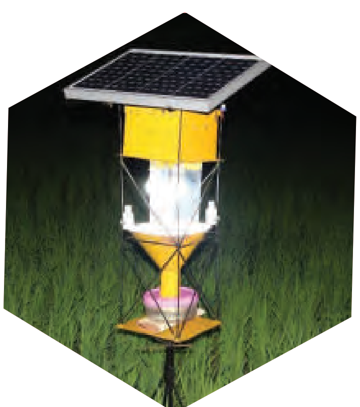
आज़ादी का अमृत महोत्सव

ANNUAL REPORT 2023



भाकृअनुप
ICAR

ICAR Research Complex for Eastern Region

ICAR Parisar, P.O.: Bihar Veterinary College

Patna-800 014 (Bihar)

Annual Report
2023

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Annual Report 2023

ICAR Research Complex for Eastern Region, Patna

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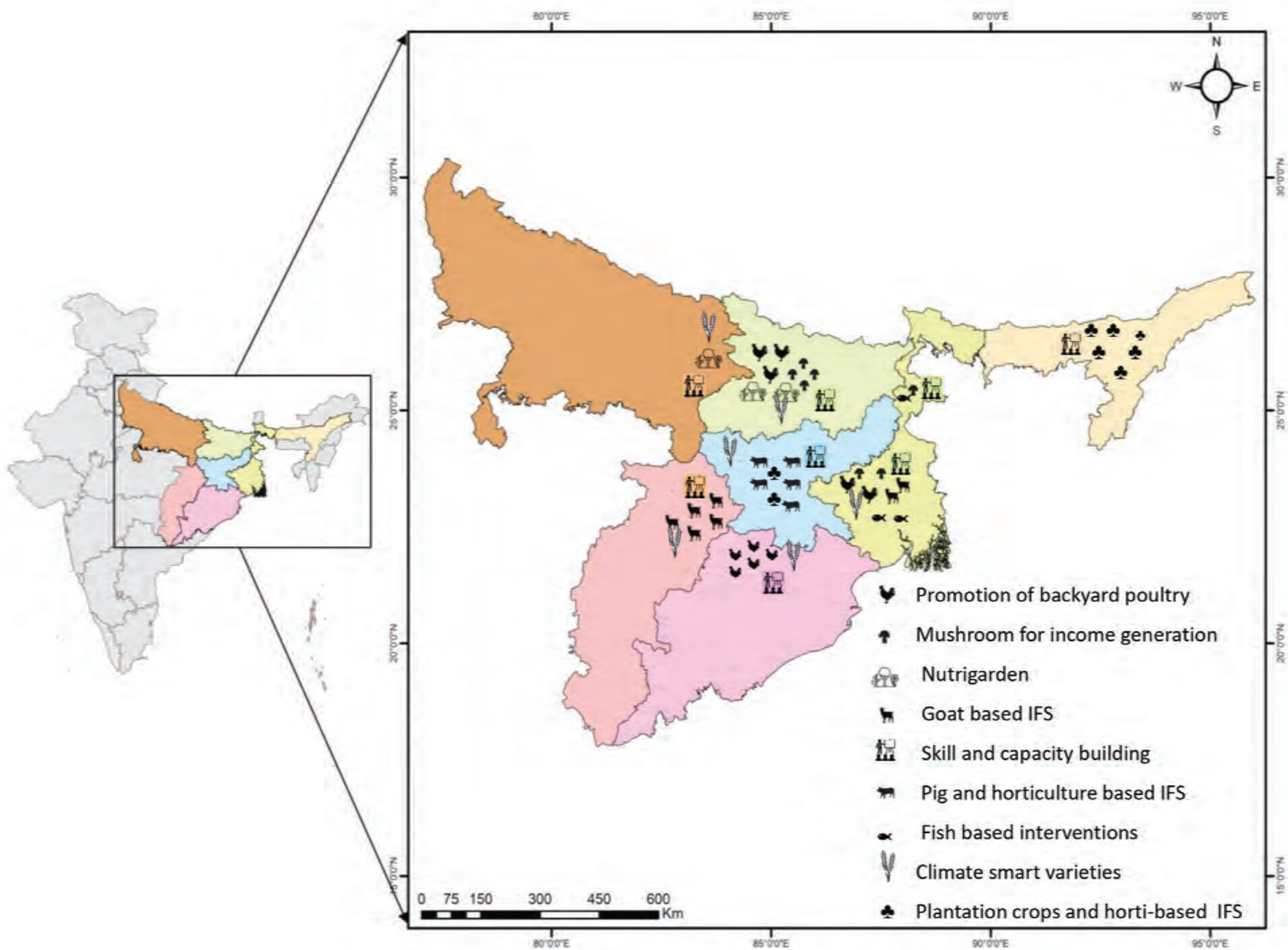
PREFACE

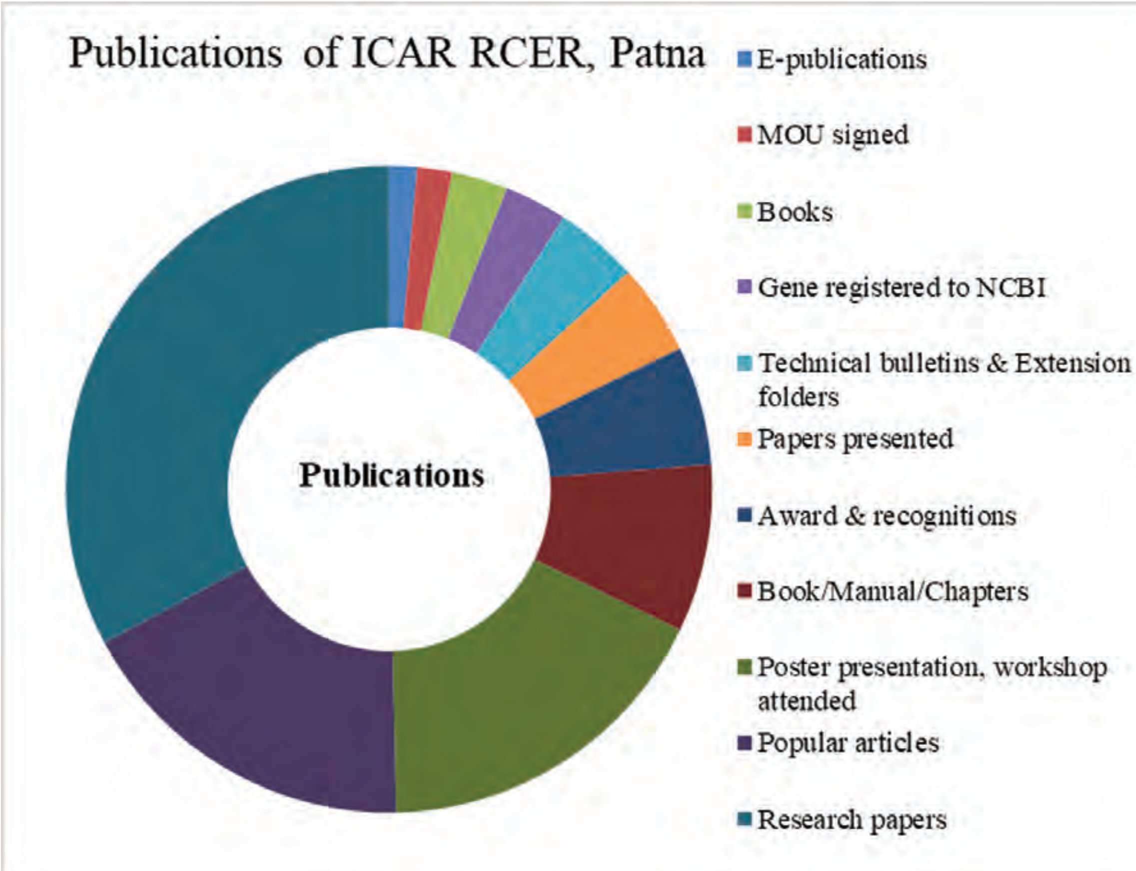
Eastern region of India is endowed with abundant natural resources like fertile soils, good rainfall, biodiversity, strong workforce among many others. However, its potential could not be realised in terms of optimum farm productivity, alleviation of malnutrition and poverty. ICAR Research Complex for Eastern Region, Patna with its centre on Farming System Research Centre for Hill & Plateau Region, Plandu, Ranchi and two KVKs, one each in Bihar (Buxar) and Jharkhand (Ramgarh) is striving hard to develop appropriate technologies since its inception to address issues like conservation of natural resources, enhancing soil and water productivity, climate change mitigation, greening vast rice fallow areas (9.55 m ha), sustainable intensification of rice-wheat cropping system through inclusion of summer mungbean, productivity enhancement of hill and plateau region through horti-livestock based integrated farming systems (IFS), location specific IFS and land use models for small and marginal farmers, characterisation and registration of indigenous livestock, enhancing productivity of seasonal and perennial water bodies, efficient technology transfer and many others. Institute could develop three rice varieties and four vegetable varieties, register two livestock (Red purnea cattle, Maithili duck), 13 technologies certified centrally, produced 25 q vegetable, 379 q pulses and 140 q rice seeds during the year 2023-24. During the year, 2 technologies were commercialised and 5 MoUs were signed with universities/ various organizations for strengthening research, teaching and development activities. Initiation of IARI- Patna hub at ICAR RCER, Patna is a milestone for the Institute where UG, PG & Ph.D teaching and guidance programme are implemented in collaboration with satellite Institutes like ATARI, CPRS, NRCL, MGIFRI and IARI, Pusa, Samastipur. New initiatives like evaluation of crop varieties for natural/organic farming, Integrated Natural/ Organic Farming Systems, model farm on multiple use of water, holistic GHG emission assessment in Rice-wheat –mungbean cropping system, nutri-cereals/millets programme etc. will go a long way in promoting resilient agriculture in the region. It's noteworthy to mention that our multiple stress tolerant rice variety "Swarna Samriddhi" is proposed to be released for Bangladesh through IRRI-NRRI Network. Our vegetable soyabean variety 'Swarna Vasundhara' is getting wider acceptability for its quality across eastern India and beyond. Solar energy based farm machineries developed by Institute like solar paddy thresher, solar fish vending machine, solar hybrid insect trap are appreciated across board for their eco-friendly nature and efficiency. CRA programme with Govt. of Bihar has generated many useful information on climate resilient agriculture in dealing with drought, moisture stress, terminal heat stress, etc. through climate resilient crop varieties, millets, intercropping, no-till farming, land lavelling, raised bed planting, custom hiring centre, sustainable croppingsystems and capacity building activities. PRAYAS (Participatory Research Application for Year-round income and Agricultural Sustainability) is a single window technology transfer module across seven eastern states for SCSP, TSP and other such activities which have been gaining attention of the stakeholders. As we enter the Silver Jubilee year and going to celebrate 25th foundation day on 22 Feb 2025, the emphasis of the Institute is to harness the potential of modern science, encourage innovations in technology generation, and provide an enabling policy support by developing effective collaborations and linkages. I sincerely convey my gratitude to honourable Secretary, DARE & DG, ICAR for providing all-round support for realising the potential of the Institute. The support and guidance of honourable DDG, NRM is highly appreciated in effective planning and implementation of various activities of the Institute. We also sincerely acknowledge our esteemed RAC in providing valuable guidance for shaping the research and development programme of the Institute. Finally, support of each and every colleague of the Institute in working as a team with renewed interest and zeal is gracefully acknowledged. I congratulate the editorial team for completing the job in a desired manner.

Anup Das
Director

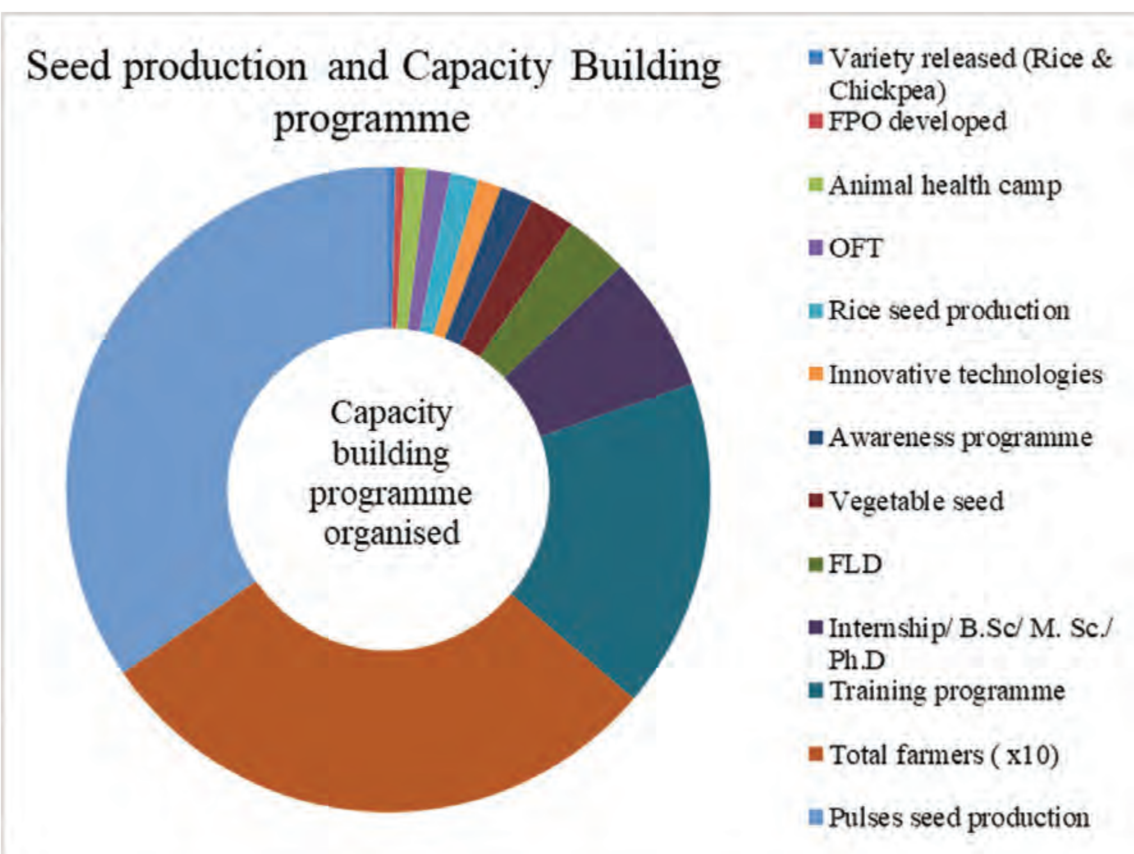
Content

Coverage of ICAR-RCER Technologies and outreach activities in eastern India





Publications of ICAR RCER, Patna
Publications
E-publications
MOU signed
Books
Gene registered to NCBI
Technical bulletins & Extension folders
Papers presented
Award & recognitions
Book/Manual/Chapters
Poster presentation, workshop attended
Popular articles
Research papers



