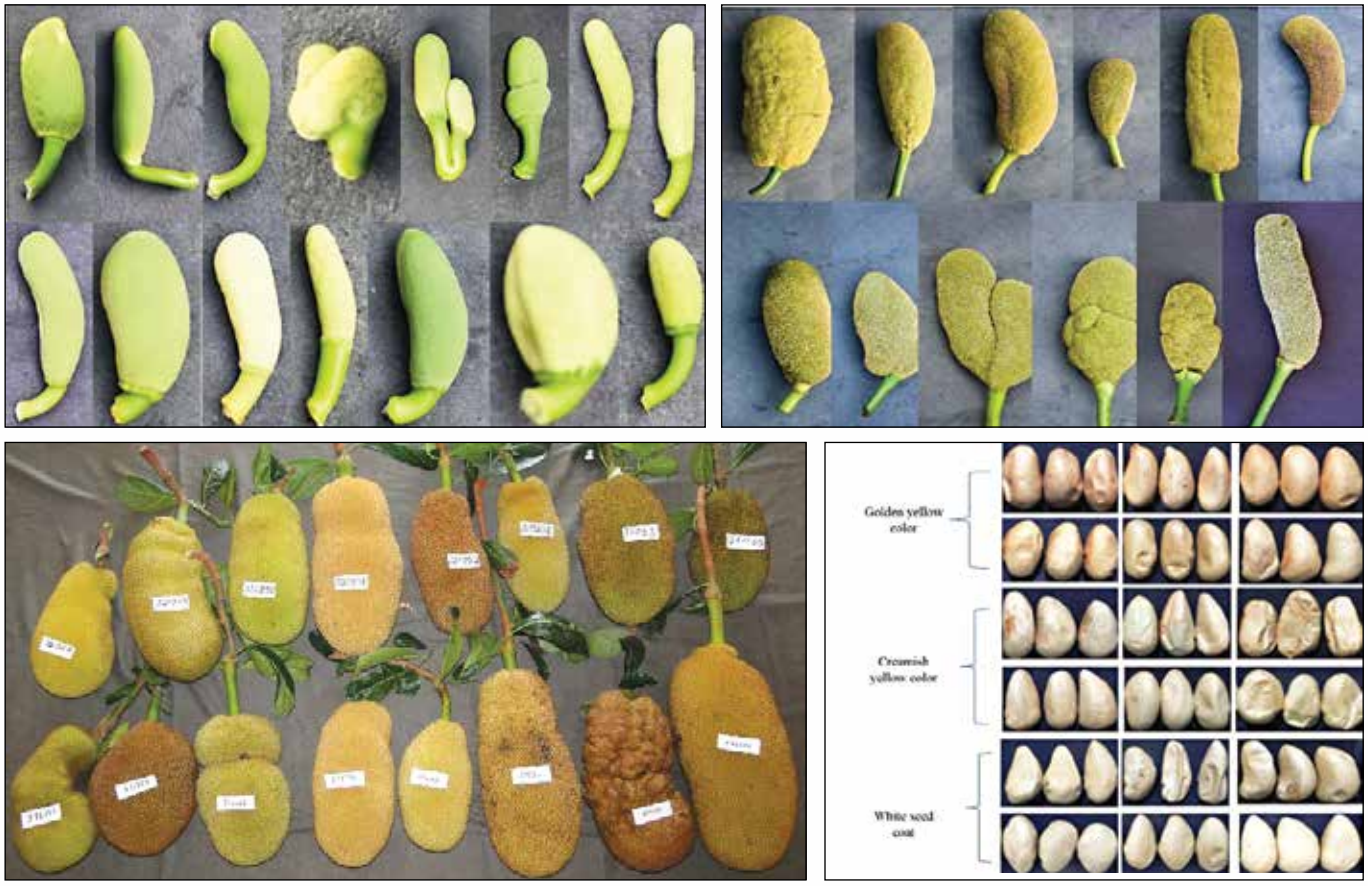


Fig 37: Diversity in the (a) flowers, (b) inflorescence, (c) fruits and (d) seeds of the germplasm accessions of *Artocarpus heterophyllus*

Paired-end sequencing, *de novo* assembly and characterization of the transcriptome in *Artocarpus heterophyllus* (Jackfruit) and *Aegle marmelos* (Bael)

A large number of Illumina NextSeq 500 reads were generated in *Artocarpus heterophyllus* (Jackfruit) and *Aegle marmelos* (Bael). Clean reads obtained by pre-processing the raw reads were assembled *de novo* into unigenes (Table 5). Raw sequence reads were deposited at the National Centre for Biotechnology Information (NCBI) Short Read Archive (SRA) under the BioProject accession numbers SRR7250836 (Jackfruit) and SRR7268533 (Bael). The datasets can be downloaded on or after 2019-07-01 from http://bioinfo.sch.ac.kr/submission/. All assembled unigenes were compared with the NCBI non-redundant protein (Nr) database and based on the results of the Nr database annotation, BLAST2GO was used to obtain Gene Ontology (GO) annotation of assembled unigenes for describing a cellular component, molecular function and biological process. WEGO was employed to perform the GO functional classification for understanding the distribution of gene functions at the macro level. The unigenes were also searched against the Cluster of Orthologous Groups (COG) database to classify their functions. The KEGG (Kyoto Encyclopedia of Genes and Genomes) pathway of the assembled unigenes was annotated by mapping the sequences obtained from BLAST2GO to the contents of the KEGG metabolic pathway database. Currently, the unigene sequences are being used for discovering miRNAs, identifying their targets and inferring miRNA functions, including miRNA functional annotation and inferring miRNA regulatory modules, by integrating heterogeneous data sources. Moreover, the unigenes are also being used for identification of transcription factors and transposable elements.

Table 5: Summary of the results of transcriptome analysis of *Artocarpus heterophyllus* and *Aegle marmelos*

Sl. No.	Particulars	Taxa	
		Artocarpus heterophyllus	***Aegle marmelos***
1	**No. of reads**	42,928,887	42,812,148
2	**No. of unigenes**	89,356	74,498
3	**Mean unigene length**	1,205	1,859
4	**No. of coding DNA sequence (CDS)**	64,215	74,502
5	**Mean CDS length**	880	944
6	**CDS with Blast hits**	61,346	72,719
7	**CDS with GO**	34,231	37,143
8	**CDS with biological process**	23,230	25,398
9	**CDS with cellular component**	17,284	18,706
10	**CDS with molecular function**	27,149	29,055
11	**Pathway classification**		
	Metabolism	3,714	3,763
	Genetic Information Processing	2,406	2,119
	Environmental Information Processing	1,070	971
	Cellular Processes	1,404	1,319
	Organismal Systems	421	387

Characterization of genic-SSR loci in *Artocarpus heterophyllus* (Jackfruit) and *Aegle marmelos* (Bael)

The unigene sequences were also used for the screening of SSRs. Statistical analysis was performed to summarize the number of SSRs with each type of motif and the length distribution of repeat units. The analysis of assembled unigenes remitted in the discovery of a total of 21,903 SSRs in jackfruit (Fig 38) and 19,300 SSRs in Bael (Fig 39). However, after discarding complex SSRs and mononucleotide repeats, only 16,852 and 15,444 SSRs in jackfruit and bael respectively were considered for further analysis. Analysis of different repeat types revealed that GAA/TTC and AAT/ATT were the most abundant repeat motifs in jackfruit and bael respectively. For a given repeat unit, the number of reiterations ranged from 4 to 22, the most common being n= 4. Repeat motifs exceeding 12 repetitions were rare while SSR loci of 12 bp were most frequent. A set of primer sequences from SSR flanking regions were identified for the validation of SSRs in a germplasm set. Primer sets for 200 genic-SSRs have been custom synthesized in both jack and bael for their validation and molecular characterization of the germplasm maintained at ICAR-NBPGR, Regional Station, Ranchi.

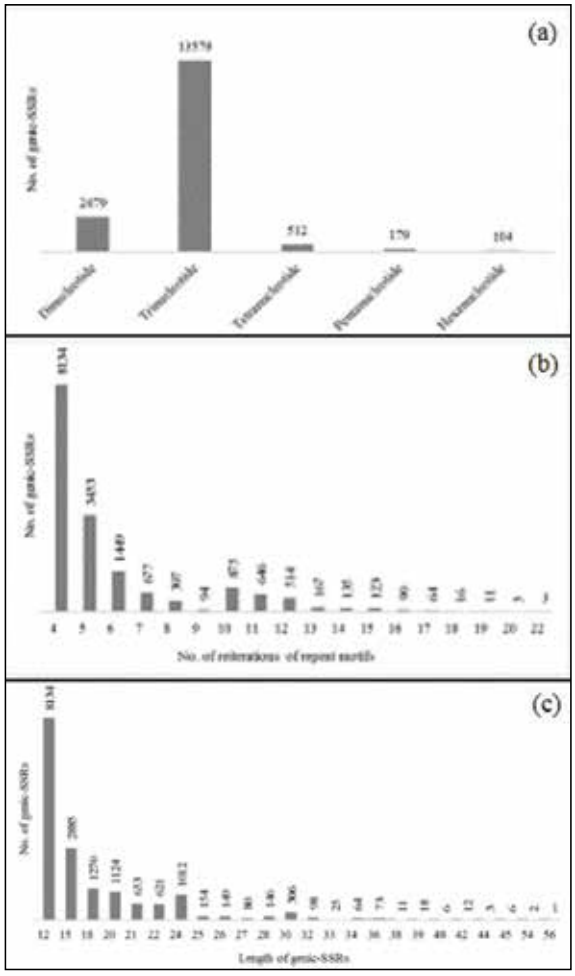


Fig 38: Occurrence and distribution of genic-SSRs in *Artocarpus heterophyllus* (a) Length of repeat motifs, (b) Number of reiterations of repeat motifs, (c) Length of SSRs

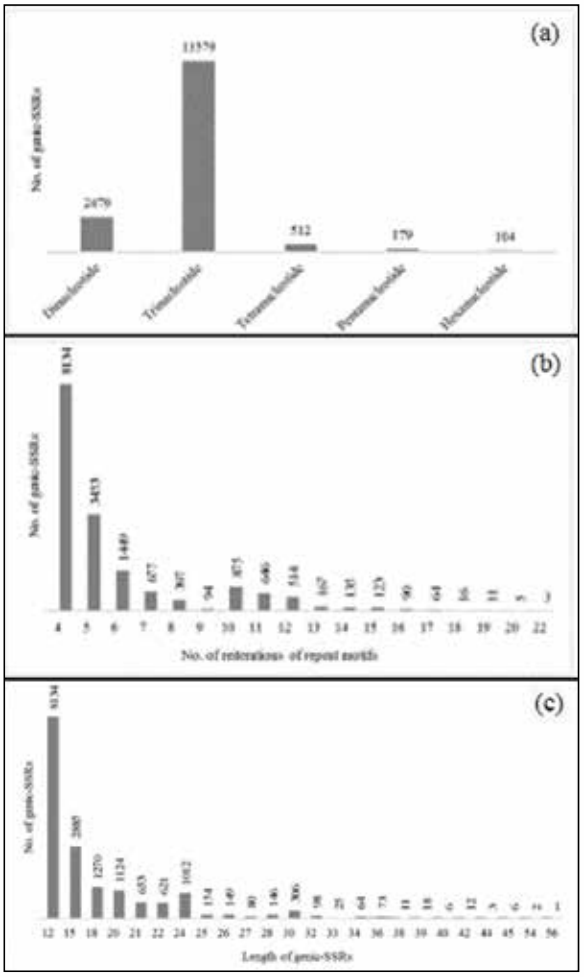


Fig 39: Occurrence and distribution of genic-SSRs in *Aegle marmelos* (a) Length of repeat motifs, (b) Number of reiterations of repeat motifs, (c) Length of SSRs

All India Coordinated Rice Improvement Programme

Conduct of AICRIP trials

Under All India Coordinated Rice Improvement Project (AICRIP), two trials namely AVT-1 E-DS and IVT-E-DS were conducted under rainfed direct seeded conditions during *kharif* 2017 at ICAR-IIAB Research Farm at Garhkhatanga. Under AVT-E-DS, 17 entries including the local check Anjali were evaluated and none of the entries yielded higher than the check. Under IVT-E-DS, 41 entries were evaluated of which nine entries namely 224 (3420.12 Kg/ha), 206 (3289.94 Kg/ha), 223 (3171.60 Kg/ha), 209(2982.25 Kg/ha), 217 (2929 Kg/ha), 210 (2917.16 Kg/ha), 216 (2905.32 Kg/ha), 218 (2887.57 Kg/ha) and 231 (2887.57 Kg/ha) recorded significantly higher grain yield than the local check, Anjali (2473.37 Kg/ha). High incidence of leaf blast was observed at different growth stages. Under, AVT-1-E-DS trial, one entry (105) and in IVT-E-DS, 03 entries (202, 207 and 238) were completely damaged due to severe infestation of leaf blast.

Nomination of promising entries under AICRIP and State Co-ordinated trials

Based on two consecutive years of testing under preliminary station trials, 03 Green Super Rice (GSR) entries namely, IABR1-GSR IR1-DQ157-R6-D1, IABR2-GSR IR1-24-D5-Y1-L1-L1 and IABR-3-GSR-IR1-6-D10-Y1-D1-L2 were nominated under different trials (IVT-IME, IVT-E-TP & IVT-IME) of AICRIP systems for multi-location testing. Besides, 06 other promising entries were also nominated for coordinated state trials to identify stable, promising genotypes under rainfed conditions.