Seed production and Capacity Building programme
Capacity building programme organised
Variety released (Rice & Chickpea)
FPO developed
Animal health camp
OFT
Rice seed production
Innovative technologies
Awareness programme
Vegetable seed
FLD
Internship/ B.Sc/ M. Sc./ Ph.D
Training programme
Total farmers (x10)
Pulses seed production

A Farmer's Journey of Innovation and Inspiration

Mr. Baijnath Mahato, a farmer from Matatu village of Ormanjhi block of Ranchi district in Jharkhand, epitomizes the transformative impact of agricultural innovation and perseverance. Inheriting three and a half acres of land from his father, Baijnath embarked on a journey that reshaped farming practices in his region. Inspired by a visit to ICAR-RCER, Plandu, Ranchi in 2003, he embraced modern techniques like bacterial wilt-resistant varieties and seedbed solarization. Undeterred by challenges, he integrated raised bed planting mulch, drip irrigation, and advanced cultivation methods, expanding his landholding to 35 acres by 2023. His farm, now a bustling hub, provides year-round employment to 50 labourers and yields an annual income exceeding one crore rupees. Baijnath's success story transcended boundaries, inspiring over a thousand farmers from neighbouring villages to adopt similar practices, thereby improving their livelihoods. Recognized with awards like the "Progressive Farmer Award, IARI-Innovative Farmer Award", his achievements were extensively covered by local and national media, solidifying his status as a beacon of inspiration. Baijnath Mahato's journey underscores agriculture's potential as a catalyst for socio-economic development, highlighting the transformative power of sustained effort and innovation in elevating living standards and catalyzing positive change within farming communities.

Progressive farmer Bajinath Mahato in his field

Baijnath Mahto honoured by State Govt

RAC team visiting field of Baijnath Mahato

1 Executive Summary

The ICAR-Research Complex for Eastern Region, Patna conducts strategic and applied research across six distinct thematic areas: Farming Systems Research, Genetic Resource Management, Improved Production and Protection Technologies, Integrated Land & Water Management, Livestock & Fisheries Management and Socio-Economics, Extension and Policy Research. Rice-fallow program, multiple uses of water, crop and fruit based land use, integrated farming systems, and characterization and registration of indigenous livestock were the major flagship programs of the institute during the reporting year. The extension program was implemented in seven eastern states through a single window program called Participatory Research Application for Year-round Income and Agricultural Sustainability (PRAYAS). The salient achievements of the research and technology transfer activities during the year 2023 are as follow:

- Three high-yielding, multiple-stress-tolerant rice varieties- Swarna Purvi Dhan 1, Swarna Purvi Dhan 2, and Swarna Shusk Dhan have been released by the Government of India. They exhibit early maturity, high yields, and tolerance to various stresses, with specific suitability for different ecological conditions in Jharkhand and Uttar Pradesh.

- Rice genotypes *viz.*, IR18R 1123, IR 95781-15-1-1-4, IR16D 1060, RCPR 82, RCPR 84, RCPR 68, IR18R 1179, IR 87707-445-B-B-B, IR18R 1033, and IR18L1446 have been identified for the dry direct seeded rainfed conditions with a productivity range of 3.88-4.48 t/ha

- Rice genotypes, Swarna Purvi Dhan 2 (4.31 t/ha), IR 14 L362 (4.30 t/ha), IR 95781-15-1-1-4 (4.24 t/ha), IR 97030-7-2-2-2 (4.22 t/ha), Swarna Shreya (4.20 t/ha), IR 14 L613 (4.16 t/ha), IR 95817-5-1-1-2 (4.09 t/ha), and IR 107891-B-B-1432-2-1(4.13 t/ha) found promising for natural farming condition.

- Rice genotypes, IR 96321-315-323-B-3-1-3, IR 96321-315-294-B-1-1-1 IR 96321-558-563-B-2-1-1, have been found promising for multiple stresses (submergence & drought) tolerance as compared to check variety Swarna Sub 1(1.10 t/ha).

- Breeder seed (126.4 q), nucleus seed (3.50 q) and truthfully labelled seed (75.45 q) of rice have been produced during *Kharif* 2023.

- Eight promising rice genotypes (RCPR 99, RCPR 100, RCPR 101, RCPR 102, RCPR 103, RCPR 104, RCPR 105, and RCPR 106) have been nominated to AICRIP for multi-locational testing/evaluation during *Kharif* 2023.

- Five rice genotypes RCPR 92 (IET 30917), RCPR 93 (IET 30902), RCPR 94 (IET 30651), and RCPR 94 (IET 30674) have been promoted from IVT to AVT 1 trial after first-year testing during *Kharif* 2022 under national AICRP on rice programme.

- Two rice genotypes RCPR 68 (IET 29036) and RCPR 84 (IET 30330) have been promoted from AVT 1-E-DS to AVT 2-E-DS trial (rainfed upland trial) after second-year testing during *Kharif* 2022 under AICRP on rice programme.

- The new Chick Pea variety 'DBGC 3' (Swarna Lakshami) (1.75 t/ha) has been approved for release by CVRC across 15 locations under irrigated conditions in NEPZ. 'DBGC 3' exhibits excellent grain quality, with a 100-seed weight of 21.27 g, high protein (20.86%), and significant levels of Zn (46.25 ppm) and Fe (53.6 ppm).

- Nutri-cereals including *Jowar, Bajra*, *Ragi*, Barnyard millet, Foxtail millet, Proso-millet, and Kodo-millet were grown in different planting windows. The second planting window, 15th July was found better in terms of crop productivity. Among major nutri-cereals, *Jowar* and *Bajra*, and among minor ones, Barnyard millet and Ragi were most productive. Bajra cv. "Progro-9001," Ragi "RAU 8," and Barnyard cv. DHBM-93-2 were identified as promising varieties.

- Out of the 216 genotypes of lablab bean assessed in field, RCPD-1, RCPD-16, IC411093, IC556808, and IC427453 were distinguished for their extra early (45-52 days for first picking) dwarf growth habit, high yield potential (450-670 g/plant), vegetable-type flattened pods, more pod production per node, and synchronized maturity. Their dwarf growth habit eliminates the need for pole or trellis structures, making them economically favourable for farmers compared to viny or pole-type genotypes.

- 144 yardlong bean genotypes were screened for yellow mosaic disease resistance. IC-626170, IC-630412, IC-20514, IC-20298, and IC-586954 showed no symptoms i.e. full resistance. IC-622570, IC-622574, IC-626139, IC166140, IC-626143, IC-630388, IC-630390, IC-630391, IC-626163, IC-630413, IC-398083, IC-202893, IC-361502, and IC-471938 displayed resistance with some mosaic symptoms.

- Cultivating short to medium duration rice varieties (Swarna Shreya, Naveen) using Zero Tillage Direct Seeded Rice (ZTDSR) or Conventional Tillage Direct Seeded Rice (CTDSR) during *Kharif*, followed by short duration high-yielding varieties of chickpea, lentil, or safflower, along with residue retention, has proven to be a viable system for greening rice fallows in Eastern India. This approach enhanced system productivity by 3-3.5 to 5-5.75 t/ha increased economic returns, and reduced the carbon footprint substantially.

- Zero-till direct seeded rice followed by (*fb*) ZT wheat *fb* ZT green gram along with efficient pre and post-emergence herbicides led to significantly higher system productivity (12.7 t/ha), as well as higher net returns (8%), water productivity (23%) and weed control efficiency (88%) than conventional tillage practice. This conservation agriculture-based practice with 34% reduction in global warming potential, could lead to sustainable crop intensification in EIGP.

- The flagship program “Rice-fallow Management through Climate Resilient Agricultural Practices” started in *Kharif* 2023 in Gaya district, Bihar. In the first year, Arhar seeds (IPA 203) were cultivated on 12.5 acres by 15 farmers during the *kharif* season. Additionally, lentil, chickpea, and mustard seeds were planted on 104.5 acres by 107 farmers during the rabi season for demonstration. Rice yields ranged from 3.5 to 5.5 t/ha. Whereas, pigeon pea yields ranged from 1.3 to 2.18 t/ha, with a rice equivalent yield of 4.17-6.99 t/ha.

- One-acre and two-acre IFS models provided an annual net income of Rs. 86,560/- (B: C: 1.72) and Rs. 2,07,805/- (B:C: 2.1), respectively which is ~ 3 to 4 times higher over rice-wheat cropping system.

- Kufri Jyoti variety of potato was grown with an irrigation cut-off ratio of 0.85, 0.80 and 0.75 in the plot with a slope of 0.30, 0.40 and 0.50% respectively. The plot having a 0.5% slope and 0.75 cut off ratio recorded the highest yield of 11.9 t/ha and water productivity (5.95 kg/m^3).

- After two years of evaluation of the Nano-DAP experiment, findings demonstrated that the highest wheat grain yield (5.03 t/ha) was attained with 100% of the recommended fertilizer dose. This yield was *at par* with the combination of 50% RDF along with two foliar sprays of nano DAP at 4 ml/l.

- LISS III and LANDSAT images of the year 2000, 2011 and 2018 have been collected, geo-referenced, classified, accuracy assessed, map generated and change in the area of rice, wheat and maize has been identified in last 18 years. It is observed that there is increase in the area of rice, wheat and maize from the year 2000 to 2018.

- A study using the DSSAT vs 4.6 model estimated the impacts of climate change on rice, wheat, maize, and potato yields in three locations. Results showed that increased temperature leads to decreased yields, while higher rainfall has a positive effect.

- Analysis of precipitation data from the Tropical Rainfall Measuring Mission (TRMM) for north Bihar’s river catchments between 2000 and 2010 revealed significant spatial variation in monsoonal rainfall in the Gandak basin (1282 mm), Kosi basin (1124 mm) and Mahananda basin (1685 mm). The pattern of rainfall distribution across these basins suggests interconnected rainfall trends, with basin areas outside Bihar receiving comparatively higher rainfall.

- Prioritization of the Sakri River basin, based on morphometric analysis and principal component analysis (PCA) approaches showed that about 46.82%, 32.46% and 20.73%, and about 56.56%, 23.66% and 19.7% of the basin areas come under high, medium and low priority, respectively.

- A prototype of manual cole crop harvester was designed, developed and evaluated in field. The prototype was designed based on data of cauliflower stem diameter and its maximum canopy cover length.

- The Rhizosphere microbiome of 3-inbreed paddy varieties grown in arsenic (As)-contaminated middle

Indo-Gangetic Plains was studied through metagenomics. Bacterial community composition was found to vary with different soil As levels. This study is the first to document the diverse and dynamic rhizosphere microbiome of HYPVs in MIGPs of Bihar

- *Tessaratoma javanica* (stink bug), has been established as a major pest of litchi. Taxonomic analysis of associated bacteria in different developmental stages revealed 46 phyla encompassing 139 classes, 271 orders, 474 families, and 893 genera of bacteria. The phyla Proteobacteria and Firmicutes exhibited the highest levels of prevalence across all the developmental phases.

- Infestation of Webbers on litchi flowers was observed in litchi orchards of Jharkhand. The species identified are *Statherotis leucaspis* and *Homona coffearia*. In experimental farm, percentage panicle damage varied from 1.9 to 34.2% by *S. leucaspis*.

- Thirty-four germplasm lines of vegetable soybean received from AVRDC-The World Vegetable Centre, Taiwan were evaluated during *kharif* season of 2023 in FRSCHPR centre. Among the lines evaluated, AGS-404 gave the highest yield of 17.34 t/ha. The genotypes from various geographic locations (clustered) suggested that their genetic composition is not influenced by their place of origin. In brinjal, six advanced breeding lines developed from HAB-917 x IC 261786, HAB x IC-545901 and HAB-917 x HAB-901, were evaluated for fruit yield, fruit quality and bacterial wilt resistance and RCBR-938/ HAB-938 was submitted under multilocation testing under AICRP (VC) IET 2023.

- Evaluation of tomato crosses was carried out for successive 7th generations at FRSCHPR. The F_7 generation of cross HADT-296 x HAT-311 (RCDT-51) showed better resistance to bacterial wilt with high yield (80 t/ha).

- Evaluation of intergeneric grafted tomato for bacterial wilt resistance using bacterial wilt resistant rootstocks of brinjal (HAB-901, HAB-921, HAB-928, HAB-930) and tomato (HADT-296) was carried out at Ranchi. Percent plant survival against bacterial wilt indicated that *Solanum torvum*, HAB-901, HAB-928, HAB-930 and HAB-921 were the best rootstocks for management of wilt in tomato.

- Five hybrids of chilli *viz.*, HC-75 x Swarna Arohi, HC-78 x Swarna Praphulya, HC-79 x Swarna Arohi, Swarna Apurva x Swarna Arohi and Swarna Apurva x HC-81 were found promising for fruit yield, fruit quality parameters and bacterial wilt resistance in Ranchi centre.

- The leaching loss of NPK nutrients below the root zone of brinjal and maize crops was evaluated using non-weighting lysimeters under four fertilizer management treatments The amount of nitrate-nitrogen present in the leachate under brinjal was highest in 100 % inorganic fertilizer management

- A field experiment was undertaken in maize and French bean crops to identify organic amendments for phosphorus mobilization in acidic soils. Yield analysis showed that treatments having organic sources significantly affected the soil phosphorus fractions content and yield of maize and French beans. The maize cob yield was highest (8.92 t/ha) when vermicompost (7 t/ha) was applied.

- Evaluating the natural farming (NF) and conventional farming (CF) modules for different cropping systems in EPHR was carried out at Ranchi centre for 4th consecutive years. The natural farming-based treatments recorded comparatively higher pod yield of cowpea (94.50 q/ha) and finger millet (18.25 q/ha) over CF (87.13 q/ha and 17.13 q/ha), respectively. In *Kharif* crop and in Rabi crop harvest index (34.65 %) and REY (34.65 q/ha) of lentil and mustard (33.63 %, 29.40 q/ha) were higher in natural farming as compared to CF. At Patna, system productivity of rice-wheat-greengram system was 10.13 t/ha for organic farming (OF), 13.67 and 14.74 t/ha for CF and INM practices whereas, soil organic carbon was found higher in OF (0.61%) followed by NF (0.55%).

- Prototype of the solar operated paddy thresher has been developed at FRSCHPR centre. Analysis showed that the threshing efficiency was maximum (99.1%) at the drum speed of 500 rpm for dry straw conditions. The highest machine capacity of 89.2 kg/hr was obtained at drum speed of 600 rpm when the moisture content was in the normal range.

- A solar operated hybrid insect trap was designed and developed in the Ranchi centre which operates on dual principle of insect attraction. The trap is provided with three LED lights to develop the sufficient light to attract insects from a distance of 40-50 m. It is found that 4-5 traps per hectare are sufficient to make effective insect catch.

- Compound growth in rice yield of Malda district, West Bengal was identified using Gompertz model, logistic model and monomolecular model. Growth rate through these models found to be 2.164, 2.135 and 1.49 percent respectively during the period 2001 to 2020.

- Under e-NAM trade study in Jharkhand, Hazaribagh district topped in e-NAM trade contributing 35% of total trade. Deoghar was second highest contributor in e-NAM trade in the state with 15.45% share in total trade. Garhwa (9.9%), Dhanbad (8.78%) and Ranchi (6.14%) were other top contributors. All others districts contributed around 24% of total trade. Among cereals, paddy, wheat, maize and ragi were the most traded commodity on e-NAM platform in Jharkhand.

- Under Climate Resilient Agriculture (CRA) programme, Gaya (1468 acre) and Buxar (1470 acres) districts were covered for demonstrations on climate resilient technologies at farmers' field. In Gaya and Buxar, rice-wheat-moong was the best suitable cropping system yielding highest profitability of Rs 204,657/ha and Rs 210,236, respectively. CRA interventions resulted in significantly higher profitability.

- In Bihar's Gandak River basin, there are 56,304 ha of diara land, determined using Google Earth and GIS techniques. Farmers cultivate watermelons exclusively in the riverbed diara, where the sand content is higher.

- Analysis of data of 500 farmers and extension workers revealed that most frequently used digital tool is websites and mobile apps (88%). More than 80% of farmers have positive view toward use of digital tools for getting agricultural information. Around 50-60% farmers frequently visit agricultural websites (https://pmkisan.gov.in) and apps (Plantix, Bihan and Kheti Bari).

- Under exploration of indigenous germplasm, native chickens in the Kaimur district, Bihar, were found to have unique plumage patterns, large ear lobes, and single comb, producing brown shell eggs, documentation and registration process of this variety is under process. Native chicken of Namkum, Bundu, and Tamad blocks of Ranchi district, Jharkhand has also been characterized based on 10-17 quantitative traits.

- Total 93 Murrah buffaloes are maintained in the Experimental Livestock Farm of the institute under the Network project on buffalo improvement. The Standard Lactation Milk Yield (SLMY) and the Total Lactation Milk Yield (TLMY) recorded during the year were found to be 2488.54 and 2814.63 kg respectively. An MS Excel-based digital information system was developed for monitoring, recording, and predicting reproductive cycle and production.

- Under cross-breeding and performance improvement programme of duck, 64.2% increase in the body weight of crossbred (native ducks X White Pekin) was recorded over that of native non-descript ducks after three generations of crossbreeding and selection.

- GeneBank accession numbers of duck available in the Eastern Region were obtained for Indian Runner duck, Khaki Campbell duck, Chhattisgarh duck, White Pekin duck, Bihar duck, Bengal duck and Maithili duck.

- Differential gene expression analysis in bovine infected with subclinical mastitis revealed that a total of 3482 genes showed differential gene expression in animals suffering from subclinical mastitis. Out of which, 2147 genes (IL12 B, SLA, CSF3R, CD177, THBD, ICOSLG, NCF1, SELPLG, IL3RA and CXCR2) showed significant up-regulation, whereas 1334 genes (KRT24, PIK3C2G, LALBA, CSN2, CSN3, CSN1S1, CD36 and CD59) showed significant down-regulation in animals suffering from subclinical mastitis in comparison to healthy animals.

- Antimicrobial drug resistance in bacteria of animal origin was evaluated phenotypically and genotypic methods. Isolates of *Escherichia coli* from faecal samples and *Staphylococcus aureus* from milk samples were studied. More than 40% *E. coli* isolates were multidrug-resistant strains and mostly resistant to commonly used antibiotic drugs.

- AICRP on Goat Improvement programme is going on in five clusters (925 households) of Bihar namely East Champaran, Samastipur, Araria, Katihar and Jamui. A total of 22 improved Black Bengal bucks were distributed among the farmers to improve the existing stock. The goat population growth in the selected villages expanded to the tune of 260.83%.

- Under fodder production programme, optimizing fodder crops yield *via* nitrogen and zinc management revealed that N_1 (whole recommended dose of nitrogen through inorganic fertilizer and Zn_1 {Zinc @ 10 kg/ha (IN)} and Zn_2 {5 kg Zinc (IN)} as basal + Four foliar spray of Nano-Zn showcased the most beneficial outcomes. These methods not only increased fodder yield (5.59 & 5.57 t/ha), but also elevated its quality (particularly dry matter).

- Under the fish based integrated farming programme, the productivity performance of Indian Major Carp under different manure combinations was attempted. The highest production was recorded at feed-based treatment (3161 kg/ha) followed by cattle & duck manure (2980 kg/ha). Catla showed the best average body weight gain, followed by Rohu and Mrigal.
- In the prawn cum fish integration, prawns attained an average body weight of 45 g in 270 days of culture. Economic analysis revealed that in composite fish culture (without prawn) a profit of Rs. 215104/ha can be obtained whereas when prawn was incorporated it was Rs. 286997/ha.
- Species diversity of Kasraiya Dhar Maun was attempted and a total of 58 fish, 2 prawns, and 3 mollusc species were identified. Based on the Bray-Curtis similarity cluster analysis and 2-D nonmetric multidimensional scaling analysis showed considerable changes in the species abundance between seasons.
- In a pioneering work, microplastic abundance in waters of the Ganga, Sone, and Punpun rivers was attempted and an average concentration of 364, 223, and 180 microplastics per litre was recorded respectively.
- Morphological traits of the barred spiny eel *Macrognathus pancalus* revealed that body weight is a function of three interdependent variables (pre-dorsal length, body depth, and post-orbital length) rather than orthogonal variables. Moreover, this species showed bimodal spawning periodicity with a prolonged spawning season from February to October.
- Principal component analysis on morphological traits of *Mystus cavasius (18)*, and *Mystus tengara* (14) revealed that the first component explained 78.19% & 68.69% of the total variance respectively.
- Naturally induced breeding of *Channa striata* was facilitated at the institute pond. A total of 300 advanced fry (53.6±1.57 mm & 1.17±0.20 g) of *Channa striata* were collected from fish ponds, and they were stocked in a nursery pond.
- During 2023 under Participatory Research Application for Year-round Income and Agricultural Sustainability (PRAYAS) a total of 16 villages (8 SCSP + 8 TSP) across seven states in eastern India was covered. A total of 43 number of awareness cum training programme was organized under PRAYAS.
- During the year, thirteen innovative technologies were certified by ICAR, two of which ranked among the top five in their respective SMDs. These technologies represent significant advancements in agricultural practices and aim to enhance productivity, sustainability and resource efficiency in the region.
- Several new initiatives were undertaken by the institute during the year including the IARI-Patna Hub, an educational initiative; the Clean and Green Campus campaign, Zero Food Wastage program, Zero-hunger zero technology gap programme in Chotka Dhakaich, and Organic farming research among others.
- The Institute published 94 research papers in peer reviewed journals, 24 book/manual/chapter, 2 technical bulletins, 10 folder, and 53 popular articles. Besides, 50 participation in Conferences/Seminars/ Workshops/ Symposia/ Meetings/Brain storming sessions, 13 papers were presented in different National and International Seminar/Symposia and Conferences and six awards received.
- In 2023, institute signed of 5 MoUs. The headquarter Patna and Ranchi center collectively conducted 36 capacity building trainings, while our KVKs organized 146 training programs. Additionally, 35 FLDs and demonstrations were conducted, alongside 18 Goshthis and awareness programs, contributing to a comprehensive outreach effort throughout the year. These programmes benefitted 10424 farmers and other stakeholders.

2 Introduction

The ICAR Research Complex for Eastern Region (ICAR-RCER) was established on February 22, 2001 by merging the former Directorate of Water Management Research (DWMR), Patna, Central Horticultural Experiment Station (CHES), Ranchi, and Central Tobacco Research Station (CTRS), Pusa, Samastipur. In December 2003, the National Research Centre for Makhana, Darbhanga was also integrated under the administrative and financial control of ICAR-RCER. Following the amalgamation of these units and the creation of new programmes, the institute developed five research programmes out of which, major programs *viz*, Land, Water, Environment and Engineering Research Programme (LWEERP), Socio-Economic and Extension Research Programme (SEERP) and Livestock and Fishery Improvement and Management Programme (LFIMP) were situated in headquarters at Patna, the Crop Research Programme (CRP) was at Pusa, Bihar and the Horticulture and Agro-forestry Research Programme (HARP) was located at Ranchi.

Presently, the institute has four divisions at its headquarters in Patna namely, Division of Land and Water Management (DLWM), Division of Crop Research (DCR), Division of Livestock and Fishery Management (DLFM), and the Division of Socio-Economics & Extension (DSEE). Additionally, it includes the Farming System Research Centre for Hill and Plateau Region (FSRCHPR), Plandu, Ranchi. The Darbhanga-based Research Center for Makhana was part of ICAR RCER, Patna until May 14, 2023. The institute also operates two Krishi Vigyan Kendras (KVKs), located at Buxar in Bihar, and Ramgarh in Jharkhand.

Main campus of ICAR Research Complex for Eastern Region, Patna, Bihar [86.57 acre]

Farming System Research Centre for Hill and Plateau Region, Ranchi, Jharkhand [426 acre]

Krishi Vigran Kendra, Buxar, Bihar [25 acre]

Krishi Vigran Kendra, Ramgarh, Jharkhand [19.4 acre]

ICAR RCER, Patna aims to tackle a wide array of issues concerning the management of land and water resources, crop production, horticulture, agroforestry, aquatic crops, fisheries, livestock, poultry, agro-processing, and socio-economic factors in the Eastern region of India. Its comprehensive approach seeks to enhance research capabilities and support agricultural productivity and sustainability. Located in one of the economically important and agriculturally intensive regions, the institute operates as a multi-commodity and multidisciplinary research institution of the ICAR.

The Eastern region of India encompasses the plains of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha, and West Bengal, accounting for 21.85% of the nation's geographical area and sustaining 33% of its population. One of the defining features of the eastern region is its agricultural significance. The fertile plains of the Ganges and Brahmaputra rivers support a thriving agricultural economy, with rice, wheat, pulses, and jute being major crops. The region's agrarian economy is predominantly driven by small and marginal farmers, who rely on traditional farming practices along side modern agricultural techniques. The eastern region is also endowed with fertile soils, abundant water resources including groundwater, optimal solar radiation, rich biodiversity, ample animal resources, and extensive open-water reserves.

Despite these abundant resources and potential, the Eastern region of the country has yet to witness the realization of a Second Green Revolution. Low crop productivity and income levels in the eastern region of India present a complex challenge rooted in various socio-economic, environmental, and institutional factors. Challenges such as erratic climate fluctuations, rapid population growth, land degradation, fragmented and small land holdings, inadequate access to quality seeds and planting materials, and deficiencies in extension services hinder the region's agricultural productivity, poverty alleviation efforts, and livelihood enhancement initiatives. Addressing these issues requires a multi-dimensional approach that considers the unique characteristics and challenges of the region. The institute has instated flagship programs on climate change mitigation, rice fallow management, livestock, fishery and horticulture improvement. In addition to its research and extension activities, ICAR-RCER also contributes to policy formulation and advocacy in agriculture, providing evidence-based recommendations to address the challenges facing the farming community and the agricultural sector in the eastern region. Engaging with policymakers and other stakeholders, the institute seeks to develop policies to promote sustainable agricultural development, rural livelihoods, and inclusive growth.

Mandate

- Strategic and adaptive research for efficient integrated management of natural resources to enhance productivity of agricultural production systems in eastern region.
- Transform low productivity-high potential eastern region into high productivity region for food, nutritional and livelihood security.
- Utilization of seasonally waterlogged and perennial water bodies for multiple uses of water.
- Promote network and consortia research in the eastern region.

Vision: To pre-position the institute with desired competitiveness for developing the kind of technologies needed to address the multiple vulnerabilities confronting agriculture and allied fields today and likely to confront tomorrow and thereby contribute towards production, profitability and sustainability in agriculture, particularly in view of Look East Policy of Govt. of India for ensuring food security in the country.

The institute is committed to innovating and developing low-cost, efficient, and sustainable technologies tailored to the specific requirements of agricultural development in the eastern region. Recognizing the diverse challenges faced by farmers in this region, the institute channels its research efforts toward creating practical solutions that are accessible, affordable, and environmentally friendly. The institute is dedicated to transforming this potential yet low-productive area, comprising six distinct Agri-ecological Economic Zones (AEZ), into highly productive zone. Through its research, development and extension initiatives, the institute has major focus on the following key areas:

- Facilitate and promote coordination and dissemination of appropriate agricultural technologies through network/consortia approach involving ICAR institutes, State Agricultural Universities, and other agencies for generating location-specific agricultural production technologies through sustainable use of natural resources.
- Provide scientific leadership and to act as a center for vocational as well as advanced training to promote agricultural production technologies.
- Act as a repository of available information and its dissemination on all aspects of agricultural production systems.
- Collaborate with relevant national and international agencies in liaison with state and central government departments for technology dissemination.
- Provide need-based consultancy and advisory support for promoting agriculture, horticulture and livestock in the region.
- Socio-economic evaluation and impact assessment of agricultural technologies.