Frontline Demonstrations (FLDs)

During *kharif* 2017-18, thirty FLDs were conducted to demonstrate the production potential of marker-assisted selection (MAS) derived drought tolerant rice variety IR-64-*drt-1*. The FLDs were performed on 31.3 ha farm area belonging to a total of 87 farmers of SC/ST communities. The critical inputs were identified through meetings and discussions with farmers and the same was provided to them on an as-needed basis. All the critical farm operations were done in the presence of scientists of ICAR-IIAB. The team of scientists implementing FLD namely Dr. B.K. Singh, Dr. Avinash Pandey, Dr. Sudhir Kumar, Dr. Rishikesh Kumar, Dr. Madan Kumar and Dr. V.P. Bhadana made several follow-up visits to the farmers' field during the season. These demonstrations were supplemented and complemented through several capacity development programmes. A field day was organized on Nov 01, 2017 under the chairmanship of Dr. T.R. Sharma, Director, ICAR-IIAB. Sh. Ram Kumar Pahan, MLA, Khijri Vidhan Sabha constituency, Ranchi graced the occasion. All the scientists of IIAB, *Panchayat Mukhiya* and Ward Members also attended the field day. The average yield of the rice variety IR-64-*drt-1* achieved under FLDs was 33.1 q/ha, whereas yield under farmers practice was 29.5 q/ha. In general, the farmers expressed their satisfaction with the performance of the variety (Fig 40).

During *rabi* 2017-18, twenty FLDs were conducted for high yielding varieties of Indian Mustard namely, NRCHB-101 and DRMR-150-35. These demonstrations were performed on an area of 20 ha belonging to a total of 26 farmers. Similar to the rice FLDs, critical inputs were identified in consultation with the farmers and the same were provided to them. The FLD implementing team of scientists regularly visited the farmers' field and provided the required knowledge and timely advisory to the farmers. The average yield achieved by the variety NRCHB-101 was 6.9 q/ha, whereas yield under farmers practice was 6.2 q/ha. During the farmers' field day, the farmers expressed their satisfaction with the performance of the varieties (Fig 41).

Fig 40: Selected photographs of FLD on rice

Fig 41: Selected photographs of FLD on mustard

Germplasm Collection

During 2017-18, three explorations of rice growing as well as forest areas of Ramgarh, Barhi Bundu, Tamar, Chandil, Golmuri-Cum-Jugsalai and Ghatshila blocks of the districts Hazaribagh, Ranchi, Saraikela Kharsawan and East Singhbhum was conducted with Prof. N.K. Singh, National Professor, ICAR-NRCPB, New Delhi and seeds of 21 genotypes of wild species of rice were collected (Fig 42).

Fig 42: Rice germplasm exploration

International Network for the Genetic Evaluation of Rice (INGER) Nursery

IRRI coordinated International Upland Rice Observational Nursery (IURON, SET-II) was evaluated at ICAR-IIAB Research Farm at Garhkhatanga under *rainfed* direct-seeded conditions to identify stress tolerant high yielding promising genotypes. A total of 35 entries including 5 different checks (early, medium, late, drought-sensitive and drought-tolerant) were tested under randomized block design and observations were recorded on various agro-morphological and physiological traits. Drought sensitive check and late check were maximally affected by drought, leading to their total damage. None of the entries were observed to be superior to the local check medium (2685 Kg/ha).

Institutional Activities

Personnel

Name Designation & E mail ID	Area of Research
Dr. Tilak Raj Sharma, Director, ICAR-IIAB, Ranchi iiab.ranchi@gmail.com/ trsharma88@gmail.com	
School of Genomics and Molecular Breeding	
Dr. Vijai Pal Bhadana Pr. Scientist (Genetics & Plant Breeding) bhadanavijai@gmail.com	Molecular Breeding in Rice
Dr. Binay Kumar Singh Sr. Scientist (Agril. Biotechnology) binaybio@gmail.com	Genomics and Molecular Breeding for Enhancing Nutrient Use Efficiency in Rice
Dr. Anil Kumar Singh Sr. Scientist (Agril. Biotechnology) anils13@gmail.com	Genomics and Stress Physiology of Crops
Dr. Soumen Naskar Sr. Scientist (Agril. Biotechnology) snrana@gmail.com	Major Histocompatibility Complex (MHC); Assisted Reproductive Technology (ART) in Livestock Species
Dr. Avinash Pandey Scientist (Genetics & Plant Breeding) nashpgr@gmail.com	Molecular Breeding for Earliness and Higher Biomass in Lentil
Dr. Sudhir Kumar Scientist (Genetics & Plant Breeding) sudhiraaidu2006@gmail.com	Molecular Breeding in Horse gram
Dr. Madan Kumar Scientist (Plant Physiology) madan.9577@gmail.com	Genomics and Molecular Breeding for Enhancing Nutrient Use Efficiency in Rice
Sh. Kishor U. Tribhuvan Scientist (Agril. Biotechnology) kish.tribhuwan@gmail.com	Genomics and Molecular Breeding for Abiotic Stress Tolerance in Pulse Crops
Sh. Shambhu Krishan Lal Scientist (Agril. Biotechnology) shambhumku@gmail.com	Genomics and Molecular Breeding for Enhancing Nutrient Use Efficiency in Rice
School of Molecular Diagnostics and Prophylactics	
Dr. Biplab Sarkar Sr. Scientist (Nanobiotechnology) biplab_puru@yahoo.co.in	Development, and Application of Nanoparticles in Disease Control, Environmental Remediation and Micronutrient Induced Fortification
Dr. Sanjay Kumar Gupta Scientist (Fish and Fisheries) sanfishlll@gmail.com	Fish Nutrigenomics
Dr. Rishikesh Kumar Scientist (Plant Pathology) rishiiari2011@gmail.com	Host-Pathogen Interactions in Plant Disease
Administration and Finance	
Sh. Rishi Kant Singh singh.rishikant4@gmail.com, afao.iiabranchi@gmail.com	Assistant Finance & Account Officer
Sh. Kameshwar Oraon koraon67@gmail.com, aao.iiab67@gmail.com	Assistant Administrative Officer

Training and Capacity Building

Details of training attended by the ICAR-IIAB staff during 2017-18

Sl. No.	Name	Subject Area	Duration	Host Institute
1.	Dr. T.R. Sharma	11th Executive Development Programme on Leadership Development	July 28 to Aug 1, 2017	ICAR-NAARM, Hyderabad
2.	Dr. A.K. Singh	Developing a Roadmap for Agricultural Knowledge Management in India	Sept 27 - 28, 2017	NASC Complex, New Delhi
3.	Dr. Madan Kumar	Harnessing NGS Data for Genetic Enhancement in Crops	Oct 3 - 13, 2018	ICAR-IIWBR, Karnal
4.	Dr. Madan Kumar	Recent Techniques and Tools for Nutritional Quality Assessment and Enhancement of Food Crops	Jan 23 - Feb 12, 2018	ICAR-IARI, New Delhi
5.	Sh. Rishi Kant Singh	Refresher Course for Section Officers, AAOs, AF&AOs & Assistant of ICAR	June 23 - 29, 2017	ICAR-NAARM, Hyderabad
6.	Sh. Rishi Kant Singh	Training & Orientation Programme on GFR 2017	July 6 - 7 & 10, 2017	ISTM, New Delhi
7.	Sh. Rishi Kant Singh	PFMS, GFR 2017 & GST	Sept 11 - 12, 2017	ICAR-NRRI, Cuttack
8.	Sh. Kameshwar Oraon	Training & Orientation Programme on GFR 2017	July 6 - 7 & 10, 2017	ISTM, New Delhi
9.	Sh. Kameshwar Oraon	Hindi in Administrative Work	Aug 11, 2017	ICAR-IIHR, Bengaluru
10.	Sh. Kameshwar Oraon	PFMS, GFR 2017 & GST	Sept 11 - 12, 2017	ICAR-NRRI, Cuttack

Important Meetings

Institute Research Council (IRC) Meeting

ICAR-IIAB conducted two IRC meetings on June 12–13 and Sept 22, 2017 (Fig 43). During the meetings, IRC reviewed the progress of ongoing research projects in the light of the observations and recommendations made in the previous IRC meetings. Subsequent to the transfer of posting as per Council order/technical resignation of scientists, the IRC decided to put two research projects (IXX12177 and IXX12178) to suspended animation and to close one research project (IXX12168). During the IRC meeting held on Sep 22, 2017, the IRC approved two new research projects (IXX13895 and IXX13896) and recommended to change the Principal Investigator (PI) of one ongoing research project (IXX12645) since the original PI was on study leave.

Fig 43: A glimpse of the IRC meeting at ICAR-IIAB

Research Advisory Committee (RAC) Meeting

The 5th RAC meeting of ICAR-IIAB, Ranchi was held during Nov 13-14, 2017 under the Chairmanship of Prof. V.L. Chopra, Former Secretary, DARE & Director General, ICAR (Fig 44). The RAC members who were present at the meeting were Prof. K. Veluthambi, Former Head, Department of Plant Biotechnology, School of Biotechnology, Madurai Kamaraj University, Madurai, Prof. H.S. Dhaliwal, Vice Chancellor, Eternal University, Baru Sahib, Sirmour, Himachal Pradesh, Dr. W.S. Lakra, Former Director, ICAR-Central Institute of Fisheries Education, Mumbai, Dr. B.P. Mishra, Joint Director (Research), ICAR-Indian Veterinary Research Institute, Izzatnagar, Bareilly, Dr. T.R. Sharma, Director, ICAR-IIAB and Dr. V.P. Bhadana, Principal Scientist, ICAR-IIAB & Member Secretary, RAC. During the meeting, Dr. T.R. Sharma made a presentation on progress in the establishment of ICAR-IIAB. Dr. V.P. Bhadana presented the Action Taken Report (ATR) on the recommendations of the previous RAC. The major recommendations of RAC are as follows:

- Creation of EFC approved scientific, administrative and technical category posts need to be given top priority.
- Initiation of School of Genetic Engineering should be done at the earliest.
- Local landraces and wild rice genotypes should be screened for abiotic and biotic stress tolerance and quality traits.
- Multi-sectoral and consortium-based research programmes in genomics, nanotechnology and molecular diagnostics and prophylaxis should be developed.
- Development of edible vaccines for animals and fishes should be one of the focus areas.
- ICAR-IIAB should establish close linkages with state line departments.

Fig 44: A glimpse of the RAC meeting at ICAR-IIAB

- On Nov14, 2017, chairman and members of RAC visited the institute site at Garhkhatanga to review the progress in farm development and the research activities undertaken at the farm.

Foundation Day Celebration

The 4th Foundation Day of ICAR-IIAB was celebrated on Aug 25, 2017. Dr. Parvinder Kaushal, Vice Chancellor, Birsa Agricultural University (BAU), Ranchi graced the occasion as chief guest. Dr. Ashwini Pareek, Professor, School of Life Sciences, Jawaharlal Nehru University, New Delhi delivered the Foundation Day Lecture on "Food and Nutritional Security Through Agri-Biotechnology". Dignitaries from ICAR-IINRG, BAU, ICAR-RCER, Regional Station, Ranchi, Institute of Forest Productivity, Birla Institute of Technology, Central University of Jharkhand, Ranchi University and KVKs attended the function. Dr. T.R. Sharma, Director, ICAR-IIAB presented the progress in the research projects taken up by the Institute. He also presented the progress in infrastructure development going on at Garhkhatanga. Dr. Parvinder Kaushal congratulated the scientists of ICAR-IIAB and stressed the need for collaborative research for enhancing the crop productivity and to meet the specific requirements of Jharkhand. Dr. K.K. Sharma, Director, ICAR-IINRG, the guest of honour at the occasion, emphasized the role of ICAR-IIAB in bringing nutritional and food security in eastern India. Dr. A.K. Singh, Head, ICAR-RCER, Regional Station, Ranchi congratulated the scientists of ICAR-IIAB on the occasion and expressed his happiness and satisfaction over the establishment of an institute like IIAB in the region. The Annual Report 2016-17 of ICAR-IIAB was released by the dignitaries on the occasion (Fig 45).

Fig 45: Release of Institute Annual Report 2016-17 during Foundation Day

Infrastructure Development

Procurement of Lab Equipments

During 2017-18, several equipments required for biotechnology research namely 2D-Gel Electrophoresis System with Scanner, UV-vis Transilluminator, Tissue Analyzer with accessories, Gel Documentation System, Water Purification System, Compound Microscope, Refrigerated Water Bath, pH Meter, Power Supply System for Gel Electrophoresis etc were added to the existing facility at ICAR-IIAB.

Research Farm Development

Systematic development of research-farm at ICAR-IIAB was continued by undertaking activities like tilling and levelling. A total of around 5 ha of cultivable land was prepared which was used for conducting paddy trials (AICRIP, INGER etc), screening of paddy trials and seed multiplication of paddy crop. To ensure continuous availability of water for irrigation and farm-related activities, deep well boring at six promising sites were completed.

Procurement of Farm Machinery

A 50 HP tractor (Jhon Deere 5050D), a 15HP power tiller (Kirloskar Mega T15) and farm implements like Rotary Grass Slasher, Power Harrow etc. have been procured and are being used for regular farm-related activities (Fig 46).

Fig 46: Tractor and farm implements procured by ICAR-IIAB

Other Activities

Mera Gaon Mera Gaurav

Under *Mera Gaon Mera Gaurav* programme, two villages namely Lalkhatanga and Garhkhatanga of Namkum block of Ranchi were selected to provide the required knowledge and regular advisory. A multi-disciplinary team of scientists from ICAR-IIAB, Ranchi made three visits during *kharif* 2017 and interacted with the farmers of adopted villages for identifying the significant problems and provided ample solutions to the farmers. Also, scientists visited the villages taken up under FLD programme on rice and mustard.

Vigilance Awareness Week

ICAR-IIAB celebrated the Vigilance Awareness Week during Oct 30 - Nov 4, 2017. The oath-taking ceremony was held on 30th October. At the inauguration, Director, ICAR-IIAB read out the pledge and all staff of ICAR-IIAB took the oath for corruption-free India. On the occasion, an elocution competition was organized in the thematic area, 'My Vision of Corruption-Free India'. All the staff of ICAR-IIAB participated in the competition. The top three speakers, selected by a panel of experts were awarded prizes. The valedictories cum sensitization programme was organized on 3rd November. In this programme, Sh. Kameshwar Oraon, Assistant Administrative Officer, ICAR-IIAB made a presentation on the rule of procurement through Government e-Marketplace (GeM) portal. Sh. Rishi Kant Singh, Assistant Finance and Accounts Officer (AF&AO), ICAR-IIAB also made a presentation on important financial rules, especially concerning vigilance. Dr. Soumen Ghosal, Vigilance Officer, ICAR-IINRG, Ranchi was the Chief Guest of the programme. He delivered a talk on 'Role of Vigilance in Agricultural Research and Development.' The programme concluded with comments from Director, ICAR-IIAB and 'Vote of Thanks' from Dr. V.P. Bhadana, Principal Scientist, ICAR-IIAB (Fig 47).

Fig 47: Glimpses of Vigilance Awareness Week celebration at ICAR-IIAB

World Soil Day

Fig 48: A glimpse of World Soil Day celebration at Farm-B, ICAR-IIAB

ICAR-IIAB celebrated World Soil Day on Dec 25, 2017. On the occasion, a soil health awareness programme was organized at the research farm of ICAR-IIAB by a team of scientists namely Dr. Avinash Pandey, Dr. Sudhir Kumar, Dr. Madan Kumar, Dr. B.K. Singh and Dr. V.P. Bhadana. Farmers from Lalkhatanga and Garhkhatanga villages participated in the programme. During the programme, scientists sensitized the farmers about the importance of soil health in agriculture. The pamphlets on Soil Health Card Scheme were also distributed to the farmers on occasion (Fig 48).

Science Day Celebration

ICAR-IIAB organized Science Day celebration on Feb 28, 2018, at D.A.V. Nageshwar Public School, Tetri, Ranchi. Dr. Biplab Sarkar and Dr. Rishikesh Kumar from ICAR-IIAB participated in the programme and encouraged and motivated the young students towards scientific career and gaining knowledge on advances in science and technology. The Principal of D.A.V. Nageshwar Public School expressed her sincere thanks to the Director and the scientists of ICAR-IIAB for selecting her school for Science Day celebration (Fig 49).

Fig 49: Glimpses of Science Day Celebration at D.A.V. Nageshwar Public School, Ranchi

Swach Bharat Abhiyaan

ICAR-IIAB organized '*Swachhta Hi Sewa*' day on Sept 22, 2017. On the occasion, Dr. T.R. Sharma, Director, ICAR-IIAB with all his staff members led a cleanup drive around the ICAR-IIAB campus and also planted a large number of saplings. Moreover, ICAR-IIAB organized *Swachhta Pakhwara* during Oct 16 - 31, 2017. ICAR-IIAB organized massive cleaning drives throughout the *pakhwara* (Fig 50).

Fig 50: Glimpses of various activities organised under Swach Bharat Abhiyaan at ICAR-IIAB

Parthenium Awareness Week

ICAR-IIAB observed "Parthenium Awareness Week" between Aug 16 - 22, 2017. Dr. T.R. Sharma, Director, ICAR-IIAB in his inaugural address stressed on the need to contain this harmful weed. Dr. N.K. Sinha, Senior Scientist at ICAR-IIAB, apprised the audiences of the damages it incurs to the crops, ecology, human beings and environment.

Organisation of Hindi Pakhwada

ICAR-IIAB organized *Hindi Pakhwada* during Sept 9-23, 2017. Various competitions such as debate, extempore, translation, dictation etc were organized during the *Pakhwada*. All the staffs of ICAR-IIAB participated in *Pakhwada*. Hindi Day was celebrated on Sept 14, 2017 and all the winners were awarded.

संस्थान की राजभाषा संबंधी गतिविधियां

भारत सरकार के राजभाषा विभाग (गृह मंत्रालय) द्वारा तैयार किए गए वार्षिक कार्यक्रम एवं राजभाषा अधिनियम व नियमों के संबंध में भारतीय कृषि अनुसंधान परिषद, नई दिल्ली से समय-समय पर प्राप्त निर्देशों पर अनुवर्ती कार्रवाई तथा सरकारी कार्य में हिन्दी के प्रयोग को गति प्रदान करने के लिए निदेशक की अध्यक्षता में संस्थान राजभाषा कार्यान्वयन समिति गठित की गई है, जिसमें विभागों/अनुभागों के अध्यक्ष, सदस्य के रुप में शामिल हैं तथा प्रभारी अधिकारी, राजभाषा सदस्य सचिव हैं। राजभाषा कार्य के सूचारू संचालन के लिए वर्ष 2017-18 में निम्नलिखित कार्य किए गए।

संस्थान राजभाषा कार्यान्वयन समिति की तिमाही बैठकों का आयोजन, कार्यसूची एवं कार्यवृत की तैयारी तथा बैठकों में लिए गये निर्णयों पर अनुवर्ती कार्रवाई। संस्थान के दैनिक कार्य में हिन्दी के प्रयोग में प्रगति एवं इसे सरल बनाने के लिए राजभाषा प्रकोष्ठ द्वारा निम्नलिखित कार्य सम्पादित होते हैं:

- संस्थान राजभाषा कार्यान्वयन समिति की बैठकों का आयोजन, कार्यसूची एवं कार्यवृत की तैयारी एवं बैठकों में लिए गये निर्णयों पर अनुवर्ती कार्रवाई।
- हिन्दी दिवस, हिन्दी चेतना मास एवं योजनानुसार नगर स्तरीय राजभाषा संबंधी, संगोष्ठी एवं कार्यशाला का आयोजन करना।
- संदर्भ साहित्य, हिन्दी पत्रिका, शब्दकोश, एवं तकनीकी शब्दावली के उपार्जन हेतु कार्य।
- हिन्दी में वैज्ञानिक गोष्ठी के साथ साथ प्रशासनिक तथा तकनीकी वर्ग के लिए कार्यशाला का आयोजन।
- निदेशक महोदय की अध्यक्षता में वर्ष 2017-18 में संस्थान राजभाषा कार्यान्वयन समिति की तीन तिमाही बैठकों का आयोजन निम्नलिखित तिथियों को किया गया तथा प्रगति की समीक्षा की गई। तिमाही रिपोर्ट एवं कार्यवृत परिषद सहित अन्य संबंधित कार्यालयों में प्रेषित की गई :

(क) दिनांक-15.06.2017 (ख) दिनांक-01.12.2017

(ग) दिनांक-23.02.2018

जिसके अर्न्तगत निम्नलिखित प्रमुख चर्चा हुई तथा सर्वसम्मति से निर्णय लिए गए :-

- वार्षिक कार्यक्रम 2016-17 एवं 2017-18 के प्रस्ताव पर चर्चा।
- नगर स्तरीय हिन्दी संगोष्ठी/कार्यशाला का आयोजन।
- स्वास्थ्य संबंधी विषय पर हिन्दी कार्यशाला/व्याख्यान का आयोजन।
- हिन्दी दिवस/हिन्दी प्रतियोगिताओं का आयोजन।
- प्रवीणता प्राप्त सभी अधिकारियों/कर्मचारियों को व्यक्तिशः आदेश जारी करना।
- सभी कम्प्यूटरों में यूनिकोड या गुगल हिन्दी सॉफ्टवेयर की व्यवस्था।
- हिन्दी पुस्तकों का उपार्जन।

राजभाषा प्रकोष्ठ की उपलब्धियां-2017

- संस्थान के आगत-निर्गत पत्रों का विस्तृत (अनुभाग/विभाग व क्षेत्रवार) विवरण तैयार कर विहित प्रपत्र में तिमाही रिपोर्ट तैयार की गयी तथा परिषद् समेत सभी संबंधित कार्यालयों को प्रेषित की गयी ।
- वैज्ञानिक उपकरणों से जुड़े कम्प्यूटरों को छोड़कर संस्थान के अन्य कम्प्यूटरों में हिन्दी फॉन्ट लगा दिये गये हैं तथा ज्यादातर कम्प्यूटरों में युनीकोड/गुगल हिन्दी सॉफ्टवेयर डाला गया है।
- समय-समय पर हिन्दी के प्रयोग को प्रोत्साहित करने के लिए विभिन्न प्रकार की हिन्दी प्रतियोगिताओं का आयोजन किया गया।
- संस्थान के सभी अधिकारियों का हिन्दी ज्ञान संबंधी घोषणा पत्र अद्यतन किया गया।
- सितम्बर 2017 माह में वर्तणी, टिप्पणी, अंताक्षरी, ह्वाब्दार्थ एवं आशुभाषण की हिन्दी प्रतियोगिताएं आयोजित की गई।
- 30 जून 2017, 31 दिसम्बर 2017, 31 मार्च 2018 को समाप्त तिमाही की अवधि का तिमाही रिपोर्ट तथा वर्ष 2017-18 का वार्षिक मूल्यांकन रिपोर्ट परिषद एवं अन्य संबंधित कार्यालयों को भेजा गया।
- रिपोर्ट की अवधि में दिनांक-16.06.2017,14.09.2017, 07.12.2017 एवं 28.03.2018 को कार्यशाला एवं संगोष्ठी का आयोजन किया गया।
- दिनांक-27.03.2018 को संस्थान के प्रवीणता प्राप्त सभी अधिकारियों को अपना अधिकतम कार्य हिन्दी में करने के लिए निदेशक महोदय के हस्ताक्षर से व्यक्तिशः आदेश जारी किए गए।

डॉ अंजेश कुमार, प्रभारी, राजभाषा द्वारा संगोष्ठी/कार्यशाला/बैठकों में प्रतिनिधित्व व अन्य

- दिनांक-08.11.2017 को जनगणना निदेशालय, नामकुम औद्योगिक क्षेत्र, राँची में आयोजित हिन्दी कार्यशाला में मुख्य अतिथि के रूप में आमंत्रित व्याख्यान दिया।
- दिनांक-31.08.2017 एवं दिनांक-31.01.2018 को मंडल रेल प्रबंधक कार्यालय, हटिया में आयोजित नगर राजभाषा कार्यान्वयन समिति की बैठक में क्रमशः डॉ संजय कुमार गुप्ता, वैज्ञानिक एवं प्रभारी अधिकारी, राजभाशा एवं निदेशक महोदय तथा डॉ अंजेश कुमार, प्रभारी अधिकारी, राजभाषा ने संस्थान का प्रतिनिधित्व किया तथा बैठकों का संचालन किया।
- भारतीय कृषि अनुसंधान परिषद, नई दिल्ली के आदेश के अनुपालन में भाकृअनुप-भारतीय प्राकृतिक राल एवं गोंद संस्थान के डॉ अंजेश कुमार, वरिष्ठ तकनीकी अधिकारी ने दिनांक - 20.10.2017 से संस्थान में प्रभारी अधिकारी, राजभाषा के रूप में योगदान दिया।

प्रभारी अधिकारी, राजभाषा को पुरस्कार व सम्मान

- नगर राजभाषा कार्यान्वयन समिति (केन्द्रीय कार्यालय), राँची की पत्रिका - राजभाषा जोहार के सम्पादक मंडल के सदस्य के रूप में मनोनयन।
- वन उत्पादकता संस्थान, ललगुटुआ, नगड़ी, राँची की ई-पत्रिका शोध तरू के सम्पादक मंडल के सदस्य के रूप में मनोनयन।

Participation in Conferences, Meetings, Seminars, Symposia and Workshops

Sl. No.	Event	Venue	Period	Participants
1.	52nd Annual Rice Research Group Meetings	Assam Agricultural University, Jorhat	April 8-11, 2017	Dr. V.P. Bhadana
2.	Varietal Identification Committee Meeting	Assam Agricultural University, Jorhat	April 9, 2017	Dr. V.P. Bhadana
3.	ICAR Foundation Day Ceremony and Directors Meet	NASC, New Delhi	July 16, 2017	Dr. T.R. Sharma
4.	Meeting on "Doubling Farmers Income"	BAU, Ranchi	Aug 23, 2017	Dr. T.R. Sharma
5.	8th Standing Finance Committee Meeting	New Delhi	Sept 18-19, 2017	Dr. T.R. Sharma Dr. V.P. Bhadana
6.	Developing a Roadmap for Agricultural Knowledge Management in India	New Delhi	Sept 27-28, 2017	Dr. A.K. Singh
7.	Methodological Framework for Implementation of Farmer FIRST project	Dehradun	Nov 06-09, 2017	Dr. S. Naskar
8.	Meeting for Approval of ICAR-IIAB Master plan & Infrastructure Drawings	New Delhi	Nov 20, 2017	Dr. T.R. Sharma Dr. V.P. Bhadana
9.	11th International Indian Fisheries and Aquaculture Forum	ICAR-CIFT, Cochin, Kerala	Nov 21-24, 2017	Dr. S.K. Gupta
10.	National Conference of Plant Physiology	Raipur	Nov 23-25, 2017	Dr. A.K. Singh Dr. Madan Kumar
11.	SAC meeting of KVK, Ramgarh	KVK, Ramgarh	Nov 27, 2017	Dr. T.R. Sharma
12.	6th NGGIBCI conference on Genomics	ICRISAT, Hyderabad	Dec 6-8, 2017	Dr. T.R. Sharma
13.	National Conference on 'Challenges and Strategies to Improve Crop Productivity in Changing Environment: An Integrated Approach	New Delhi	Jan 12, 2018	Dr. A.K. Singh
14.	ICWWMM-2018	Central University of Jharkhand	Jan 16 -17, 2018	Dr. B. Sarkar