Finance

The institute's finances reflect agility and demonstrate its efficiency in budget utilization. A summary of budget allocation and expenditure during the financial year 2022-23 of the complex is presented below (Table 2.1).

Table 2.1. Financial allocation and expenditure during the year 2023-24 (Rs. in Lakhs)

Head of accounts	BE allocation		Actual expenditure	
	Inst Grant	SCSP	Inst Grant	SCSP
Establishment Charges	2907.00	0.00	2906.80	0.00
TA	45.80	0.00	45.80	0.00
HRD	3.36	0.00	3.36	0.00
Capital	136.00	4.50	136.00	4.49
Other charges	1041.37	15.00	1041.36	15.00
Total	**4133.53**	**19.50**	**4133.32**	**19.49**

Staff position

A summary of the staff position both sanctioned and filled one of ICAR RCER till Dec 2023 is summarized in the Table 2.2.

Table 2.2. Staff position as on 31st December, 2023

Category	Position	
	Sanctioned	Filled
Scientific*	91	71
Technical	61	41
Administrative	46	22
Skilled Supporting Staff	61	26

***Including Director and Staff of Research Centre for Makhana**

Noting that Research Center for Makhana becoming an independent institute under the Agricultural Engineering Division of ICAR on May 15, 2023, presently the ICAR RCER in Patna has 80 sanctioned positions of scientist, with 66 positions in-place.

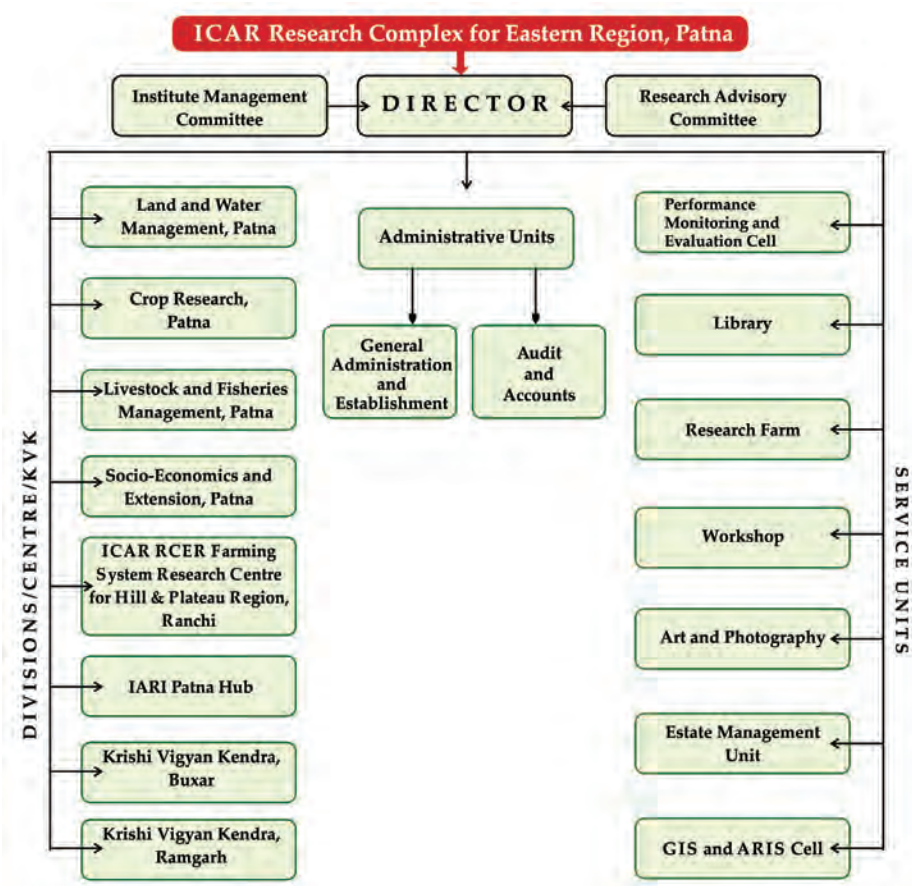


Fig. 2.1. Organogram of ICAR Research Complex for Eastern Region, Patna

Research Facilities

At present the Complex has developed well-equipped laboratories for plant, soil and water analysis, natural resource management and livestock and fisheries laboratory. Details of different instruments under these laboratories are listed (Table 2.3) below:

Table 2.3 List of instruments available with ICAR RCER

Sr. No.	Facilities	Instruments/Equipments
ICAR RCER, Patna		
1	Soil and Water Analysis laboratory	Atomic absorption spectrometer, Kjeldahl distillation and digestion unit, spectrophotometer, flame photometer, pH meter, EC meter, TOC analyzer, and pressure plate apparatus
2	Pressurized Irrigation lab	Solar pump, electrical pump, sand filters, screen filters, multi parameter water quality meter, sprinklers, raingun
3	Institute Workshop	Portable Arc Welding machine, electric welding machine, pipe bending machine, hammer drill, Bench grinder, air compressor, tachometer, digital vernier caliper, load cell, hand grinder, cut off machine
4	Plant Science laboratory	UV-VIS spectrophotometer, centrifuge, deep freezer, multiparameter pH & EC meter, IR Thermometer, water purification system
5	GHG analysis laboratory	Gas chromatograph for greenhouse gas analysis
6	Conservation Agriculture Laboratory	Cone penetrometer, soil moisture probe, vacuum desiccator and incubator shaker
7	Fisheries laboratory	Soil water digester, water bath, trinocular research microscope with digital photographic system, hot air oven, spectrophotometer, centrifuge
8	Animal health laboratory	ELISA plate reader, laminar flow hood, refrigerated centrifuge, microtome, BOD incubator, autoclave, microscope, distillation unit
9	Livestock production and reproduction laboratory	Thermal cycler, real time PCR, BOD incubator, gel documentation system, gel electrophoresis centrifuge, -20°C deep freezer
10	Fisheries wet laboratory	Biofloc, eco-hatchery
11	Feed analytical & biochemical laboratory	Refrigerated centrifuge, thermal cycler, spectrophotometer, nitrogen analyzer, milk analyzer, sonicator, fat analyzer, double distillation unit, fiber analyzer, bomb calorimeter
12	Library	Total 3211 no. of books covering different areas of agriculture and allied sciences, 41 Indian and 51 foreign journals and periodicals, electronic scientific reference databases like CAB abstracts, Agricola etc., online access for e-journals through CeRA.
FSRCHPR, Ranchi		
13	Pathology Laboratory	Wood microtome, phase contrast stereoscopic binocular microscope, incubators and spore trapper. A laboratory for preparation of uncontaminated mushroom spawn of different species is also available
14	Post Harvest Laboratory	Tray dryer, pulper, shrink wrapping machines, refractometer, centrifugal juice
15	Soil Science Laboratory	Lypholyzer, nitrogen analyser, flame photometer, Atomic Absorption Spectrophotometer and Time Domain reflectometry

Sr. No.	Facilities	Instruments/Equipments
16	Quality Analysis Laboratory	Infra-Red Gas Analyzer, UV–VIS spectrophotometer, pH meter, canopy analyser, leaf area meter,
17	Molecular laboratory	Refrigerated centrifuge, thermo cycler, electrophoresis apparatus, gel documentation unit, micro centrifuge

Allied facilities

The Farmers Hostel in Patna is a comprehensive facility available for farmers, scientists, and other visitors. It features 3 dormitories, 3 air-conditioned double rooms, 1 air-conditioned triple room, and 3 VIP suites. An auditorium and a seminar room with modern facilities are available for scientific meetings and group discussions.

The institute offers farmers viable solutions through various flagship programs like rice fallow management, development of location specific IFS models for small and marginal farmers in irrigated, rainfed, flood prone and plateau region, multiple use of water for enhanced agricultural productivity in eastern India, climate resilient agriculture and ecosystem services by indigenous livestock species and Diara farming system. The institute has also taken major initiatives like zero hunger and zero technology gap program, establishment of IARI Patna hub, Innovation cell and weekly seminar by institute staff. Thirteen technologies of the institute have been certified by Indian Council of Agricultural Research, New Delhi. Total 94 research papers have been published with >60% in journals having more than 6 NAAS rating.

The Annual Report 2023 has been prepared, reflecting the vision and mandate of the institute. The document comprises 27 chapters, each summarizing and presenting various research and extension activities and achievements.

3 Weather

The Weather at ICAR-RCER, Patna

Weather parameters, *viz.*, air temperature, humidity, rainfall, sunshine hours and pan evaporation, were collected from Agri-Met Centre, Patna. The Long Period Average (LPA) of the annual total rainfall of Patna is 1127.30 mm. Based on the overall amount of rainfall received, 2023 was a year with a 13.65% deficit in rainfall. The total annual precipitation accumulated at the end was 973.50 mm which was distributed among 51 meteorological rainy days. The monsoon rainfall (858.30 mm) was below normal (951.90 mm), the maximum (297.30 mm) and minimum (171.60 mm) were recorded in August and June, respectively. About 142.80 mm rainfall was received in a single day on June 30. The mean monthly maximum temperature varied from 40.4° C in June to 20.6° C in January. In 2023, June remained the warmest month. The trend of monthly variation of temperature and rainfall is presented in Fig 3.1. Similarly, the mean monthly minimum temperature varied from 10.2° C in January to 28.2° C in June. The months with the lowest & highest mean monthly relative humidity were April (36%) and August (84%). The highest average daily sunshine hours were recorded in May (8.6 h/day). A summary of the monthly meteorological data for the year 2023 is presented in Table 3.1.

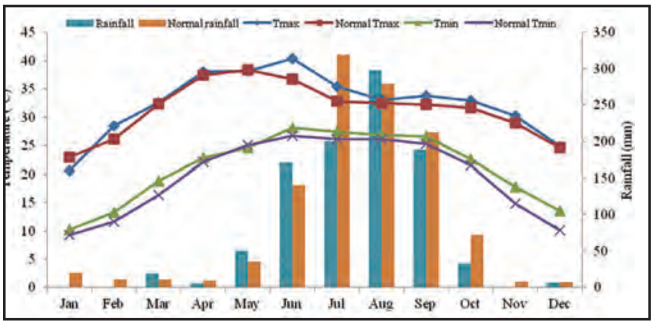


Fig. 3.1 Monthly variation of temperature and rainfall during 2023

Table 3.1 Mean monthly weather parameters of the year 2023

Month	Temperature (°C)				Avg. RH (%)	Avg. Sun shine (h/day)	Total rainfall (mm)		Rainy days
	Max	Normal	Min	Normal			Observed	Normal	
January	20.6	23.1	10.2	9.3	83	3.6	0.2	20.4	0
February	28.5	26.1	13.3	11.6	64	7.6	0.0	11.1	0
March	32.6	32.4	18.8	16.4	55	7.0	19.3	11.4	3
April	38.0	37.4	22.9	22.1	36	8.4	5.7	9.0	1
May	38.1	38.4	24.7	25.1	49	8.6	50.2	35.6	3
June	40.4	36.7	28.2	26.7	50	7.1	171.6	141.1	5
July	35.5	32.9	27.4	26.1	76	3.9	200.5	319.2	9
August	33.1	32.5	26.9	26.1	84	-	297.3	279	14
September	33.7	32.2	26.6	25.3	83	-	188.9	212.6	9
October	33.0	31.7	22.6	21.6	76	-	33.0	72.3	6
November	30.2	28.9	17.7	14.8	78	-	0.0	8.2	0
December	24.9	24.6	13.5	10.1	83	-	6.8	7.4	1
Annual	32.4	31.4	21.1	19.6	68	-	973.5	1127.3	51

Extreme weather observations recorded in 2023

Extremes in weather variables have been observed for the year 2023. Based on daily mean temperature data, the warmest and coldest days of the year were determined. The 17th June was the hottest day of the year (44.7°C), while the 17th January was the coldest day (5.5°C). The maximum amount of rainfall in a day (Most rainy day) was recorded on 30th June (142.8 mm), and the highest and lowest relative humidity were recorded on 23rd September (98.7%) and 18th April (21%), respectively.

Climate at FSRCHPR, Ranchi

The mean monthly maximum temperature ranged from 23.9°C in January to 36.2°C in the month of May, while the mean monthly minimum temperature varied from 10.1°C in January to 25.3°C in June, depicting January as the coldest month of the year 2023 (Fig. 3.2). The lowest temperature of 4°C was recorded on 1st January while the highest temperature of 42.5°C was recorded on 18th April. The maximum diurnal variation of 17.6°C was recorded for the month of February while it was lowest (5.8°C) during July.

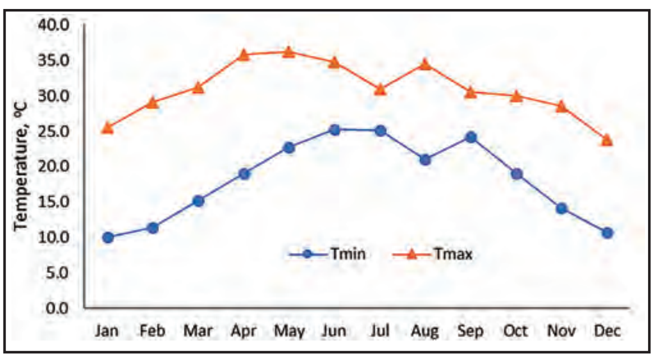


Fig. 3.2 Variations in average monthly minimum and maximum air temperature

The annual rainfall at Ranchi Center for 2023 was 1445.8 mm which was very close to the normal rainfall (1398 mm) at the Center (Fig. 3.2). On an average, 82% of the annual rainfall is received during monsoon season; however, for the reporting year it was 67%. Rainfall received during the four monsoon months (979.2 mm) was 15.03% lower than the normal monsoon rainfall. The monthly rainfall receipts during June, July and September were respectively 24.5, 51.6 and 19.3 percents lower than the normal rainfall of respective months.

The year 2023 had 78 rainy days, out of which 60 rainy days occurred during the monsoon season. The months of July and August had 18 and 20 rainy days, respectively (Fig. 3.3).