Participation in Conferences, Meetings, Seminars, Symposia and Workshops

Sl. No.	Event	Venue	Period	Participants
15.	International Symposium on Biodiversity and Biobanking, BIODIVERSE 2018	IIT- Guwahati	Jan 27-29, 2018	Dr. S. Naskar
16.	17th ''नगर राजभाषा कार्यान्वयन समिति''	Ranchi	Jan 31, 2018	Dr. T.R. Sharma
17.	International Conference on Trends in Biochemical and Biomedical Research: Advances and Challenges	BHU, Varanasi	Feb 13-15, 2018	Dr. Rishikesh Kumar
18.	National Symposium on Plant Biotechnology	Jodhpur	Feb 16-18, 2018	Dr. A.K. Singh
19.	Functional Genomic Approaches for Crop Improvement under Changing Climate Scenario	Jaipur	Feb 26-27, 2018	Dr. A.K. Singh
20.	Germplasm Field Day on Rabi Pulses (Lentil and Pea)	ICAR-NBPGR, New Delhi	Feb 26, 2018	Dr. Avinash Pandey
21.	Annual Review Workshop of ICAR-funded Farmer FIRST Programme	New Delhi	Feb 21-22, 2018	Dr. S. Naskar
22.	2nd International Conference on Advances in Environment and Agricultural Biotechnology	St. Xavier College, Ranchi	Feb 22-24, 2018	Dr. B. Sarkar Dr. S.K. Gupta
23.	ICAR Directors Meet	NASC, New Delhi	Mar 8-9, 2018	Dr. T.R. Sharma
24.	Krishi Unnati Mela 2018	ICAR-IARI, New Delhi	Mar 16-18, 2018	Dr. B.K. Singh Dr. Avinash Pandey
25.	Smart Metabolic Engineering of Plants for Drug Biosynthesis	ICGEB, New Delhi	Mar 16-17, 2018	Dr. S.K. Lal
26.	Biodiversity Fair cum PGR Awareness Workshop	KVK, Simdega	Mar 26, 2018	Dr. T.R. Sharma
27.	2nd International conference on Food & Agriculture	Dhanbad	Mar 29-31, 2018	Dr. T.R. Sharma, Dr. V.P. Bhadana, Dr. B. Sarkar, Dr. Avinash Pandey, Dr. S.K. Gupta, Dr. Sudhir Kumar, Dr. Madan Kumar, Dr. Rishikesh Kumar

Joining of New Staff

Name of staff	Designation	Date of Joining
Dr. T.R. Sharma	Joint Director (Research)	May 16, 2017
Dr. Avinash Pandey	Scientist (Genetics & Plant Breeding)	June 28, 2017
Dr. Sudhir Kumar	Scientist (Genetics & Plant Breeding)	July 01, 2017
Dr. Madan Kumar	Scientist (Plant Physiology)	July 8, 2017
Sh. Kameshwar Oraon	Assistant Administrative Officer (Dep.)	July 01, 2017

Transfer of ICAR-IIAB Staff

Name of staff	Designation	Place to Transfer
Dr. Nirmal Kumar	Pr. Scientist (Agril. Extension)	ICAR-IINRG, Ranchi
Dr. N.K. Sinha	Sr. Scientist (Seed Science & Technology)	ICAR-IINRG, Ranchi
Sh. Anutosh Paria	Scientist (Genetics & Plant Breeding)	ICAR-NBFGR, Lucknow

Institute-Funded Projects

Project Title	Date of Start	Principal Investigator	Co- Principal Investigator (s)
Genomics and Bioinformatics			
IXX12585: Identification and characterization of drought-responsive genes of wild chickpea (*Cicer microphyllum*)	April, 2016	Dr. A.K. Singh	Sh. Kishor U. Tribhuvan Dr. V.P. Bhadana
IXX12644: Identification of genes/QTLs for heat tolerance in lentil	April, 2016	Dr. A.K. Singh	Dr. B.K. Singh Dr. V.P. Bhadana Sh. S.K. Lal
IXX12950: Molecular characterization of the Major Histocompatibility Complex (MHC) genes of indigenous pig (*Sus scrofa*)	Sept., 2016	Dr. S. Naskar	Dr. A.K. Singh Dr. V.P. Bhadana Dr. S. Banik
Translational Research for Crop Improvement			
IXX12645: Identification and functional characterization of genes/QTLs responsible for zinc homeostasis in rice	April, 2016	Dr. Madan Kumar	Dr. B.K. Singh Dr. V.P. Bhadana Dr. Avinash Pandey Dr. Sudhir Kumar Dr. Rishikesh Kumar
IXX12649: Introgression of genes/ QTLs for drought tolerance and efficient phosphorus uptake in rice using MAS	April, 2016	Dr. V.P. Bhadana	Dr. B.K. Singh Dr. Avinash Pandey Dr. Sudhir Kumar Dr. Madan Kumar Dr. Rishikesh Kumar
IXX12651: Identification and mapping of novel genes/QTLs for phosphorus uptake and use efficiency in rice	April, 2016	Dr. B.K. Singh	Dr. V.P. Bhadana Dr. Avinash Pandey Dr. Sudhir Kumar Dr. Madan Kumar

Project Title	Date of Start	Principal Investigator	Co- Principal Investigator (s)
IXX12951: Understanding host- pathogen interactions and identification of novel blast and false smut resistance gene(s) in rice	Sept., 2016	Dr. Rishikesh Kumar	Dr. B.K. Singh Dr. V.P. Bhadana Dr. Avinash Pandey Dr. Sudhir Kumar Dr. Madan Kumar
IXX13895: Molecular mapping of QTLs for early plant vigour, early maturity and harvest index traits in lentil	Sept., 2017	Dr. Avinash Pandey	Dr. Sudhir Kumar Dr. Kuldeep Tripathy Dr. B.K. Singh Dr. Madan Kumar Dr. Rishikesh Kumar Dr. V. P. Bhadana
IXX13896: Ideotype breeding in horse gram for Jharkhand region	Sept., 2017	Dr. Sudhir Kumar	Dr. Avinash Pandey Dr. B.K. Singh Dr. V.P. Bhadana Dr. Madan Kumar Dr. Rishikesh Kumar
Biotechnological Interventions for Fish Health Management			
IXX12177: Development of nanoparticle based recombinant protein oral vaccine for Indian major carps against *Aeromonas hydrophila*	Oct., 2015	Suspended animation	
IXX12178: Molecular characterization and functional analysis of antimicrobial peptides in response to pathogenic bacteria in striped catfish *Pangasianodon hypophthalmus*	Oct., 2015	Suspended animation	
IXX12206: Identification and characterization of genes responsible for immune response in *Labeo rohita* fingerlings	Nov., 2015	Dr. S.K. Gupta	
IXX12919: Development and evaluation of the efficacy of novel nanoparticles for enhancing yield in rice and Indian major carp	June, 2016	Dr. B. Sarkar	Sh. Rishikesh Kumar Dr. S.K. Gupta Dr. B.K. Singh

Externally-Funded Projects

Screening of various lentil (*Lens culinaris* L.) genotypes for drought tolerance using physiological and molecular approaches (SERB, DST, GOI funded under N-PDF scheme)	July, 2016	Dr. Ragini Sinha	Dr. A.K. Singh (Mentor)
Characterization of molecular marker(s) associated with X- and/or Y-chromosome bearing spermatozoa in cattle (SERB, DST, GOI funded under N-PDF scheme)	April, 2017	Dr. Laxmi Vandana Rongala	Dr. S. Naskar (Mentor)
Enhancing food, nutritional and livelihood security of marginal and small farmers in Jharkhand through need-based agricultural technologies (ICAR-Funded)	Jan., 2017	Dr. S. Naskar	Dr. S.K. Gupta Dr. Rishikesh Kumar Dr. Nirmal Kumar Dr. N.K. Sinha Dr. A.K. Singh Dr. B.K. Jha Dr. P.R. Kumar Dr. S. Karmakar Dr. D.K. Rusia
Tribal Sub-Plan (TSP)	2016	Dr. S. Naskar	All scientists of ICAR-IIAB

Awards and Recognitions

- Dr. T.R. Sharma received Life Time Achievement Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. V.P. Bhadana received Distinguished Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. B. Sarkar received Indo Global Excellence Award by the Indo Global Chamber of Commerce, Industries and Agriculture (IGCCIA), Pune at the International Conference on Advances in Environmental and Agricultural Biotechnology – 2018, held at St. Xavier's College, Ranchi during February 22 - 24, 2018.
- Dr. B. Sarkar received Best Poster Presentation Award for the topic "photo catalytic degradation of methylene blue by zinc oxide nanoparticle" at the International Conference on Advances in Environmental and Agricultural Biotechnology – 2018, held at St. Xavier's College, Ranchi during February 22 - 24, 2018.
- Dr. B. Sarkar received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. B.K. Singh received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. B.K. Singh received Best Oral Presentation Award for the topic entitled "molecular approaches to improve stress tolerance in Indian Mustard" at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Sudhir Kumar received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Sudhir Kumar received Best Oral Presentation Award for the topic entitled "molecular characterization of rice germplasm of north eastern India thorough SSR Markers" at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Avinash Pandey received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Madan Kumar received Best Oral Presentation Award for the topic entitled "genetic diversity in rice germplasm collected from Jharkhand as revealed by SSR marker" at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Madan Kumar received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. Rishikesh Kumar received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. A.K. Singh joined as Academic Editor, PLoS ONE, an international multidisciplinary Open Access journal.
- Dr. A.K. Singh joined as Editor, Indian Journal of Plant Physiology, an International Journal published by Indian Society for Plant Physiology, New Delhi.
- Dr. A.K. Singh invited as External Reviewer for Discovery Grant Proposal submitted for funding to Natural Sciences and Engineering Research Council (NSERC), Canada.
- Dr. A.K. Singh invited as External Reviewer for ICGEB CRP Research Grant Programme submitted for funding to ICGEB, Trieste, Italy.

Awards and Recognitions

- Dr. A.K. Singh invited as External Reviewer for project proposal submitted under Young Investigator Programme in Biotechnology (YIPB) to Kerala Biotechnology Commission, Kerala State Council for Science, Technology and Environment, Kerala, India.
- Dr. A.K. Singh invited to join REPRISE, a web-based database of expert reviewers of the Italian Ministry of Education, Universities and Research.
- Dr. A.K. Singh invited to deliver a lecture in 9th International Rosaceae genomics Conference held at Nanjing, China during June 26-30, 2018.
- Dr. S.K. Gupta received Endeavour Postdoctoral Research Fellowship at Curtin University, Perth Western Australia, for six months' duration, sponsored by Australian Department of Education and Training, Govt. of Australia.
- Dr. S.K. Gupta invited as External Expert in the interview panel for the position of Project Coordinator – Fishery and District Project Officer – Fishery at Saptrishi Sewa Bhawan, Tupudana, Ranchi.
- Dr. S.K. Gupta invited for screening the applications for the post of Assistant Professor at BAU, Ranchi
- Dr. S.K. Gupta appointed as an Expert in the Selection Committee constituted for the selection of Assistant Professor (on contractual basis) BAU, Ranchi.
- Dr. S.K. Gupta appointed as a committee member by Vice-Chancellor, BAU for screening the applications received for the post of Assistant professors for College of Fisheries Technology under BAU, Ranchi
- Dr. S.K. Gupta appointed as paper setter & examiner by BAU, Ranchi.
- Dr. S.K. Gupta invited as Expert Fishery under JOHAR Fisheries Component, JSLPS for one-day consultative meeting.
- Dr. S.K. Gupta received Indo Global Excellence Award at "International conference on Advances in Environment and Agricultural Biotechnology" held at St. Xavier College, Ranchi during February 22-24, 2018.
- Dr. S.K. Gupta received Best Oral Presentation Award for the topic "modulation of cytokine expression in pathogen aggravated rohu, *Labeo rohita*" at "International conference on Advances in Environment and Agricultural Biotechnology" held at St. Xavier College, Ranchi during February 22-24, 2018.
- Dr. S.K. Gupta received Young Scientist Award at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. S.K. Gupta received the Best Oral Presentation Award for the topic "Nutrigenomics: An emerging approach of fish nutritional Research" at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.
- Dr. S.K. Gupta acted as Rapporteur at 2nd International Conference on Food and Agriculture 2018 held at Dhanbad, Jharkhand during March 29-31, 2018.

Publications

Research Articles

Badri J, Dey S, Prakasam V, Nymagoud S, Priyanka C, Shaik H, Sundaram RM, Sheshu Madhav M, Eswari KB, Bhadana VP, Ram T, Subba Rao LV. 2017. Allelic variation of sheath blight QTLs among genotypes promising for sheath blight tolerance. *Journal of Rice Research* **10**(1): 36-39.

Bangale U, Balija V, Kumar PS, Devi SJS, Bhadana VP, Senguttuvel P, Kumar S, Sharma SK, Sharma PK, Prasad MS and Madhav MS. 2017. Diverse rice landraces of north-east India enables the identification of novel genetic resources for *Magnaporthe* resistance. *Frontiers in Plant Science* **8**: 01-13.

Chahota RK, Sharma V, Ghani M, Sharma TR, Rana JC and Sharma SK. 2017. Genetic and phytochemical diversity analysis in *Bunium persicum* populations of northwestern Himalaya. *Physiology and Molecular Biology of Plants* **23**(2): 429-441.

Chahota RK, Shikha D, Rana M, Sharma V, Nag A, Sharma TR, Rana JC, Hirakawa H and Isobe SN. 2017. Development and characterization of SSR markers to study genetic diversity and population structure of horse gram germplasm (*Macrotyloma uniflorum*). *Plant Molecular Biology Reporter* **35**(5): 550-561.

Chakraborty A, Baruah A, Sarmah BC, Goswami J, Bora A, Dutta DJ, Biswas RK, Kalita D, Naskar S, Vashi Y and Phangchopi D. 2017. Enzymatic response to antioxidants and seasonal stress. *Current Journal of Applied Science and Technology* **22**(2): 1-5.

Chakraborty A, Baruah A, Sarmah BC, Goswami J, Bora A, Dutta DJ, Biswas RK, Kalita D, Naskar S, Vashi Y and Phangchopi D. 2017. Thyroid response to temperature humidity index in crossbred pigs supplemented with antioxidants during summer and winter season. *Advances in Animal and Veterinary Sciences* **5**(6): 271-275.

Chakraborty A, Baruah A, Sarmah BC, Goswami J, Bora A, Dutta DJ, Biswas RK, Kalita D, Naskar S, Vashi Y and Phangchopi D. 2017. Physiological responses in pigs on antioxidant supplementation during summer and winter. *Indian Journal of Animal Research* DOI: 10.18805/ijar. B-3401

Devi EL, Devi Ch P, Kumar S, Sharma SK, Beemrotea A, Chongtham SK, Singh Ch P, Tania Ch, Singh TB, Ningombama A, Akoijama R, Singh IM, Singh YR, Monteshori S, Omitta Y, Prakash N and Ngachan SV. 2017. Marker assisted selection (MAS) towards generating stress tolerant crop plants. *Plant Gene* **11**: 205–218.

Dutta SS, Pale G, Pattanayak A, Aochen C, Pandey A and M Rai. 2017. Effect of low light intensity on key traits and genotypes of hilly rice (Oryza sativa) germplasm. *Journal of Experimental Biology and Agricultural Sciences* **5**(4): 463-471.

Gahtyari NC, Patel PI, Choudhary R, Kumar S, Kumar N and Jaiswal JP. 2017. Combining ability studies for yield, associated traits and quality attributes in rice for South Gujarat (*Oryza sativa* L.). *Journal of Applied and Natural Science* **9** (1): 60–67.

Gokuldas PP, Singh SK, Tamuli MK, Naskar S, Vashi Y, Thomas R, Barman K, Pegu SR, Sharma CG and Agarwal SK. 2018. Dietary supplementation of n-3 polyunsaturated fatty acid alters endometrial expression of genes involved in prostaglandin biosynthetic pathway in breeding sows (*Sus scrofa*). *Theriogenology* **110**: 201-208.

Gupta BK, Sahoo KK, Ghosh A, Tripathi AK, Anwar K, Das P, Singh AK, Pareek A, Sopory S K and Singla-Pareek SL. 2018. Manipulation of glyoxalase pathway confers tolerance to multiple stresses in rice. *Plant, Cell & Environment* **41**(5): 1186-1200.

Gupta S, Santra L, Naskar S, Maurya SK, Rana M, Ghosh J and Dhara SK. 2017. Heterologous expression of porcine elongase 6 (*ELOVL6*) gene in a human cell line. *Indian Journal of Medical Research* **145**: 563-568.

Gupta SK, Sarkar B, Bhattacharjee S, Kumar N, Naskar S and Uppuluri KB. 2018. Modulation

of cytokine expression by dietary levan in the pathogen aggravated rohu, L*abeo rohita* fingerlings. *Aquaculture* **495**: 496-505.

Harsha, Deo I, Kumar S and Tallah Md. 2017. Assessment of genetic variability and inter-character association studies in rice genotypes (*Oryza sativa* L.). *International Journal of Current Microbiology and Applied Sciences* **6**(9): 2041-2046.

Jha R, Bohra A, Jha U, Rana M, Chahota RK, Kumar S and Sharma TR. 2017. Analysis of an intraspecific RIL population uncovers genomic segments harbouring multiple QTL for seed relevant traits in lentil (*Lens culinaris* L.). *Physiology and Molecular Biology of Plants* **23**(3): 675–684.

Kaldate R, Rana M, Sharma V, Hirakawa H, Kumar R, Singh G, Chahota RK, Isobe SN and Sharma TR. 2017. Development of genome-wide SSR markers in horse gram and their use for genetic diversity and cross-transferability analysis. *Molecular Breeding* **37**: 103. https://doi.org/10.1007/s11032-017-0701-1

Kaushik P, Naskar S, Handique PJ, Rahaman H and Sarma DK. 2017. Genetic polymorphism of growth hormone releasing hormone gene in exotic and crossbred pigs. *Indian Journal of Animal Research* **51**(2): 231-234.

Koul PM, Sharma V, Rana M, Chahota RK, Kumar S and Sharma TR. 2017. Genetic structure and interrelationships in lentil species using morphological and SSR markers. *3Biotech* 7: 83. https://doi.org/10.1007/s13205-017-0683-z

Kumar N, Krishnani KK, Brahmane MP, Gupta SK, Kumar P and Singh NP. 2017. Temperature induces lead toxicity in *Pangasius hypophthalmus*: An acute test, antioxidative status and cellular metabolic stress. I*nternational Journal of Environmental Science and Technology* **15**(1): 57-68.

Kumar N, Krishnani KK, Gupta SK and Singh NP. 2017. Selenium nanoparticles enhanced thermal tolerance and maintained cellular stress protection of *Pangasius hypophthalmus* reared under lead and high temperature. *Respiratory Physiology & Neurobiology* **246**: 107-116.

Kumar N, Krishnani KK, Gupta SK and Singh NP. 2018. Effects of silver nanoparticles on stress biomarkers of *Channa striatus*: immuno-protective or toxic? *Environmental Science and Pollution Research* **25**(15): 14813-14826.

Kumar S, Bhuvaneswari S, Devi EL, Sharma SK, Ansari MA, Singh IM, Singh YR and Prakash N. 2017. Estimation of genetic variability, correlation and path analysis in short duration Rice Genotypes of Manipur. *Journal of AgriSearch* **4**(2): 112-118.

Kumar S, Devi EL, Sharma SK, Ansari MA, Phurailatpam S, Chanu Ng T, Singh Th S, Prakash N, Kumawat N, Mandal D and Kumar A. 2017. Rice breeding strategies of North Eastern India for resilience to biotic and abiotic stresses: A review. *Oryza* **54**(1): 1-12.

Kumar S, Kumar A, Pandey A, Pattanayak A, Singh J, Singh IM, Prakash N and Bhagawati R, Ngachan S. 2017. Genotype x environment interaction, adaptability and yield stability of rice genotypes of north east India. *Vegetos* **30** (Spl-1): 52-57.

Mohapatra S, Mohanta PR, Sarkar B, Daware A, Kumar C and Samantaray DP. 2017. Production of polyhydroxyalkanoates (PHAs) by Bacillus strain isolated from waste water and its biochemical characterization. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences* **87**: 459–466.

Padmavathi G, Satyanarayana PV, Vasantha Bhanu K, Jhansi Lakshmi V, Bhadana VP, Sheshu Madhav M and Ravindra Babu V. 2018. RP 5448-RIL-501 (IC0617119; INGR16001), a rice (Oryza sativa) germplasm with novel dual donor for resistance to both Brown Plant Hopper (BPH) and White Backed Plant Hopper (WBPH) possesses resistance at vegetative and reproductive stages. *Indian Journal of Plant Genetic Resources*, **31**(1): 101-102.

Rather S, Pandey ID, Panda GS and Kumar S. 2017. Relative efficiency of different emasculation methods in rice (*Oryza sativa* L.). *Environment & Ecology* **35** (3B): 2205-2208.

Sarkar B, Daware A, Gupta P, Krishnani KK, Barua S and Bhattacharjee S. 2017. Nanoscale wide band semiconductor for remediating aquatic pollution. *Environmental Science and Pollution Research* **24**: 25775-25797.

Sarkar B, Verma SK, Akhtar J, Netam SP, Gupta, SK, Panda PM and Mukherjee K. 2018. Molecular aspect of silver nanoparticles regulated embryonic development in zebrafish (*Danio rerio*) by *Oct-4* expression. *Chemosphere* **206**: 560-567.

Sengar N, Dutta MK and Sarkar B. 2017. Computer vision based technique for identification of fish quality after pesticide exposure. I*nternational Journal of Food Properties* **20**(2): 2192-2206.

Shafi A, Pal AK, Sharma V, Kalia S, Kumar S, Ahuja PS and Singh AK. 2017. Transgenic potato plants overexpressing SOD and APX exhibit enhanced lignification and starch biosynthesis with improved salt stress tolerance. *Plant Molecular Biology Reporter* **35**: 504–518.

Sharma P, Sirhindi G, Singh AK, Kaur H and Mushtaq R. 2017. Consequences of copper treatment on pigeon pea photosynthesis, osmolytes and antioxindants defense. *Physiology and Molecular Biology of Plants* **23**(4): 809-816.

Singh AK, Naskar S, Saikia B, Vashi Y, Gupta S, Banik S, Tamuli MK, Pande V, Sarma DK, Dhara SK. 2017. Effect of testicular tissue lysate on developmental competence of porcine oocytes matured and fertilized in vitro. *Reproduction in Domestic Animals* **52**(2): 183-188.

Singh BK, Choudhary SB, Yadav S, Malhotra EV, Rani R, Ambawat S, Priyamedha, Pandey A, Kumar R, Kumar S, Sharma HK, Singh DK and Rai PK. 2018. Genetic structure identification and assessment of interrelationships between *Brassica* and allied genera using newly developed genic-SSRs of Indian Mustard (*Brassica juncea* L.). *Industrial Crops and Products* **113**: 111-120.

Singh G, Singh G, Singh P, Parmar R, Paul N, Vashist R, Swarnkar MK, Kumar A, Singh S, Singh AK, Kumar S and Sharma RK. 2017. Molecular dissection of transcriptional reprogramming of steviol glycosides synthesis in leaf tissue during developmental phase transitions in *Stevia rebaudiana* Bert. *Scientific Reports* **7**: 11835.

Singh I, Smita S, Mishra DC, Kumar S, Singh BK and Rai A. 2017. Abiotic stress responsive miRNA-target network and related markers (SNP, SSR) in *Brassica juncea*. *Frontiers in Plant Science* **8**: 1943.

Sinha NK, Bhadana VP, Meena SR, Giri SP, Brajendra. 2017. Seed dormancy its alleviation and importance in agriculture. J*ournal of Pharmacognosy and Phytochemistry* **6**(6): 333-334.

Sinha NK, Ghosh J, Lohot VD, Monobrullah Md, Bhadana VP and Brajendra. 2017. Enhancement in seed set and seed yield in *Flemingia semialata* by using plant growth regulators. *Progressive Research – An International Journal* **11**: 644-648.

Soni SK, Yadav VK, Bhadana VP, Yadav MC and Sundaram RM. 2017. Prediction of heterosis using hypervariable microsatellite markers in tropical *japonica* × *indica* rice hybrids. *International Journal of Current Microbiology and Applied Sciences* **6**(10): 1419-1427.

Vashi Y, Naskar S, Chutia T, Banik S, Singha AK, Goswami J and Sejian V. 2018. Comparative assessment of native, crossbred and exotic pigs during different seasons (winter, spring and summer) based on rhythmic changes in the levels of serum cortisol, lactate dehydrogenase levels and PBMC HSP70 mRNA expression pattern. *Biological Rhythm Research* https://doi.org/10.1080/09291016.2017.1410019

Verma VK, Pandey A, Jha AK and Ngachan SV. 2017. Genetic characterization of chayote [*Sechium edule* (Jacq.) Swartz.] landraces of North Eastern Hills of India and conservation measure. *Physiology and Molecular Biology of Plants* **23**(4): 911-924.

Books

Banik S, Naskar S and Gandhi RS. 2017. *Swine genetic resources of India*. Indian Council of Agricultural Research, New Delhi.

Book Chapters

Aochen C, Pohlong J, Dutta SS, Pyngrope S, Aochen S and Pandey A. 2017. Physiological adaptations and dynamics for plant productivity under low light intensity. *Advances in Plant Physiology* **17**: 96-118.

Banik S and Naskar S. 2017. Breeding and selection strategies for piggery development. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp 27-34.

Banik S and Naskar S. 2017. Housing requirement for small scale piggery. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp 59-64.

Banik S and Naskar S. 2017. Pig genetic resources of India. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp 13-18.

Banik S and Naskar S. 2017. Sources of improved pig germplasm in North-Eastern states of India. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp 19-26.