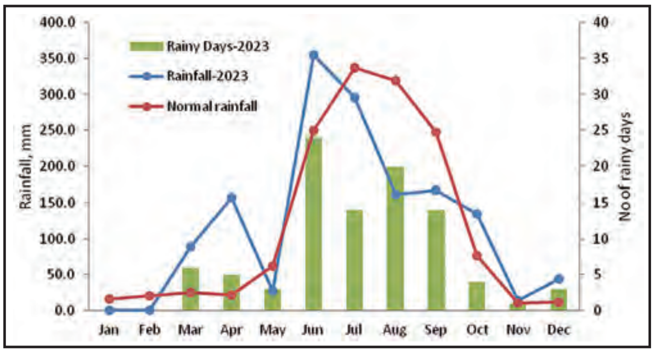


Fig. 3.3 Comparison of monthly normal rainfall with monthly rainfall of 2023

4 Climate Resilient Agriculture

Climate change impact studies through crop simulation models at selected locations in Bihar

Climate change has added a new dimension to the uncertainty in crop yields in India in general, and Bihar in particular. The present study estimated the potential impacts of projected climate change on rice, wheat, maize and potato yields at three representative locations in Bihar using the DSSAT (Decision Support System for Agrotechnology Transfer) vs 4.6 model. The CERES-rice, CERES-wheat, CERES-maize, CROPGRO-chickpea, and SUBSTOR-potato models were calibrated and validated using experimental published data collected at three locations (Patna, Samastipur, and Sabour) for above mentioned crops. The rice, wheat and potato yields were simulated yearly from 2020 to 2099 for three locations under climate change scenarios (Representative Concentration Pathway: Rcp4.5 and Rcp8.5). Rcp4.5 and Rcp8.5 represent the moderate and high emission scenario, respectively. Among all locations, Patna records a minimum yield reduction of 5.5% to 14.4% from 2030 to 2050 for the intermediate scenario (Rcp4.5); however, a higher yield reduction would be observed under the high emission scenario (Rcp8.5) from 2030 to 2050. Yield variation in rice, wheat and potato under projected climate change are presented in Fig. 4.1. It may be seen that among the three locations, Patna shows a minimum decrease trend in wheat yield up to 2030 under the Rcp4.5 scenario, while Sabour shows higher yield reductions of 11.2% to 28.2% from 2030 to 2050 under both scenarios. This study projects that under both climate scenarios, climate change will reduce wheat yield by 8.9 to 14.3% by 2030 and 7.6 to 28.2% by 2050. Patna and Samastipur show similar decreasing trends in potato yield variation, ranging from 10.7% to 28% over the years under both scenarios, while Sabour exhibits a minimum yield reduction ranging from 8.3 to 18% under Rcp4.5 and 8.5 scenarios.

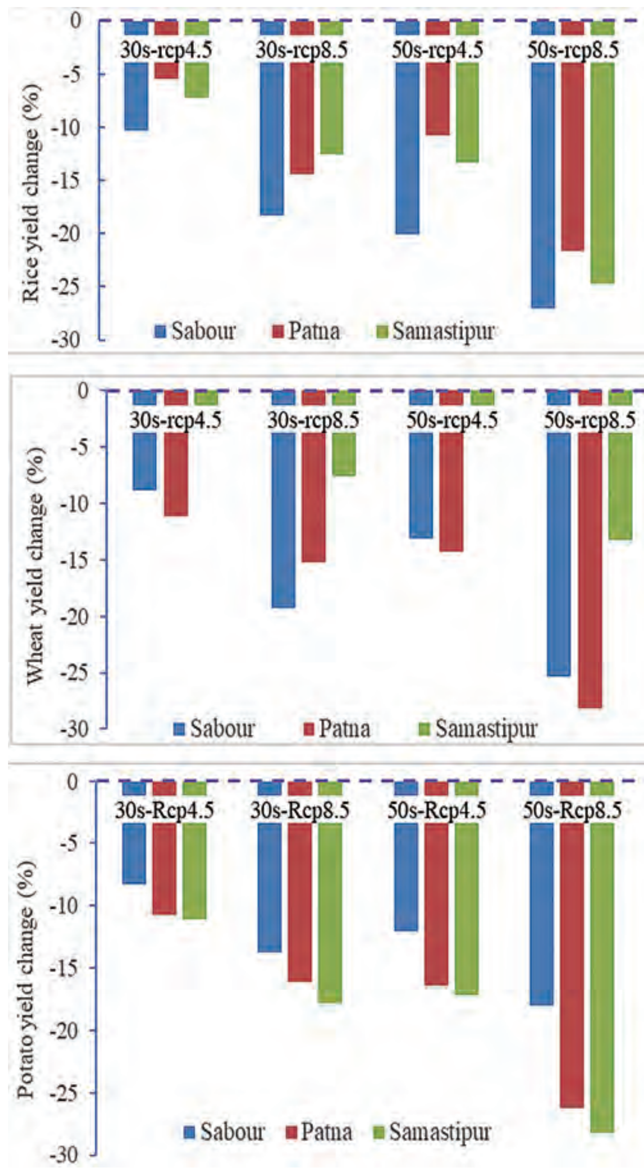


Fig. 4.1 Percent change in yield of rice, wheat and potato in three different locations of Bihar under changing climate scenarios (30s-Rcp4.5: in 2030 under Rcp 4.5; 30s-Rcp8.5: in 2030 under Rcp 8.5; 50s-Rcp4.5: in 2050 under Rcp 4.5; 50s-Rcp8.5: in 2050 under Rcp 8.5)

5

Cereals

Rice

Release and Notification of rice varieties

Three high yielding multiple stress-tolerant rice varieties 'Swarna Purvi Dhan 1' (IET 24660), 'Swarna Purvi Dhan 2' (IET 26767) and 'Swarna Shusk Dhan' (IET 27962) have been released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, GOI (vide notification number S.O. 1056 (E) dated 6th March 2023). Detailed descriptions are provided in Table 5.1 below:

Table 5.1 Salient features of rice varieties released and notified during 2023

Name	Characteristic	Photographs
Swarna Purvi Dhan 1	An early duration (115-120 days), semi-dwarf, high yielding (4.5-5.0 t/ha), multiple stresses (drought, disease and insect pest) tolerant aerobic rice variety. It is rich in micronutrients, i.e., zinc (20.4 ppm) and iron (13.8 ppm). This variety showed desirable quality parameters like high HRR (68.3%) and intermediate amylose content. It is recommended for cultivation under direct-seeded aerobic condition in water limiting irrigated as well as drought-prone rainfed area of Jharkhand.	 **Fig. 5.1a Swarna Purvi Dhan 1**
Swarna Purvi Dhan 2	A semi-dwarf, high yielding (5.0-5.5 t/ha), early duration (115-120 days), multiple stresses tolerant and fertilizer responsive variety. It is lodging resistant with desirable cooking quality traits and long slender grain type. It is recommended for the cultivation under transplanted condition in irrigated ecology of Jharkhand.	 **Fig. 5.1b Swarna Purvi Dhan 2**
Swarna Shusk Dhan	A semi-dwarf, high yielding (4.0-4.5 t/ha), early duration (110-115 days), multiple stresses tolerant and fertilizer responsive variety. It is lodging resistant with desirable cooking quality traits and long slender grain type. It is recommended for cultivation under direct seeded condition in the drought prone rainfed midland to upland ecosystem of Uttar Pradesh	 **Fig. 5.1c Swarna Shusk Dhan**

Nomination and promotion of rice entries and trials conducted under AICRP on rice programme

Two rice genotypes 'RCPR 68' (IET 29036) and 'RCPR 84' (IET 30330) have been promoted from AVT 1-E-DS to AVT 2-E-DS trial (rainfed upland trial) after second year of testing during *Kharif* 2022 under AICRP on rice programme. In addition, one promising rice genotype 'RCPR 70' (IET 29405) has also been promoted from AVT 1-aerobic to AVT 2-aerobic trial after second year of testing. Moreover, five rice genotypes 'RCPR 92' (IET 30917), 'RCPR 93' (IET 30902), 'RCPR 94' (IET 30651) and

'RCPR 95' (IET 30674) have been promoted from IVT to AVT 1 trial after first year of testing during *Kharif* 2022 under AICRP on rice.

Based on performance under on-station trials, eight promising advance breeding lines (RCPR 99, RCPR 100, RCPR 101, RCPR 102, RCPR 103, RCPR 104, RCPR 105 and RCPR 106) of rice have been nominated (under different trials/ecology) to national AICRP trials for multi-locational testing/evaluation during *Kharif* 2023. Moreover, during *Kharif* 2023, two hundred twenty rice genotypes (comprising advanced breeding lines and check varieties) belonging to six AICRP trials (AVT 2-E-TP, AVT 1-E-TP, IVT-E-TP, IVT-aerobic, AVT-1-aerobic and AVT-2-aerobic) were conducted at ICAR RCER, Patna (Fig. 5.2).

Fig. 5.2 Evaluation and monitoring of rice trials under AICRP programme

IC Number assignment to traditional rice collections

Eighty-eight traditional rice germplasm collections from flood-prone areas of Assam, Bihar and West Bengal were deposited in national gene bank at ICAR-NBPGR, New Delhi. The deposited accessions were allotted IC No. from IC 0648667 to IC 0648754 by the ICAR-NBPGR, New Delhi.

Evaluation of rice genotypes under dry direct seeded rainfed conditions

A field evaluation was done during *kharif* 2023 with the aim to identify new rice genotypes suitable for dry DSR conditions and tolerance to drought for middle Indo-Gangetic Plains. Three hundred ten (Stage 1 trial) and fifty rice genotypes (Stage 2 trial) (comprising advanced breeding lines developed by IRRI, partners breeding lines, global checks, and local checks) were evaluated under rainfed dry DSR condition (Fig. 5.3). All genotypes used in this study belong to early maturity group. Under Stage 1 trial, grain yield of rice genotypes ranged from 0.011-2.89 t/ha, with mean grain yield of 0.728 t/ha. Promising genotypes (RCPR 92, IR22EL1245, IR22EL1466, IR22EL1257, IR22EL1242, RCPR 95, IR22EL1420, Swarna Shreya, Swarna Purvi Dhan 1 and IR13LT799) with productivity range of 1.75-2.68 t/ha compared to check varieties 'IRRI 163' (1.14 t/ha) and 'IRRI 154' (1.11 t/ha) were identified. Under stage 2 trial, rice genotypes, *viz.*, 'RCPR 17', 'RCPR 21', 'IR 97212-86-3-3-1', 'Swarna Shreya', 'RCPR 79', 'RCPR 19', 'Swarna Shakti Dhan', 'IR 132084-B-26-1-2-B-8', 'RCPR 15' and 'IR 132084-B-26-1-2-B-8' were identified promising for rainfed dry DSR condition with productivity range of 3.25-3.85 t/ha compared to check varieties 'Sahbhagi Dhan' (2.44 t/ha), 'IRRI 163' (1.51 t/ha) and 'IRRI 154' (1.76 t/ha). The mean and range of grain yield were 2.11 t/ha and 0.14-3.91 t/ha, respectively under Stage 2 trial. Identified promising genotypes showed better seedling emergence, early vegetative vigour, weed suppressing ability, phenotypic acceptability (PAcp) and drought stress tolerance compared to most check varieties.

Fig. 5.3 Evaluation of rice genotypes under dry DSR rainfed condition

Evaluation of rice genotypes under direct seeded rainfed conditions

Fifty rice genotypes (comprising advanced breeding lines and check varieties) were evaluated under dry direct seeded rainfed condition during *kharif* 2023 (Fig. 5.4). Mean and range of grain yield were 2.55 t/ha and 0.554-4.488 t/ha, respectively. Among the rice genotypes, IR18R 1123 (4.48 t/ha), IR 95781-15-1-1-4 (4.32 t/ha), IR16D 1060 (4.26 t/ha), RCPR 82 (4.23 t/ha), RCPR 84 (4.18 t/ha), RCPR 68

(4.17 t/ha), IR18R 1179 (4.04 t/ha), IR 87707-445-B-B-B (3.97 t/ha), IR18R 1033 (3.91 t/ha), and IR18L1446 (3.88 t/ha) found promising for dry direct seeded rainfed condition and showed better drought tolerance as compared to check varieties Sahbhagi Dhan (3.03 t/ha), IRRI 154 (1.26 t/ha) and Vandana (1.58 t/ha). Identified promising genotypes showed better seedling emergence, early vegetative vigour, weed suppressing ability, phenotypic acceptability and drought stress tolerance as compared to most of the check varieties.

Fig. 5.4 Field view of rice genotypes grown under direct seeded rainfed conditions

Evaluation and identification of rice genotypes for multi-stages drought tolerance

Under present study, thirty-six rice genotypes were evaluated for multi-stages drought (MSD) tolerance in rainout shelter, and non-stress (irrigated) conditions during *kharif* 2023 (Fig. 5.5). In MSD experimental field, water was provided only once on day immediately after sowing so that seeds could properly germinate. The non-stress experimental trial was maintained by applying irrigation as and when required. Grain yield of different genotypes varied from 0.082 to 1.62 t/ha, and 2.869 to 4.542 t/ha under MSD and non-stress conditions, respectively. Results of the study revealed that irrespective of the genotypes, there was a significant reduction (80.02 %) in mean grain yield under MSD as compared to non-stress condition. Among rice genotypes, IR83929-B-B-291-2-1-1-2 (1.62 t/ha), IR18R 1123 (1.59 t/ha), IR14L 613 (1.44 t/ha), IR 95781-15-1-1-4 (1.32 t/ha), IR83929-B-B-291-3-1-1 (1.27 t/ha), IR 84899-B-185-8-1-1-1 (1.20 t/ha) and IR 84899-B-184-16-1-1-1 (1.19 t/ha) were identified promising for multi-stages drought tolerance as compared to the check varieties ‘Sahbhagi Dhan’ (0.995 t/ha) and ‘Vandana’ (0.474 t/ha).