Devi EL, Kumar S, Singh TB, Sharma SK, Beemrotea A, Devi Ch P, Chongtham SK, Singh Ch H, Yumlembam RA, Haribhusan A, Prakash N and Wani SH. 2017. Adaptation strategies and defense mechanisms of plants during environmental stress. In: Ghorbanpour, Varma A (eds.) *Medicinal Plants and Environmental Challenges*. Springer International Publishing AG, https://doi.org/10.1007/978-3-319-68717-9_20, pp 359-413.

Goel P and Singh AK. 2018. Single-versus multiple gene transfer approaches for crop abiotic stress tolerance. In: Wani SH (ed.) *Biochemical, Physiological and Molecular Avenues for Combating Abiotic Stress Tolerance in Plants*. Elsevier Inc. (doi. org/10.1016/B978 -0-12-813066-7.00014-0).

Jain M, Nagar P, Goel P, Singh AK, Kumari S, Mustafiz A. 2018. Secondary messengers: central regulators in plant abiotic stress response. In: Zargar S, Zargar M. (eds.) *Abiotic Stress-Mediated Sensing and Signaling in Plants: An Omics Perspective*. Springer-Nature, Singapore. pp 47-94. (doi. org/10.1007/978-981-10-7479-0_2).

Kumar S, Gahtyari NC, Kumar M, Kumar N. 2018. Enhancement of iron and zinc content in rice and wheat: A sustainable strategy to combat malnutrition. In: Singh V, Melkania U, Kushwaha GS, Negi V (eds.) *Agriculture against the climate odds*. SSDN Publisher and Distributors, pp 87.

Kumawat N, Kumar R, Kumar S and Meena VS. 2017. Nutrient solubilizing microbes (NSMs): Its role in sustainable crop production. In: Meena VS, Mishra PK, Bisht JK, Pattanayak A (eds.) *Agriculturally Important Microbes for Sustainable Agriculture*. Springer Nature DOI 10.1007/978-981-10-5343-6_2, pp: 25-61.

Lal SK, Kumar S, Sheri V, Mehta S, Varakumar P, Ram B, Borphukan B, James D, Fartyal D and Reddy MK. 2018. Seed priming: An emerging technology to impart abiotic stress tolerance in crop plants. In: Rakshit A, Singh HB (eds.) *Advances in Seed Priming*. Springer Nature DOI 10.1007/978-981-13-0032-5.

Naskar S, Vashi Y, Banik S and Singh AK. 2017. Genetics of pig reproduction. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp111-118.

Naskar S, Vashi Y, Banik S. 2017. Advances in molecular pig breeding. In: Thomas R, Sharma DK (eds.) *Pig Production and Pork Processing - Indian Perspective*. Jaya Publishing House, Delhi, pp 35-42.

Pandey A, Kumar A, Aochen C and Bhattacharyajee B. 2017. Research contribution of Plant Breeding and Biotechnology. In: Das A *et al*. (eds.) *4 Deacdes of Agricultural Research in NEH Region 1975-2017*.

ICAR RC for NEH Region, Umiam, Meghalaya, pp 11-23.

Prakash N, Ningombam A, Singh KR, Singh TB, Singh IM, Bashudha C, Sahoo MR, Roy SS, Kumar S *et al*.. 2017. Research contribution of ICAR Research Complex Manipur Centre. In: Das A *et al*. (eds.) *4 Deacdes of Agricultural Research in NEH Region 1975-2017*. ICAR RC for NEH Region, Umiam, Meghalaya, pp 198-220.

Papers in Seminar/Symposia/Conference

Bhuria M, Kumar S and Singh AK. 2017. *AtUSP17* negatively regulates salt tolerance and mediates cross-talk between ABA, ethylene, ROS and G protein signalling. Lecture delivered at the *National Conference of Plant Physiology*, at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur during Nov 23-25, 2017.

Hirakawa H, Chahota RK, Shirasawa K, Nagano S, Nagasaki H, Sharma TR and Isobe S. 2017. Draft genome sequence of horsegram (*Macrotyloma uniflorum*) In: *Plant and Animal Genome Conference*, Asia, May 29-31, 2017, Seoul, South Korea.

Pal AK, Acharya K, Shafi A, Kumar S, Ahuja PS and Singh AK. 2018. Development of biotic and abiotic stress tolerant transgenic potato. Oral presentation delivered at *National Symposium on Plant Biotechnology* organized by Plant Tissue Culture Association (India) at Arid Forest Research Institute, Jodhpur during Feb 16-18, 2018.

Rana M, Verma P, Hussian W, Kaldate RC, Divya Shikha, Kaachra A, Chahota RK, Bhatia S, Sharma TR. 2017. Molecular mapping of quantitative trait loci for drought tolerance and yield traits in lentil. In: *International Conference on InterDrought-V*, HICC, Hyderabad during Feb 21-25, 2017.

Singh AK. 2018. Application of next generation genomics for climate smart agriculture. Invited lecture delivered in the *National Conference on Challenges and Strategies to Improve Crop Productivity in Changing Environment: An Integrated Approach* at Zakir Hussain Delhi College, University of Delhi, Delhi on Jan 12, 2018.

Singh AK. 2018. Functional genomic approaches for crop improvement under changing climate scenario. Oral presentation at *National Conference on "Biodiversity Conservation and Environmental Management"* at Poddar International College, University of Rajasthan, Jaipur during Feb 26-27, 2018.

Vashi Y, Laxmi Vandana R, Kalita D, Banik S, Sahoo NR and Naskar S. 2018. Mitochondrial genetic diversity and population structure in indigenous pig breeds of India. In: *International Symposium on Biodiversity and Biobanking, BIODIVERSE 2018* at IIT Guwahati during Jan 27-29, 2018.

Technical/Popular Articles

Banik S, Ahmed SP, Handique S, Das PJ, Naskar S and Sahoo NR. 2017. Polyacrylamide gel electrophoresis. In: *Training Manual of DBT-sponsored Winter School on "Advances in molecular techniques in animal health and production with particular reference to pigs"* (24 Nov - 14 Dec, 2017), org. by/at ICAR-NRC on Pig, Guwahati, pp. 93-96.

Choudhury TG, Vinay TN, Gupta SK, Gita S and Sarkar B. 2017. *Edwardsiellosis*: An Emerging Disease in Indian Aquaculture. *Aquaculture times* 3(2): 38-40.

Gupta SK, Pal AK, Kumar N and Sarkar B. 2017. Dietray Nutraceutical and Immunity A new facet for modern aquaculture. *Livestock and feed trends*, June-July issue. Vol. 15 (2) 7-9.

Gupta SK. 2017. हिमालय क्षेत्र कि नदियों में पाई जानेवाली *गारा गोत्यला गोत्यला* (पत्थर चटा) मछली : भा.कृ.अनु.प.–क्रेद्रीय मीठाजीव पालन अनुसन्धान संस्थान की जल पत्रिका, अंक 1 सितंबर, संपादक डा. धनंजय कुमार वर्मा, डा. शैलेश सौरभ, श्रीमती विजयलक्ष्मी धीर 1 पृष्ठांक 55-57.

Mohapatra S, Patnaik S, Samantaray DP, Singh BK, Gupta SK, and Sarakar B. 2017. Biodegradable plastics from marine microbial sources. *Aqua International*, June issue. 58-62.

Pawar DV, Mahajan M, Prajapt RK and Tribhuvan KU. 2017. Metabolomics for rice blast resistance. *Biotech articles.* http://www.biotecharticles.com/Biotech-Research-Article/Metabolomics-for-Rice-Blast-Resistance-3846.htm

Pawar DV, Mahajan M, Prajapt RK, Tribhuvan KU. 2017. Diagnosis of plant diseases. *Biotech articles*. http://www.biotecharticles.com Biotech-Research-Article/Diagnosis-of-Plant-Diseases-3967.html

Pawar DV, Mahesh Mahajan, Prajapt RK and Kishor U Tribhuvan. 2017. Consequences of amino acid substitutions on protein function. *Biotech articles.* http://www.biotecharticles.com/Genetics-Article/Consequences-of-Amino-Acid-Substitutions-on-Protein-Function-3849.html

Pawar DV, Tribhuvan KU and Singh J. 2017. Gene Switching and GURTs: What, How, and Why? *Biotech articles.* https://www.biotecharticles.com/Biotech-Research-Article/Gene-Switching-and-GURTs-What-How-and-Why-4112.html

Pawar DV, Tribhuvan KU and Singh J. 2017. How Genetic Engineering is different from Conventional Breeding? *Biotech articles.* https://www.biotecharticles.com/Biotech-Research-Article/How-Genetic-Engineering-is-different-from-Conventional-Breeding-4056.html

Pawar DV, Tribhuvan KU and Singh J. 2017. In-silico Gene Prediction Tools *Biotech articles.* https://www.biotecharticles.com/Biotech-Research-Article/In-silico-Gene-Prediction-Tools-4070.html

Pawar DV, Tribhuvan KU and Singh J. 2017. Microbial Fermentation for Plant Nutrition and Battling Weeds and Pests. *Biotech articles.* https://www.biotecharticles.com/Biotech-Research-Article/Microbial-Fermentation-for-Plant-Nutrition-and-Battling-Weeds-and-Pests-4057.html

Saikia T, Nath A, Pegu SR, Naskar S, Banik S and Das PJ. 2017. Quantitative PCR and its application. In: *Training Manual of DBT-sponsored Winter School on "Advances in molecular techniques in animal health and production with particular reference to pigs"* held at ICAR-NRC on Pig, Guwahati during Nov 24 - Dec 14, 2017, pp 25-32.

Sanand S, Tribhuvan KU, Kumar S, Tyagi A. 2017. Nanostructured materials: Classification and methods of characterization. *Biotech articles.* http://www.biotecharticles.com/ Nanotechnology-Article/Nanostructured-Materials-Classification-and-Methods-of-Characterization-3922.html

Sen SK, Sarkar B and Bandyopadhay P. 2017. Biofloc Technology: a value addition in shrimp culture. *Aquastar* 55-58.

Singh BK, Kumar R, Pandey A, Kumar S, Sarkar B, Bhadana VP. 2017. *Abhasi kand* (False Smat) *dhan ki ak ubharti bimari* (In Hindi). *Laksha*, 51.

Singh BK, Kumar R, Pandey A, Kumar S, Sarkar B, Bhadana VP. 2017. Phosphorous evam khadya suraksha (In Hindi). *Laksha*, 49-50.

Tribhuvan KU, Das A, Sanand S, Watts A and Junaid A. 2017. Journey of immunoglobulin protein: An antibody to plantibody. *Biotech articles.* http://www.biotecharticles.com/Biotech-Research-Article/Journey-of-Immunoglobulin-Protein-An-Antibody-to-Plantibody-3921.html

Tribhuvan KU, Pawar DV, Watts A, Watts A and Saini RP. 2017. Biogenesis of siRNA: Exogenous or Endogenous? *Biotech articles.* http://www.biotecharticles.com/Biotech-Research-Article/Biogenesis-of-siRNA-Exogenous-or-Endogenous-3829.html

Vashi Y, Naskar S, Banik S, Das PJ and Rajkhowa S. 2017. Basics of primer designing and use of softwares. In: *Training Manual of DBT-sponsored Winter School on "Advances in molecular techniques in animal health and production with particular reference to pigs"* held at ICAR-NRC on Pig, Guwahati during Nov 24 - Dec 14, 2017, pp 73-78.

Vashi Y, Naskar S, Banik S, Das PJ and Rajkhowa S. 2017. Biosafety guidelines on safety measures in respect of rDNA research. *In: Training Manual of DBT-sponsored Winter School on "Advances in molecular techniques in animal health and production with particular reference to pigs"* held at ICAR-NRC on Pig, Guwahati during Nov 24 - Dec 14, 2017, pp 81-84.

Vashi Y, Naskar S, Banik S, Das PJ and Rajkhowa S. 2017. Genetic variation and its application in pig health and production. In: *Training Manual of DBT-sponsored Winter School on "Advances in molecular techniques in animal health and production with particular reference to pigs"* held at ICAR-NRC on Pig, Guwahati during Nov 24 - Dec 14, 2017, pp 79-80.

Watts A, Watts A, Tribhuvan KU, Malhotra EV and Meena RP. 2017. Cell to cell communication in plants. *Biotech articles.* http://www.biotecharticles.com/Microbiology-Article/Cell-to-Cell-Communication-in-Plants-3905.html

Watts A, Watts A, Tribhuvan KU, Malhotra EV and Meena RP. 2017. Method of determining transcription start sites. *Biotech articles.* http://www.biotecharticles.com/Microbiology-Article/Methods-of-Determining-Transcription-Start-Site-3812.html

Abstract In Scientific Proceedings

Debnath P, Pande R, Patra S, Layek J, Pandey A and Majumdar D. 2017. Evaluation of botanicals against mustard aphid, *Lipaphis erysimi* (Kaltenbach) in Mid Hills of Meghalaya. In: *National Seminar on Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES)* at ICAR Research Complex for NEH Region, Umiam, Meghalaya during Sep 19-21, 2017, pp 103.

Devi YS, Pandey A, Kumar A, Ansari MA, Rai M, Tyagi W and Das A. 2017. Genetic variability analysis by morphological and molecular markers in ricebean (*Vigna umbellata*). In: *National Seminar on Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES)* at ICAR Research Complex for NEH Region, Umiam, Meghalaya during Sep 19-21, 2017, pp 258.

Gupta SK, Sarkar B, Bhattacharjee S, Naskar S and Kumar N and Uppuluri KB. 2018. Modulation of cytokines expression in pathogen aggravated *L. rohita* H. post dietary delivery of microbial levan In: *Genius* **VI**(II, Feb- July): 16-17.

Gupta SK, Sarkar B, Bhattacharjee S, Naskar S and Kumar N. 2017. Expression analysis of some immuno-responsive genes in pathogen aggravated, *Labeo rohita* fed with dietary microbial levan In: *Book of abstract on 11th International Indian Fisheries and Aquaculture forum*. Abstract No. AH-OR22, pp 300.

Kumar A, Lego A, Pandey A, Das A, Ngachan SV and Prakash N. 2018. Assessment of genetic diversity in indigenous rice germplasm of North East India. *3rd ARRW International symposium, Frontiers of Rice Research for Improving Productivity, Profitability and Climate Resilience*, at Cuttack, Odisha, India during Feb 6-9 , 2018.

Kumar A, Pandey A, Kumar S, Iangrai B, Sarika K and Das A. 2017. Evaluation of soybean genotypes for agro-morphological traits in Meghalaya. In: *National Seminar on Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES)* at ICAR Research Complex for

NEH Region, Umiam, Meghalaya during Sep 19-21, 2017, pp 250.

Kumar A, Pandey A, Rai M and Das A. 2018. Evaluation of genetic diversity and interrelationship of agro-morphological characters in flax genotypes. In: *International Congress on Cotton and Other Fibre Crops at ICAR RC for NEH Region*, Umiam, Meghalaya during Feb 20-23 , 2018.

Kumar M, Pandey A, Kumar S, Kumar R, Singh BK and Bhadana VP. 2018. Genetic diversity in rice germplasm collected from Jharkhand as revealed by SSR markers. In: *souvenir cum lead proceeding book of 2nd International Conference on Agriculture*, Dhanbad Jharkhand, pp 118-119.

Kumar R, Choudhury AR, Kumari, R, Singh BK, Bhadana VP and Sarkar B. 2018. Inhibitory role of silver nanoparticles against important bacterial pathogen of rice (*Oryza sativa*). In: *Book of abstract on International Conference on trends in biochemical and biomedical research-Advances and challenges*'' at Banaras Hindu University, Varanasi, pp 175.

Kumar R, Lal S K, Singh BK, Kumar S, Pandey A, Kumar M, Kumari R, Sarkar B and Bhadana VP. 2018. Large-scale screening of germplasm for identification of novel rice blast resistance sources In: *souvenir cum lead proceeding book of 2nd International Conference on Food and Agriculture 2018* held at Dhanbad, Jharkhand during March 29-31, 2018.

Kumar S, Prakash N, Singh IM, Kumar A, Bhadana VP, Kumar M, Pandey A and Singh BK. 2018. Molecular characterization of rice germplasm of north eastern India thorough SSR markers. In: *souvenir cum lead proceeding book of 2nd International Conference on Food and Agriculture 2018* held at Dhanbad, Jharkhand during March 29-31, 2018.

Sarkar B and Gupta SK. 2018. Environmental nanotechnology promises Innovations in remediating aquatic pollution. In: *Genius* **VI** (Feb-July): 2.

Sarkar B, Choudhury AR, Gupta SK and Srivastava S. 2018. Nanoscale zinc remediates water pollution. *ICWWMM-2018*, held at Central University of Jharkhand during Jan 16-17, pp 6.

Sarkar B, Gupta SK, Choudhury AR, Srivastava S. 2018. Nanoscale zinc remediates water pollution In: *Abstract book of International conference on water and waste water management and modelling*. pp 6.

Singh AK, Naskar S, Saikia B, Vashi Y, Santra L, Tamuli MK, Banik S, Pande V and Dhara SK. 2018. Effect of oviductal fluid-conditioned media and variable co-incubation time on developmental competence of porcine oocytes matured and fertilized in vitro. In: *Compendium, XXXIII Annual Convention and National Symposium of the Indian Society for Study of Animal Reproduction (ISSAR) on "Use of reproductive technologies and production improvement in livestock species aiming to socio-economic development of rural mass"* (9-11 Feb, 2018), org. by ISSAR West Bengal Chapter in collaboration with Animal Resources Development Department, Govt. of West Bengal and West Bengal University of Animal & Fishery Sciences, org. at WB Veterinary Council, Kolkata, pp 140.

Vashi Y, Laxmi Vandana R, Kalita D, Banik S, Sahoo NR and Naskar S. 2018. Mitochondrial genetic diversity and population structure in indigenous pig breeds of India. In: *Souvenir and Abstract Book, International Symposium on Biodiversity and Biobanking, BIODIVERSE 2018* (27-29 January, 2018), org. by IIT-Guwahati and Association for the Promotion of DNA Fingerprinting and other DNA Technologies (ADNAT), Hyderabad, org. at IIT-Guwahati, pp 31-32.

Verma VK, Pandey A and Jha AK. 2017. Genetic diversity of important legume vegetables in North Eastern States of India. In: *National Seminar on Smart Farming for Enhancing Input Use efficiency, Income and Environmental Security (SFEIES)* at ICAR Research Complex for NEH Region, Umiam, Meghalaya during Sep 19-21, 2017, pp 262.

e-Publication

Naskar S, Gupta SK, Kumar R and Puran A. 2018. Enhancing food, nutritional and livelihood security of marginal and small farmers in jharkhand through need based agricultural technologies by ICAR-IIAB, Ranchi under FFP. (https://ffp.icar.gov.in/Publications/Grap hical%20 Abstract%201_FFP_IIAB,%20Ranchi_Asha.pdf)

Puran A, Maurya S, Naskar S and Gupta SK. 2018. Increase in income of women by mushroom production at ICAR-IIAB, Ranchi. (https://ffp.icar.gov.in/Publications/Mushroom%20 Production_ICAR-IIAB,%20Ranchi.pdf)

Leaflets

- झारखण्ड में कुपोषण निवारण हेतु उच्च प्रोटीन युक्त धान की खेती। मदन कुमार, ऋषिकेश कुमार, सुधीर कुमार, अविनाश पाण्डेय, विनय कुमार सिंह, विजय पाल भडाना एवं देवेन्द्र कुमार सिंह। **आई. आई. ए. बी. तकनीकी पत्रक : 2017(2)**
- सूखारोधी धान आई० आर० 64 डी०आर०टी०-1: झारखंड के लिए बहुपयोगी धान। सुधीर कुमार, ऋषिकेश कुमार, मदन कुमार, अविनाश पाण्डेय, विनय कुमार सिंह, विजय पाल भडाना एवं रितु कुमारी। **आई. आई. ए. बी. तकनीकी पत्रक : 2017(3)**
- झारखण्ड में सरसों की उन्नत खेती। सुधीर कुमार, ऋषिकेश कुमार, मदन कुमार, अविनाश पाण्डेय, विनय कुमार सिंह, विजय पाल भडाना। **आई. आई. ए. बी. तकनीकी पत्रक : 2017(4)**

Budget Allocation And Utilization

(Rs. In Lakhs)

S. No.	Head	Expenditure during 2017- 2018			
		B.E. 2017-18	R.E. 2017-18	Expenditure during 2017-18	Utilization % with respect to RE
1	2	3	4	5	6
Grants for creation of Capital Assets (CAPITAL)					
1	**Works**				
	A. Land	0.00	0.00	0.00	-
	B. Building	0.00	0.00	0.00	-
	i. Office building	400.00	400.00	47.21	11.8
	ii. Residential building	0.00	0.00	0.00	-
	iii. Minor works	0.00	0.00	0.00	-
2	**Equipments**	**75.00**	**75.00**	**35.49**	**47.3**
3	**Information Technology**	**5.00**	**5.00**	**4.74**	**94.8**
4	**Library Books and Journals**	**5.00**	**5.00**	**3.08**	**61.6**
5	**Vehicles & Vessels**	**12.00**	**12.00**	**0.00**	**-**
6	**Livestock**	**0.00**	**0.00**	**0.00**	**-**
7	**Furniture & Fixtures**	**5.00**	**5.00**	**4.88**	**97.6**
8	**Others**	**0.00**	**0.00**	**0.00**	**-**
	Total-CAPITAL (Grants for creation of Capital Assets)	**502.00**	**502.00**	**95.40**	**19.0**
Grants in Aid - Salaries (REVENUE)					
1	**Establishment Expenses**	**0.00**	**0.00**	**0.00**	**-**
	A. Salaries	**0.00**	**0.00**	**0.00**	**-**
	i. Establishment Charges	240.00	240.00	210.35	87.6
	ii. Wages	0.00	0.00	0.00	-
	iii. Overtime Allowances	0.00	0.00	0.00	-
	B. Loans and Advances	**0.00**	**0.00**	**0.00**	**-**
	Total-Establishment Expenses (Grants in Aid - Salaries)	**240.00**	**240.00**	**210.35**	**87.6**

Budget Allocation And Utilization

1	2	3	4	5	6
Grants in Aid - General (REVENUE)					
1	**Pension & Other Retirement Benefits**	**10.00**	**10.00**	**10.00**	**100**
2	**Travelling Allowance**				
	A. Domestic TA/Transfer TA	11.00	11.00	10.88	98.9
	B. Foreign TA	0.00	0.00	0.00	-
	Total - Traveling Allowance	**11.00**	**11.00**	**10.88**	**98.9**
3	**Research & Operational Exp.**				
	A. Research Expenses	20.00	20.00	19.98	99.9
	B. Operational Expenses	20.50	20.50	20.49	99.9
	Total - Res. & Operational Exp.	**40.50**	**40.50**	**40.47**	**99.9**
4	**Administrative Expenses**				
	A. Infrastructure	**46.00**	**46.00**	**45.43**	**98.8**
	B. Communication	**2.00**	**2.00**	**1.61**	**80.5**
	C. Repairs & Maintenious	**0.00**	**0.00**	**0.00**	**-**
	i. Equipments, Vehicles & Others	2.00	2.00	0.50	24.9
	ii. Office building	0.00	0.00	0.00	-
	iii. Residential building	0.00	0.00	0.00	-
	iv. Minor Works	5.00	5.00	5.00	100
	D. Other (excluding TA)	**8.00**	**8.00**	**6.62**	**82.8**
	Total - Administrative Expenses	**63.00**	**63.00**	**59.16**	**93.9**
5	**Miscellaneous Expenses**				
	A. HRD (Institute)	2.00	2.00	2.00	100
	B. HRD (TSP)	2.00	2.00	0.28	14.0
	C. Other items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	-
	D. Publicity & Exhibitions	0.50	0.50	0.43	86.0
	E. Other Miscellaneous (Institute)	2.00	2.00	0.82	41.0
	F. Other Miscellaneous (TSP)	5.00	5.00	0.47	9.4
	Total - Miscellaneous Expenses	**11.50**	**11.50**	**4.00**	**34.8**
	Total Grants in Aid - General	**136.00**	**136.00**	**124.51**	**91.6**
	Total Revenue (Grants in Aid - Salaries + Grants in Aid - General)	**376.00**	**376.00**	**334.86**	**89.1**
	Grand Total (Capital + Revenue)	**878.00**	**878.00**	**430.26**	**49.0**