Fig. 5.5 Evaluation of rice genotypes for multi-stages drought tolerance

Evaluation of rice genotypes for natural farming

Sixty rice genotypes comprising advanced breeding lines and high yielding varieties were evaluated under natural farming conditions during *Kharif* 2022 (Fig. 5.6). The objective of this experiment was to identify rice genotypes suitable for natural farming. The mean and range of grain yield were 3.15 t/ha and 1.79-4.31 t/ha, respectively. Among rice genotypes, ‘Swarna Purvi Dhan 2’ (4.31 t/ha), ‘IR 14 L362’ (4.30 t/ha), ‘IR 95781-15-1-1-4’ (4.24 t/ha), ‘IR 97030-7-2-2-2’ (4.22 t/ha), ‘Swarna Shreya’ (4.20 t/ha), ‘IR 14 L613’ (4.16 t/ha) ‘IR 95817-5-1-1-2’ (4.09 t/ha) and ‘IR 107891-B-B-1432-2-1’ (4.13 t/ha) were found promising for natural farming.

Fig. 5.6 Evaluation of rice genotypes under natural farming condition

Evaluation of rice genotypes for tolerance to multiple stresses (submergence and drought)

Eight rice genotypes were evaluated under control (non-stress), vegetative stage drought (VSD), reproductive stage drought (RSD), submergence, multiple submergence and combine stress (submergence + drought) conditions during *Kharif* 2023. Average grain yields of 6.18, 3.79, 3.44, 1.06, 0.65 and 0.48 t/ha were recorded under non-stress, VSD, RSD, submergence, multiple submergence and combine stress condition, respectively. Results of the present study revealed that irrespective of the genotypes, there was a significant reduction in grain yield of rice under VSD (38.7%), RSD (44.4%), submergence (82.8%), multiple submergence (89.9%) and combine stress (92.2%) condition as compared to non-stress (control) condition. Among rice genotypes, 'IR 96321-315-323-B-3-1-3', 'IR 96321-315-294-B-1-1-1' and 'IR 96321-558-563-B-2-1-1' were found promising for different stresses either for individual or combine stresses tolerance as compared to check variety 'Swarna Sub 1' and 'Swarna'.

Evaluating performance of inbred and hybrid rice cultivars under direct seeded conditions

A field experiment was conducted during *kharif* 2023 to study the comparative performance of inbred and hybrid rice cultivars under direct seeded conditions in RCBD with three replications. Altogether, 24 inbred & hybrid rice cultivars were tested. Out of 24 tested inbred/hybrid rice, 11 varieties (Swarna Shreya, Swarna Shakti Dhan, Swarna Unnat Dhan, Swarna Purvi Dhan-3, Swarna Sukha Dhan, CR Dhan 201, CR Dhan 202, PR 126, Arize 6129 Gold, RCPR 68 & RCPR 92) were of short duration, and 13 [Sarju 52, Swarna Samriddhi Dhan, BPT 5204 (Samba Mahsuri), Arize 6444 Gold, Arize 8433 DT, 27P37 (XRA 37923), 28P67 (XRA 38967), 25P85 (XRA 752PJ6), Sava 134, Sabour Sampann Dhan, MTU 7029 (Swarna), DRR 56, DRR 64] were of medium/long-duration. The crop was sown on 17th of June, 2023 under CTDSR. After sowing, light irrigation was given to ensure good germination and crop stand. At initial stage, pressure of weed loads was managed through application of bispyribac Na 10% SC+Pyrazosulfuron ethyl 10% WP (200 ml+160 g/ha) at 20 DAS. Among tested short duration inbreds/hybrids, 'Arize 6129 Gold' (4.80 t/ha) recorded maximum grain yield followed by 'RCPR 68' (4.57 t/ha) and 'Swarna Purvi Dhan-3' (4.15 t/ha). Among tested medium/long duration inbreds/hybrids, '27P37' (XRA37923) (5.74 t/ha) was maximum grain yielder followed by 'MTU 7029' (Swarna) (5.55 t/ha) and 25P85 (XRA 752PJ6) (5.26 t/ha) (Fig. 5.7 & Fig. 5.8).

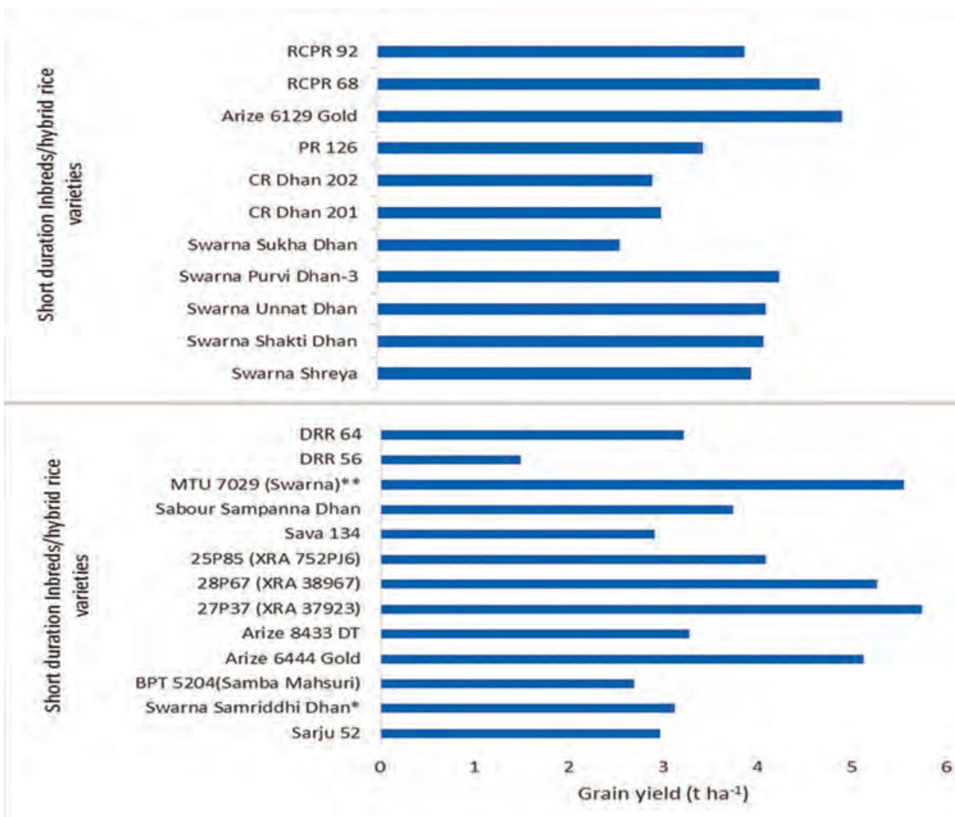


Fig. 5.7 Crop yields of inbred/hybrid rice cultivars in dry-direct seeded conditions in irrigated ecosystem of Bihar (mean data of *Kharif* 2023)

Fig. 5.8 Crop view of Dry-DSR during experimentation at the ICAR RCER Patna (*Kharif* 2023)

Frontline demonstrations of rice varieties

Frontline demonstrations of rice varieties 'Swarna Shreya', 'Swarna Shakti Dhan', 'Swarna Samriddhi Dhan', 'Swarna Sukha Dhan' and 'Swarna Unnat Dhan' were conducted during *Kharif* 2023 at 52 beneficiary farmers' (including 14 women farmers) fields covering 10.2 hectares in two districts (Patna and Gaya) of Bihar and Ramgarh district of Jharkhand (Fig. 5.9). The performance of the demonstrated rice varieties (Swarna Shreya, Swarna Shakti Dhan, Swarna Samriddhi Dhan Swarna Sukha Dhan and Swarna Unnat Dhan) were found superior to the respective check varieties. At the farmer's field, rice varieties 'Swarna Shreya', 'Swarna Shakti Dhan', 'Swarna Samriddhi Dhan', 'Swarna Sukha Dhan' and 'Swarna Unnat Dhan' recorded an average grain yield of 4.16, 4.32, 5.11, 3.89, and 4.59 t/ha, respectively, showing 13.2, 9.22, 8.29, 11.8 and 18.4 percent yield advantage over respective local check varieties.

Fig. 5.9 Frontline demonstrations of rice varieties in different districts of Bihar

Breeder Seed Production of Rice Varieties

Breeder seeds of rice varieties 'Swarna Shreya' (41.0 q), 'Swarna Shakti Dhan' (21.0 q), 'Swarna Samriddhi Dhan' (46.7 q), 'Swarna Unnat Dhan' (6.0 q), 'Swarna Sukha Dhan' (1.50 q), 'Swarna Shusk Dhan' (1.20 q), 'Swarna Purvi Dhan' 1 (2.75 q), 'Swarna Purvi Dhan 2' (1.75 q) and 'Swarna Purvi Dhan 3' (4.50 q) were produced during *Kharif* 2023. The representatives of National Seed Corporation (NSC), Patna, Bihar State Seed and Organic Certification Agency (BSSOCA), Patna and scientific staff of ICAR RCER, Patna participated in the monitoring of breeder seed production of these rice varieties (Fig. 5.10). Besides, nucleus seeds (3.50 q) of above-mentioned rice varieties were also produced during *Kharif* 2023. In addition, truthfully labeled (TL) seeds of rice varieties 'Swarna Shreya' (15.0 q), 'Swarna Shakti Dhan' (4.00 q), 'Swarna Samriddhi Dhan' (32.0 q), 'Swarna Unnat Dhan' (7.0 q), 'Swarna Sukha Dhan' (3.25 q), 'Swarna Shusk Dhan' (6.20 q), 'Swarna Purvi Dhan 1' (3.50 q), 'Swarna Purvi Dhan 2' (1.5 q) and 'Swarna Purvi Dhan 3' (3 quintals) were also produced during *Kharif* 2023.

Fig. 5.10 Breeder seed production of rice varieties and their monitoring

Seed distribution of rice varieties

More than 5 quintals of quality seeds of climate resilient rice varieties (Swarna Shreya, Swarna Shakti Dhan, Swarna Samriddhi Dhan, Swarna Unnat Dhan and Swarna Sukha Dhan) were distributed to more than 200 farmers belonging to different districts of the state of Bihar and Jharkhand for on-farm demonstrations or on-farm testing during *Kharif* 2023 (Fig. 5.11).

Fig. 5.11 Seed distribution of rice varieties

Maintenance and generation advancement of rice breeding materials

One hundred thirty-three rice genotypes comprising advanced breeding lines and released varieties of different duration were grown, purified, and maintained in rice cafeteria during *Kharif* 2023. Besides, ten F_7, fourteen F_6, nine F_5 generation rice breeding materials along with parents were also raised. Uniform plants or lines of early and medium-early duration were selected based on plant type, panicle length, effective tiller numbers, grain features, lodging resistance and tolerance to diseases and insect pests. Seeds of rice breeding materials have been retained for further evaluation and generation advancement.

Evaluation of traditional rice germplasm from flood prone ecosystem

Thirty-six traditional short grain aromatic rice germplasm were evaluated under direct seeded condition for grain yield and other agro-morphological traits. 'Satlakha Local', 'Sataria Malbhog', 'Kanakjeera', 'Kunkuni Joha-1' and 'Kunkuni Joha-2' were top yielding genotypes with more than 2.0 t/ha grain yield. Grain yield ranged from 0.67 t/ha (Kalanamak) to 2.66 t/ha (Satlakha Local). Days to 50% flowering ranged from 122 days (Rajendra Kasturi) to 156 days (Katarni). Similarly, Plant height ranged from 98 cm (Rajendra Kasturi) to 160 cm (Kalanamak). The top yielding genotypes could be useful for cultivation under organic or natural farming as premium rice crop.

Fe and Zn content in 30 short grain aromatic rice and 70 traditional lowland rice germplasm were estimated at ICAR-IIRR, Hyderabad. There appeared a wide variation for the Fe and Zn content in short grain aromatic rice accessions as well as in traditional lowland rice germplasm (Table 5.2).

Table 5.2 Range of Fe and Zn content in traditional rice germplasm accessions of Eastern India

Iron and Zn	Short grain aromatic rice		Lowland rice	
	Lowest value	Highest value	Lowest value	Highest value
Fe	5.9 ppm (NB/RKR-21)	12.3 ppm (NB/RKR-17)	5.4 ppm (NB/RKR61)	16.6 ppm (NB/RKR-87)
Zn	17.4 ppm (NB/RKR-21)	26.4 ppm (NB/RKR-17)	15.4 ppm (NB/RKR-18)	31.9 ppm (Lalsar)

Evaluation of flood-prone rice genotypes

Eleven elite genotypes of flood tolerant rice selected from IIRSTN-FP, 2022 were evaluated during *kharif* 2023 for grain yield other agronomic characters. Although none of the test genotypes were significantly superior in grain yield to check 'Swarna sub1' (5.93 t/ha), 'ING-296' (5.94 t/ha) and 'ING-289' (5.34 t/ha) were at par with 'Swarna sub1' in grain yield with nearly one month early in maturity. Thus, these two genotypes were considered promising for flood-prone rice ecosystem (Table 5.3).

Table 5.3 Performance of flood prone rice genotypes

Genotypes	Days to 50% flowering	Plant height (cm)	Panicles/ hill	Panicle length (cm)	Grain yield (t/ha)	Harvest index (%)
ING-288	92	101.4	11	27.2	4.24	41.6
ING-289	95	101.3	10	24.7	5.34	38.7
ING-290	96	92.4	11	24.5	4.88	44.0
ING-296	93	114.7	10	28.4	5.94	45.3
ING-299	88	99.1	12	25.8	4.11	39.4
ING-301	90	98.4	9	25.4	4.63	40.2
ING-305	89	105.1	11	25.9	4.31	41.7
ING-306	86	91.4	10	28.9	3.98	35.1
ING-316	91	93.2	11	24.1	4.81	40.1
ING-318	90	101.3	11	28.1	3.78	29.9
ING-319	92	81.9	11	23.1	3.11	30.7
FR13A	92	93.7	12	25.9	3.89	32.7
IR64 sub1 (check)	88	92.7	11	23.2	4.29	37.7
Swarna sub1 (check)	123	93.7	10	25.1	5.93	39.9
SEm (±)	0.55	2.84	0.55	0.72	0.22	3.35
CD (P=0.05)	1.60	8.26	1.59	2.10	0.65	9.73

Evaluation of lowland rice genotypes

Ten elite rice genotypes selected from IIRON-2022 of IRRI, Philippines were evaluated for their suitability in irrigated ecosystem during *kharif* 2023. Under late duration, 'Swarna' was the top yielding check with grain yield of 3.17 t/ha, whereas in mid-early duration 'Naveen' was the best check with grain yield of 3.56 t/ha. Among test genotypes, 'ING003' (4.61 t/ha) and 'ING024' (4.33 t/ha) are significantly superior in grain yield to the best check, and hence were found promising for irrigated ecosystem within mid-early duration group Table 5.4).