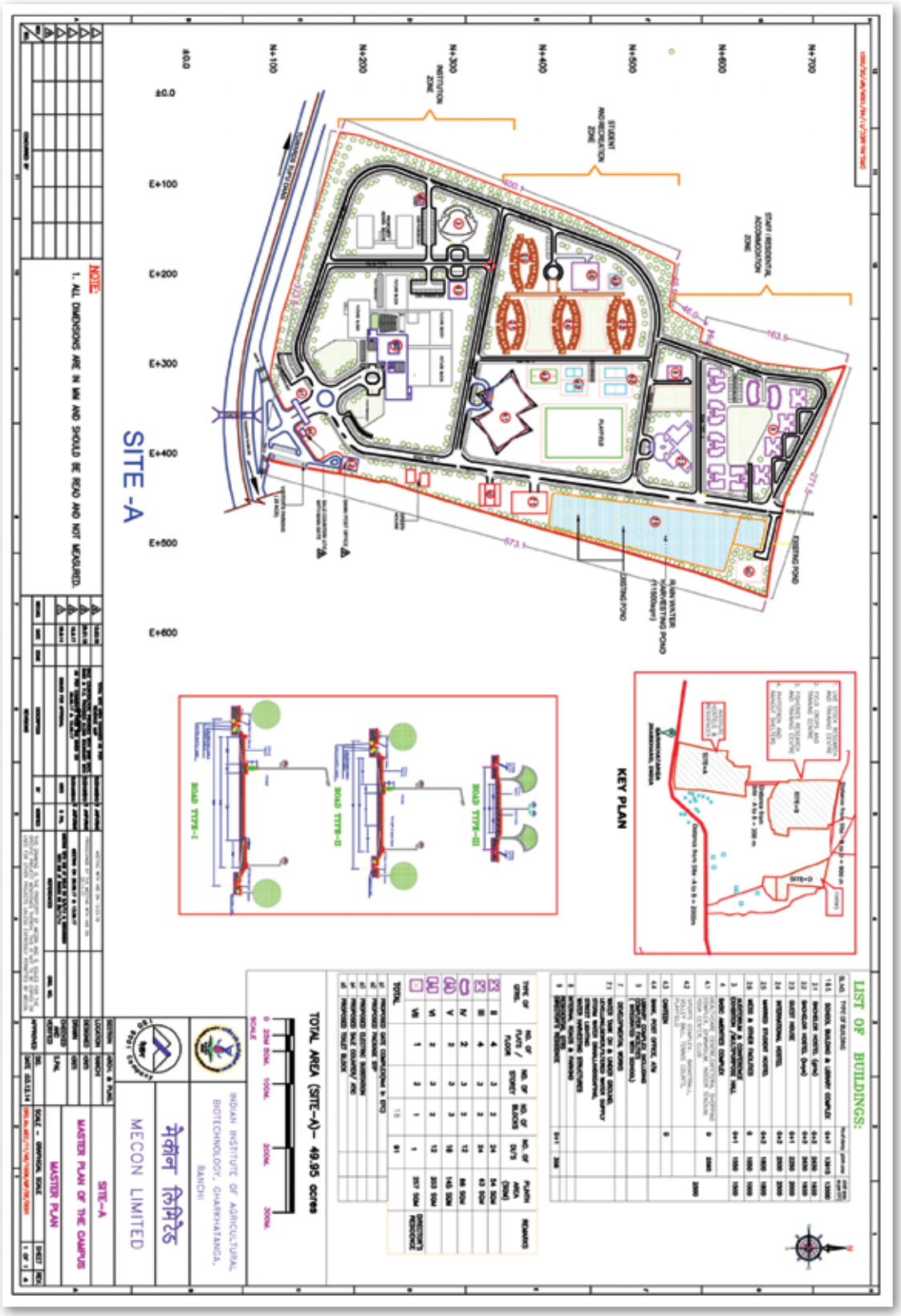
Important Committees

Research Advisory Committee	
Prof. V.L. Chopra, Former Secretary, DARE & DG, ICAR, New Delhi	Chairman
ADG (Seed), ICAR, New Delhi	Member
Prof. K.R. Koundal, Former Joint Director (Research), ICAR-IARI & Scientist Emeritus, ICAR-NRCPB, New Delhi	Member
Dr. W.S. Lakra, Former Director, ICAR-Central Institute of Fisheries Education, Mumbai	Member
Dr. B.P. Mishra, Joint Director (Research), ICAR-Indian Veterinary Research Institute, Izzatnagar, Bareilly, UP	Member
Prof. H.S. Dhaliwal, Vice-Chancellor, Eternal University, Baru Sahib, Sirmour, Himachal Pradesh	Member
Dr. T.R. Sharma, Director, ICAR-IIAB, Ranchi	Member
Prof. K. Veluthambi, Former Head, Department of Plant Biotechnology, School of Biotechnology, Madurai Kamraj University, Madurai, Tamil Nadu	Member
Two persons representing agricultural/rural interests on the management committee of the Institute in terms of Rule 66(a)(5)	Member
Dr. V.P. Bhadana, Principal Scientist, ICAR-IIAB, Ranchi	Member Secretary
Institute Management Committee (IMC)	
Dr. T.R. Sharma, Director, ICAR-IIAB, Ranchi	Chairman
Dr. Kishor Gaikwad, Principal Scientist, ICAR-NRCPB, New Delhi	Member
Dr. J.C. Rana, Head, Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi	Member
Dr. Vindhya Mohindra, Head, Fish Conservation Division, ICAR-NBFGR, Lucknow	Member
Dr. Anil Rai, Head, ICAR-IASRI, New Delhi	Member
ADG (Seeds) ICAR, New Delhi	Member Secretary
Institute Research Committee (IRC)	
Dr. T.R. Sharma, Director, ICAR-IIAB, Ranchi	Chairman
All Scientific Staff of ICAR-IIAB, Ranchi	Member
Dr. S. Naskar, Sr. Scientist, ICAR-IIAB, Ranchi	Member Secretary

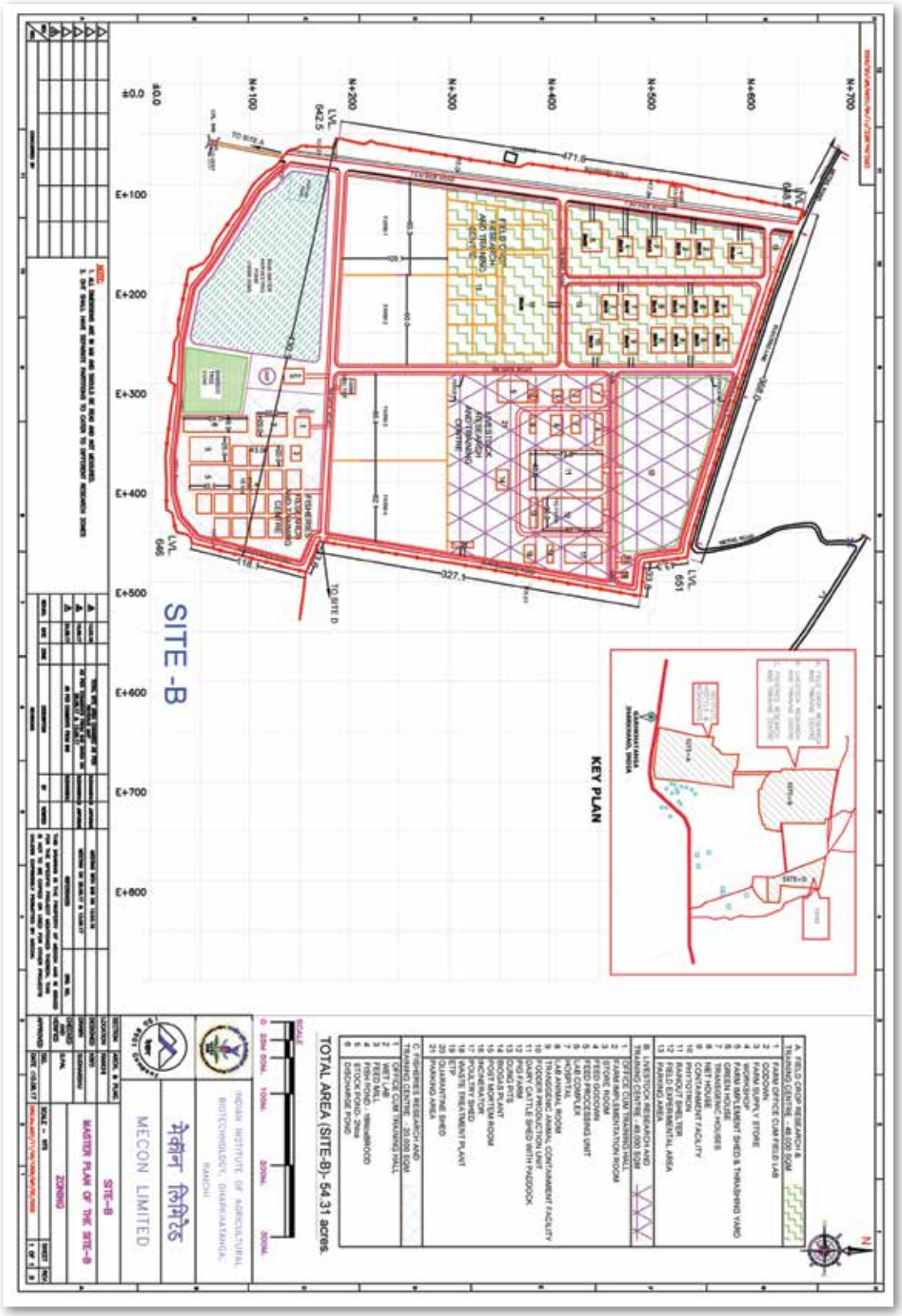
Distinguished Visitors

Sl. No.	Name	Designation	Date of Visit
1	Dr. D.K. Yadav	ADG (Seed), ICAR, New Delhi	May 11-12, 2017
2	Dr. T. Mohapatra	Secretary, DARE & DG, ICAR, New Delhi	July 23, 2017
3	Dr. P. Kaushal	Vice Chancellor, BAU, Ranchi	Aug 25, 2017
4	Dr. Ashwani Pareek	Professor, School of Life Sciences, JNU, New Delhi	Aug 25, 2017
5	Dr. N.K. Singh	National Professor, ICAR-NRCPB, New Delhi	Sept 18, 2017
6	Prof. V.L. Chopra	Former Secretary, DARE & DG, ICAR, New Delhi	Nov 14-15, 2017
7	Prof. H.S. Dhaliwal	Vice-Chancellor, Eternal University, Baru Sahib, Himachal Pradesh	Nov 14-15, 2017
8	Prof. K. Veluthambi	Former Head, Department of Plant Biotechnology, School of Biotechnology, Madurai Kamaraj University, Madurai	Nov 14-15, 2017
9	Dr. W.S. Lakra	Former Director, ICAR-Central Institute of Fisheries Education, Mumbai	Nov 14-15, 2017
10	Dr. B.P. Mishra	Joint Director (Research), ICAR-Indian Veterinary Research Institute, Izzatnagar, Bareilly, UP	Nov 14-15, 2017
11	Dr. S.K. Singh	Agricultural Specialist, USDA, USA	Jan 16, 2018
12	Dr. Narendra Tuteja	Professor & Director, Amity Institute of Microbial Technology, Amity University, Noida, UP	Mar 28, 2018

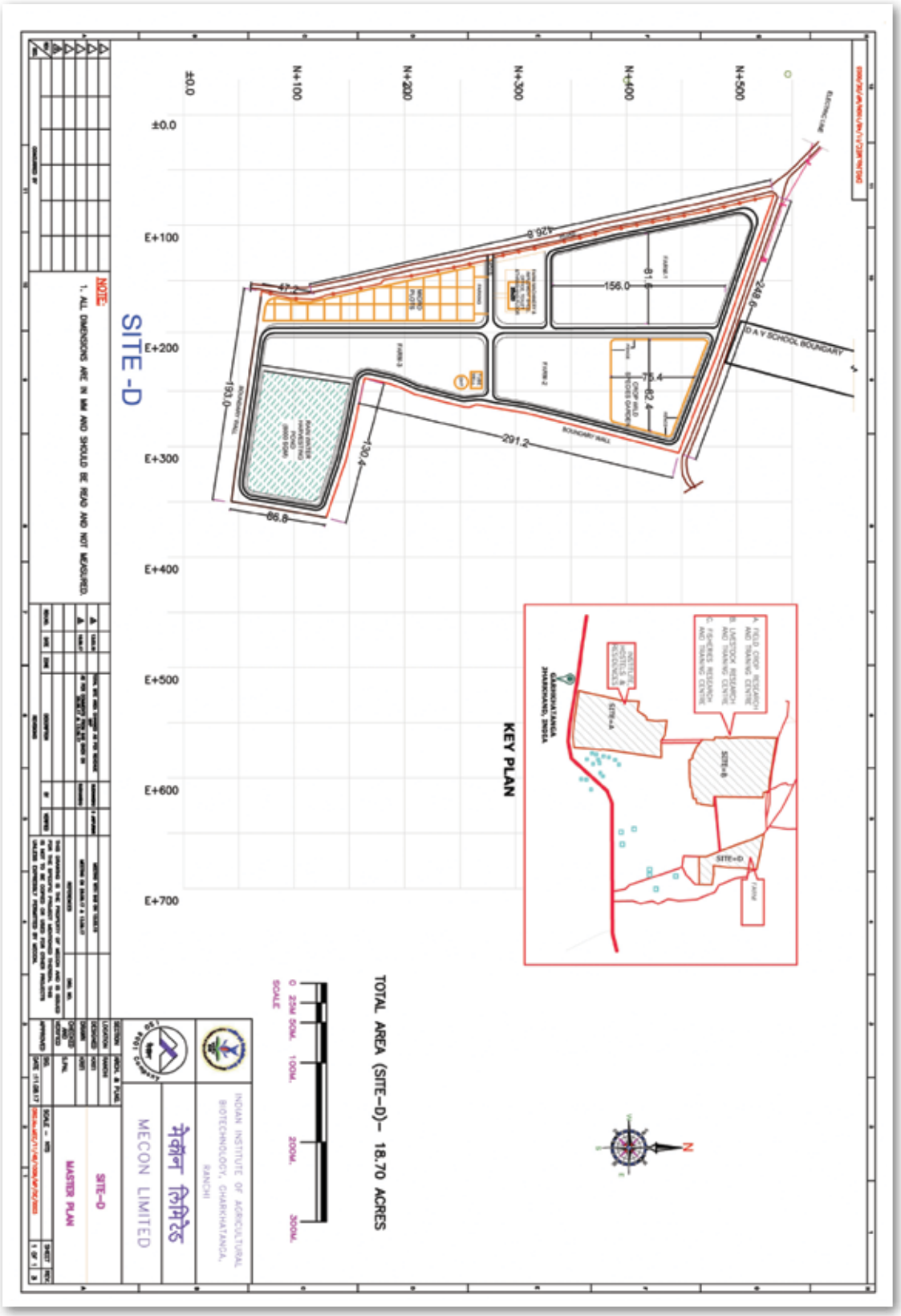
ICAR-IIAB Master Plan & Infrastructure Design



ICAR-IIAB Master Plan & Infrastructure Design



ICAR-IIAB Master Plan & Infrastructure Design



ICAR - Indian Institute of Agricultural Biotechnology

Garhkhatanga, Ranchi – 834 010, Jharkhand, India
Phone: +91 651 2261125; Fax: +91 651 2261122
Email: iiab.ranchi@gmail.com | Website: https://iiab.icar.gov.in

Present address : ICAR-IIAB, PDU Campus, ICAR-IINRG
Namkum, Ranchi - 834 010 (Jharkhand)