Table 5.4 Performance of rice genotypes under irrigated ecosystem

Genotypes	Days to 50% flowering	Plant height (cm)	Panicles/ hill	Panicle length (cm)	Grain yield (t/ha)	Harvest index (%)
ING003	92	111	12	28	4.61	44
ING024	96	118	11	28	4.33	46
ING008	92	112	13	28	4.12	46
ING034	93	108	11	26	4.10	40
ING013	92	110	12	28	3.99	46
ING012	92	109	12	29	3.91	45
ING002	87	104	11	27	3.88	43
ING006	87	109	11	29	3.82	46
ING030	89	95	12	27	3.74	43
ING011	86	109	12	29	3.69	48
Naveen (check)	91	122	11	29	3.56	39
Swarna (Check)	119	83	12	23	3.17	31
IR 64 (check)	88	90	13	25	2.94	31
Rajendra Sweta (check)	120	91	12	23	2.52	26
SEm (±)	1.8	4.9	0.5	0.6	0.25	2.8
CD (P=0.05)	5.2	14.3	1.6	1.8	0.74	8.0

Evaluation and selection in M_2 generation mutant population

The M_2 generation derived from three traditional short grain aromatic rice varieties, *viz*., 'Kalajoha', 'Katarni' and 'Shyamjeera' following Gamma ray and ethyl methane sulphonate treatments was raised during *Kharif* 2023. Individual plant selections were performed based on plat height, maturity duration and other agro-morphological traits. These selections will be evaluated in M_3 generation for further selection.

Wheat

Effect of heat and drought stress in wheat

Eastern Indo-Gangetic Plains in the current context of climate change is highly vulnerable in terms of rising temperature and frequent occurrence of drought and heat waves. Hence, wheat grown under rainfed conditions or under restricted irrigation is highly vulnerable to these stresses. Thirteen genotypes/varieties under timely (26th of November) and late (26th of December) sown conditions were evaluated. Three drought treatments, *viz.*, control (full irrigation), vegetative stage drought (VSD) and reproductive stage drought (RSD) were imposed under both sowing dates. Fig. 5.12 and Fig. 5.13 show wheat yield under timely and late sown condition, where yield of wheat declined under late sown condition by 12-22% as compared to normal sown condition. Under combined stress (heat + drought stress), grain yield reduced by 20-29% compared to normal sown condition. Physiological traits like RWC (27.9%), chlorophyll content (15.3%), and MSI (16.65%) declined under late sown conditions, while level of lipid peroxidation (74.97%) and proline content (312.63%) were higher under late sown stress condition. Fig. 5.14 shows that the top five varieties, i.e., 'Raj 3765', 'HD 2967', 'HD 3093', 'DBW 187' and 'DBW 14', were found promising under late sown conditions for MIGPs.

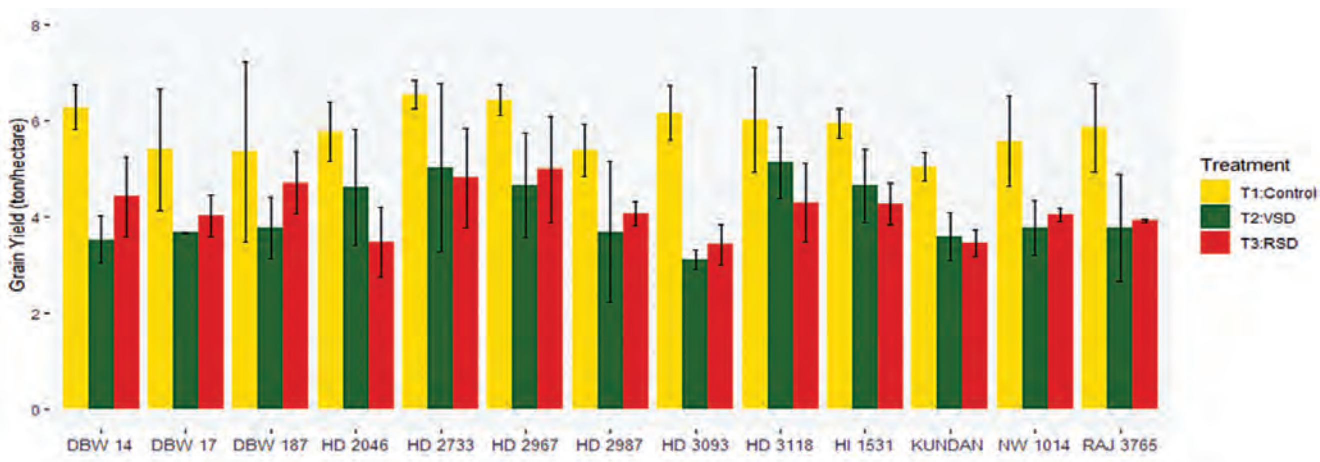


Fig. 5.12 Effect of drought and heat stress on wheat yield under timely sown condition

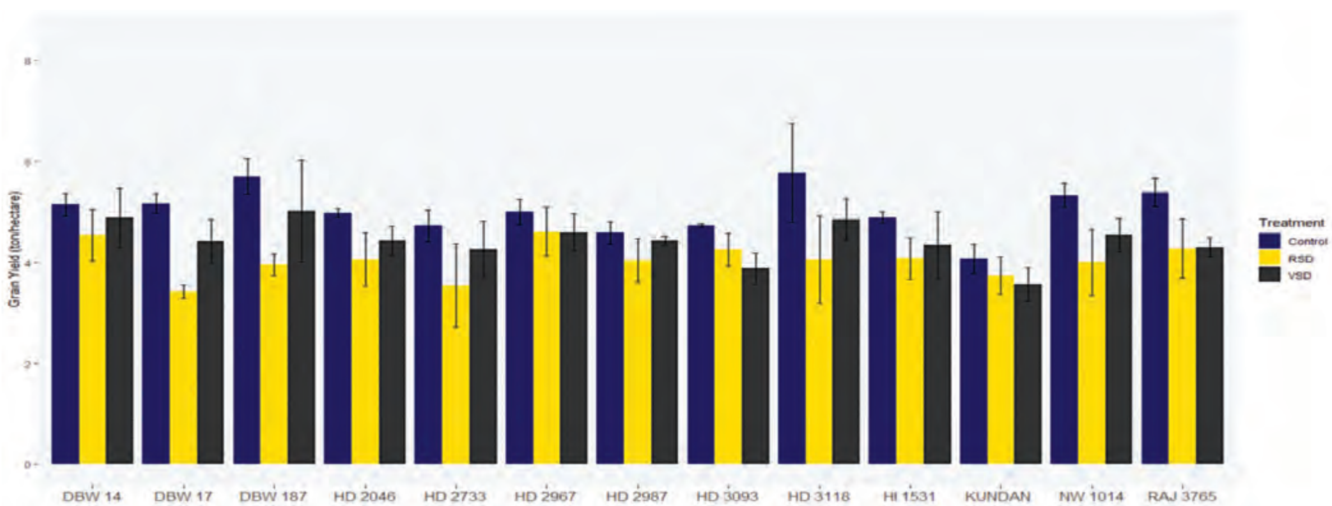


Fig. 5.13 Effect of drought and heat stress on wheat yield under timely sown condition

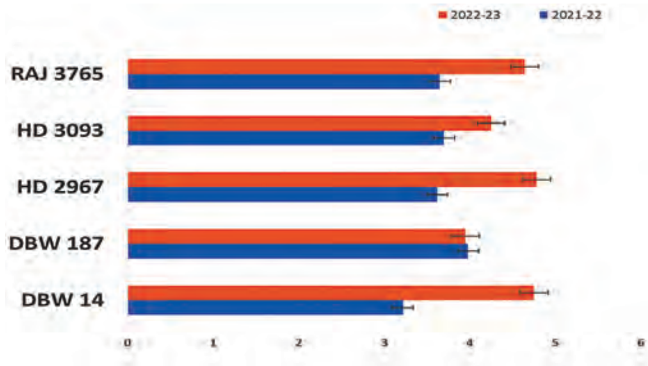


Fig. 5.14 Promising wheat varieties for heat and drought stress under late sown condition for MIGP

Rice-Wheat System

Evaluation of nano DAP fertilizer on the performance and yield of rice and wheat crops

A field experiment with wheat variety 'DBW 187' (Karan Vandana) was carried out during *Rabi* 2022-2023 to evaluate the efficacy of nano DAP fertilizer on crop growth and grain yield (Fig. 5.15). There were ten treatments, viz., T1: 0% P & N (no basal DAP) and 100% K; T2: 100% NPK (University Recommendation), 100% basal DAP; T3: 75% P & N and 100% K; T4: 50% P & N and 100% K; T5: T3 + ST with Nano DAP @ 5 mL/kg seed + FS with nano DAP @ 2 mL/ liter of water at 20-25 DAT; T6: T3 + ST with Nano DAP @ 5 mL/kg seed + FS with nano DAP @ 4 mL/ liter of water at 20-25 DAT; T7: T4 + ST with nano DAP @ 5 mL/kg seed + FS with nano DAP @ 2 mL/ liter of water at 20-25 DAT; T8: T4 + ST with Nano DAP @ 5 mL/kg Seed + FS with Nano DAP @ 4 mL/ liter of water at 20-25 DAT; T9: T4 + ST with nano DAP @ 5 mL/kg seed + First FS with nano DAP @ 2 mL/ liter of water at 20-25 DAT and second Spray- 45 days after seed germination/transplanting; T10: T4 + ST with nano DAP @ 5 mL/kg seed + First FS with Nano DAP @ 4 mL/ liter of water at 20-25 DAT and Second Spray- 45 days after seed germination/transplanting. The highest grain yield was achieved with 100% NPK (5.03 t/ha) followed by 50% RDF + two foliar spray of nano DAP @ 4 mL/liter (T10), i.e., 4.81 t/ha followed by 50% RDF + two foliar spray of nano DAP @ 2 mL/liter (T9), i.e., 4.77 t/ha. The range of soil N, P, K and OC were 173 – 188, 19-20.6, 168-234 kg/ha and 0.56-0.73%, respectively were recorded after wheat harvesting (Table 5.5), but no significant difference was observed among the treatments.

Fig. 5.15 Field view of Nano-DAP experiments

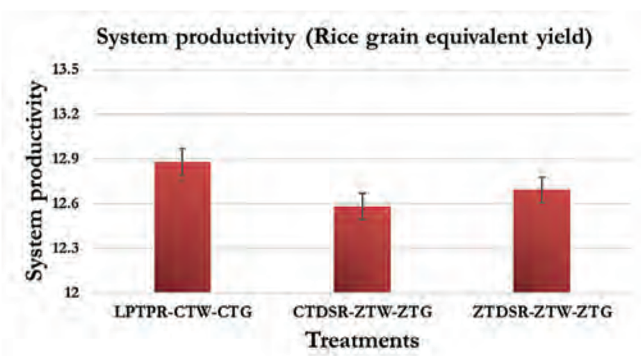
Table 5.5 Wheat yield and soil properties (0-15 cm) after wheat harvest during *Rabi* 2022-23

Treatments	Grain Yield (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	OC (%)	pH	EC (dS/m)
T1	1.02	176.58	19.00	168.11	0.58	7.97	0.18
T2	5.03	188.45	20.20	188.38	0.70	8.07	0.19
T3	4.61	182.72	20.00	192.05	0.66	8.04	0.22
T4	4.31	182.51	19.60	181.22	0.63	7.97	0.18
T5	4.25	183.35	19.30	183.87	0.72	7.99	0.19
T6	4.32	173.32	20.60	210.11	0.73	7.99	0.17
T7	4.15	179.17	20.20	208.95	0.66	8.03	0.23
T8	4.67	187.32	20.10	234.34	0.72	8.00	0.22
T9	4.77	176.66	19.60	190.29	0.56	8.05	0.20
T10	4.81	175.82	20.50	198.54	0.64	8.01	0.19
CD (P=0.05)	1.33	NS	NS	NS	NS	NS	NS

Weed seed bank dynamics, resource-use efficiency and greenhouse gas footprint under diverse tillage production systems in Eastern Indo-Gangetic Plains

A field study was initiated during *Kharif* season of 2021 to identify an effective weed management strategy as well as a climate resilient tillage and crop establishment method for sustainable intensification of rice-fallows in Eastern India. The treatments comprised different tillage and crop establishment practices as main plot treatments and weed management practices as sub plot treatments. The experiment was conducted in a rice-wheat-green gram system.

Results of the study revealed that among weed management practices, pre-emergence application of pyrazosulfuron-ethyl (25 g/ha) *fb* post-emergence application of cyhalofop butyl + penoxulam (100 +25) g/ha (tank-mix) led to significant reduction of weed density as well as biomass in rice. The dominance of broad leaf weeds was higher than grassy weeds and sedges in direct seeded (conventional and zero tillage) rice compared to puddled line transplanted rice (LPTPR). Post-emergence application of clodinafop-propargyl + metsulfuron methyl (60+5) g/ha (tank-mix) at 30 days after sowing in wheat significantly suppressed weed seedling emergence, whereas in case of green gram, application of pendimethalin (1000 g/ha) as pre-emergence *fb* post-emergence application of imazethapyr (100 g/ha) at 25 DAS significantly increased weed control efficiency. Zero-till direct seeded rice followed-by (*fb*) zero till wheat *fb* zero till green gram (ZTDSR-ZTW-ZTG) along with application of efficient pre-emergence and post-emergence herbicides led to 23% higher water productivity and 88% higher weed control efficiency than line puddled transplanted rice *fb* conventional till wheat *fb* conventional till green gram (LPTPR-CTW-CTG). This treatment also led to significant improvement in soil organic carbon up to 30 cm soil depth and reduced 34% global warming potential than LPTPR-CTW-CTG. Zero-till direct seeded rice *fb* zero till wheat *fb* zero till green gram (with 12.7 t/ha system productivity and 8% increase in system net returns) could lead to sustainable crop intensification in Eastern Indo-Gangetic Plains of India (Fig. 5.16).



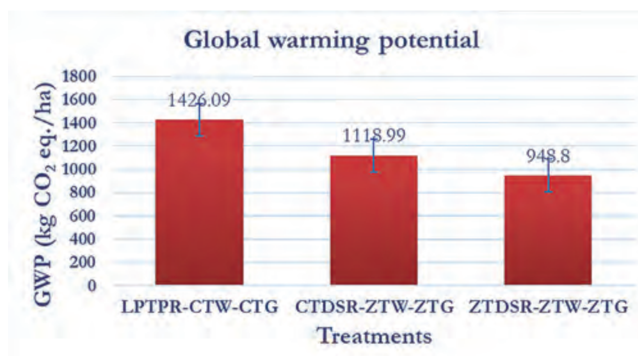


Fig. 5.16 System productivity, global warming potential and net returns in rice-wheat-green gram system across treatments

6 Oilseeds and Pulses

Identification and release of a chickpea variety

The variety 'DBGC 3' (Swarna Lakshami), derived from a cross between 'ICC 13124' and 'WR 315' following pedigree method of breeding, has been identified, and recommended for release by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties in its 91st meeting held at New Delhi on November 21, 2023. The variety has recorded an overall mean yield of 1.75 t/ha weighted over 15 locations in the national AICRP trials under timely sown irrigated conditions of the NEPZ (Fig. 6.1). It recorded a yield advantage of 26.9, 17.3 and 13.2 %, respectively over recently released checks such as 'PBG 9', 'GNG 2207' and 'BG 3043'. It has an excellent grain colour, size, and shape, having an average 100-seed weight of 21.27 g and high '*Dal recovery ratio*' (>0.98). Seeds of the variety are rich in protein content (20.86%), Zn (46.25 ppm) and Fe content (53.6 ppm). The variety exhibited consistent wilt reaction (*resistant to moderately resistant*) to Fusarium wilt in wilt-sick plots at Tirhut College of Agriculture, Dholi (2017-18, 2018-19, 2020-21, 2021-22 and 2022-23). Besides, it is also *moderately resistant* to dry root rot and collar rot.

Fig. 6.1 Chickpea variety 'Swarna Lakshami'

Assignment of National Identity No. to chickpea and lentil accessions: Four unique genotypes (two of *Desi* chickpea, one of *Kabuli* chickpea, and one of lentil) were sent to NBPGR, New Delhi for assignment of national identity number. *Desi* chickpea genotypes 'DBGC 1' and 'DBGC 3' were respectively assigned the identity no. IC 650180 and IC 650181. Determinate Kabuli type 'RCECK 17-4' and super early type lentil 'RCEL 19-1' were assigned No. IC 650182 and IC 650183, respectively (Fig. 6.2).

DBGC 1 (IC650180) **RCECK 17-4 (IC650182)** **RCEL 19-1 (IC650183)**

Fig. 6.2 Potential chickpea and lentil genotypes

Performance of Advance breeding lines in AICRP/ State Trials

- In chickpea, one entry 'RCEC 3' (Pusa 256×ICC 4958) was promoted to AVT-1 of AICRP on Chickpea for timely sown condition of south zone based on its performance during the crop season 2022-23.
- The genotype 'DBGC 1' (Pusa 256 × WR 315) of chickpea also excelled in SVT and has been promoted for the next stage of testing during 2023-24.

- One genotype 'DBGL 105' of lentil and another of chickpea 'RCEC 6003' have been contributed to the State Varietal Trial (SVT) for their evaluation during 2023-24.

Performance of advance breeding lines in wilt sick nursery

Six genotypes of chickpea (DBGC 3, RCEC 3, RCEC 2310, RCEC 6003, RCEC 6059 and RCECK 17-4) and three genotypes of lentil (DBGL 105, RCEL 59025 and RCEL 19-1) were put to pathological trials for assessment of wilt reaction at TCA, Dholi (Muzaffarpur) during 2022-223. The plant mortality data showed that chickpea genotypes showed moderate (RCEC 2310 and RCEC 6059) to resistant (RCEC 6003, DBGC 3, RCEC 3 and RCECK 17-4) wilt reaction (Table 6.1). In lentil, 'DBGL 105' showed resistant reaction whereas 'RCEL 59025' exhibited moderately resistant wilt reaction. Genotype 'RCEL 19-1' showed substantially greater mortality percent (76.67%) than susceptible check 'Sehore 74-3' (63.73%), indicating that 'RCEL 19-1' could be a better susceptible check than existing one (Sehore 74-3) for assessing wilt sick reaction of lentil genotypes in AICRP pathological trial.

Table 6.1 Wilt reaction of chickpea and lentil genotypes at TCA, Dholi (2022-23)

Chickpea			Lentil		
Test genotypes	Mean wilting (%)	Wilt reaction	Test genotypes	Mean wilting (%)	Wilt reaction
DBGC 3	05.76	R	DBGL 105	8.63	R
RCEC 3	09.10	R	RCEL 59025	14.0	MR
RCEC 2310	12.49	MR	RCEL 19-1	76.67	HS
RCEC 6003	03.38	R	Seohore 70-3 (S-check)	63.75	HS
RCEC 6059	11.29	MR			
RCECK 17-4	10.23	R			
JG 62 (S-check)	85.48	HS			

R: resistant; MR: Moderately resistant; HS: Highly susceptible

Promising genotypes of chickpea and lentil multiplied during Rabi 2022-23 for further evaluation in AICRP and SVT systems: A number of varieties and promising genotypes of chickpea and lentil were multiplied during the crop season 2022-23. The main agronomic characteristics of these genotypes and varieties are given below in the Table 6.2.

Table 6.2 Yields and other attributes of chickpea and lentil varieties/genotypes

Chickpea				Lentil			
Variety/ Genotypes	Yield (t/ha)	SW (g/100 seeds)	MD (day)	Variety/ Genotypes	Yield (t/ha)	SW (g/100 seeds)	MD (day)
Sabour Chana 1	1.44	26.3	120	DBGL 135	0.600	1.83	104
RCEC 3	1.906	23.8	122	HUL 57	2.012	2.21	115
Sabour Chana 2	1.250	13.0	114	PusaVaibhav	1.100	1.87	104
GNG 2207	1.625	14.5	120	Ranjan	0.192	2.33	100
Pusa 3043	1.437	21.0	114	Arun	0.884	2.73	104
Sabour Chana 3	1.375	16.9	117	PusaMasoor 5	1.106	2.00	105
RCEC 6125	1.750	14.0	115	DPL 15	1.348	2.74	104
DBGC 3	2.655	22.0	125	DPL 62	0.896	3.14	117
DBGC 1	1.910	28.5	127	K 75	0.456	2.23	114
RCECK 17-4	1.806	29.8	121	IPL 225	1.056	2.08	100
Shubhra	1.736	34.0	119	IPL 406	1.172	3.35	116
RCEC 6003	2.087	23.7	132	IPL 316	0.500	2.78	117
RCEC 6059	1.652	23.0	125	KLS 218	1.265	2.10	104
RCEC 6141	1.687	28.0	126	PDL 1	0.530	2.54	116

SW: Seed weight; MD: Maturity duration

Preliminary Yield Trial in Lentil: During 2022-23, a total of 40 lines (selected from ICARDA nursery materials during the preceding crop season) were assessed in four blocks following augmented design. Each block comprised 10 test genotypes and two check varieties (IPL 220 and HUL 57). Yield, seed size and field resistance/tolerance to diseases were the prime criteria for selection of genotypes in each block. A total of 10 lines that yielded at/above par with the checks were selected for further evaluation in the station trial during 2023-24.

Grass pea Station Trial (2022-23): Seven low ODAP advance breeding lines of grass pea (selected from ICARDA nursery) were evaluated in the station trial along with two checks (*Ratan* and *Mahateora*) following randomized complete block design (RCBD). Details of crop yield and other agronomic data are given below in Table 6.3.

Table 6.3 Performance of advance breeding lines of grass pea in station trial (2022-23)

Genotypes	Yield (t/ha)	100 seed wt (g)	Maturity duration (days)
75016	1.273	8.82	129
75017	1.375	8.27	127
75022	1.582	8.88	123
75024	1.919	8.72	115
75040	1.738	7.13	129
75046	1.498	7.26	127
75049	1.785	7.41	120
Ratan	1.900	7.86	118
Mahateora	1.056	6.90	110
LSD (P=0.05)	0.16	0.91	1.10

Pulse Seed Hub

Under aegis of NFSM funded mega project on "Creation of seed hubs for increasing indigenous production of pulses in India", Breeder seed production of pigeonpea (IPA 203) and chickpea (Pusa 3043 and GNG 2207) was taken up at ICAR RCER, Patna during 2022-23. In lentil, breeder seeds of biofortified varieties 'IPL 220' and 'Pusa Ageti Masoor' were also produced. In addition, quality seeds (C/S and T/L) of mungbean (Virat, Shikha, IPM 2-3, IPM 2-14 and Samrat) were also taken up at the RCER, Patna. At KVK, Buxar, quality seed production of red gram (IPA 203), chickpea (Pusa 3043, GNG 2299 and GNG 2207) and lentil (IPL 220) were taken up in participatory mode. Details of quality seeds produced are mentioned in Table 6.4.

Table 6.4 Quality seeds of pulses produced under Pulse Seed Hubs during 2022-23.

Crop	Variety	Class of Seed	Seed production (q)
Mungbean	IPM 2-3	C/S	05
	Virat	C/S	10
	IPM 2-14	C/S	05
	Shikha	C/S	05
	Samrat	T/L	05
Chickpea	Pusa 3043	B/S C/S	15 63*
	GNG 2299	F/S, C/S	29 (05+24*)
	GNG 2207	B/S, F/S	12 (05+7*)
Lentil	IPL 220	B/S, F/S, C/S	140 (15+125*)
	Pusa Ageti	B/S	15
	PL 8	TL	05
Pigeonpea	IPA 203	B/S, T/L	65 (25+40*)
	IPA 206	B/S	02
		Total	376

B/S: Breeder seed; F/S: Foundation seed; CS: Certified seed; T/L: Truthfully labelled seed; *: Seed produced under Pulse seed hub, KVK, Buxar

Evaluation of Toria genotypes

Thirty elite genotypes of *toria*, received from the ICAR-DRMR, Bharatpur, were evaluated for their performance during 2022-23 *rabi* with two irrigations: one after seed germination and the second during siliqua formation stage. From siliqua formation stage to maturity, there was heavy infestation of aphids on the crop, which was controlled by spraying of suitable insecticides. M27 (8.50 q/ha), TS38 (8.33 q/ha) and TS36 (7.91 q/ha) were the top yielding three genotypes amongst the tested materials.

Performance of Mustard cv. DRMR 150-35 under FLDs plots of rice-fallow project site at Guleriyachak, Tekari, Gaya, Bihar

During the year 2023-24, a frontline line demonstration on mustard under the aegis of Institute's flagship program on rice-fallow management through climate resilient agriculture was done at the farmers' fields at the project site at Guleriyachak, Tekari, Gaya, Bihar. Altogether 15 farmers were selected covering an area of 12.5 acre. Crop seed and other necessary inputs were received from the ICAR-DRMR Bharatpur, Rajasthan to greening the rice-fallow area for double cropping. Crop was raised under residual fertility and moisture through ZT-tillage system. Crop yield ranged from 0.9 to 1.27 t/ha, which was better than targeted national average yield of oilseeds 0.5 t/ha for rice-fallow areas.

Fig. 6.3 Input distribution and crop performance at the farmers' field at project site

7 Fruits

Bacterial diversity associated with developmental stages of litchi stink bug

Litchi stink bug [*Tessaratoma javanica* (Thunberg)] (Hemiptera: Tessaratomidae) has been reported to cause substantial yield loss in litchi (*Litchi chinensis* Sonn.). To design effective and environmentally safe management strategies, an understanding of the diversity and functions of microbiota harbored across the development stages is very essential. The assessment of the diversity of development-associated bacteria in *T. javanica* and their predicted functions was conducted using 16S rRNA amplicon sequencing obtained by the Illumina MiSeq technology. The result showed (Fig. 7.1) a total of 46 phyla encompassing 139 classes, 271 orders, 474 families, and 893 genera of bacteria. A total of 42.82 percent of operational taxonomic units (OTUs) were found to be shared across all developmental stages of *T. javanica*, considering a similarity level of 97% (Fig. 7.2). Alpha diversity indices showed maximum species richness in the egg and adult stages. The phyla Proteobacteria and Firmicutes exhibited the highest levels of prevalence across all the developmental phases of *T. javanica*. Maximum dissimilarities among microbiota were observed between egg and 4th nymphal stage (χ^2=711.67) and minimum dissimilarities among 2nd and 4th nymphal instars (χ^2 = 44.45). The principal coordinate analysis (PCoA) results showed significant differences in developmental stages (ANOSIM, R=0.85354, $P\leq$ 0.001) (Fig. 7.1 and 7.2).

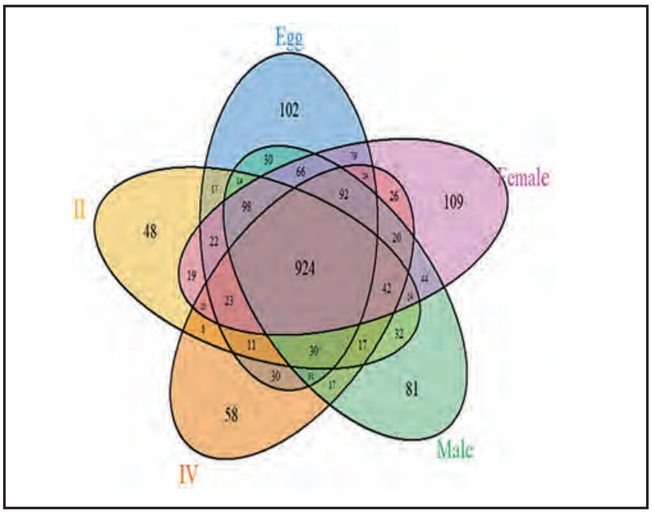


Fig. 7.1 Venn diagram of *T. javanica* developmental stages showing unique and shared OTUs: 924 OTUs are shared among all stages, including II (2nd nymphal stage) and IV (4th nymphal stage).

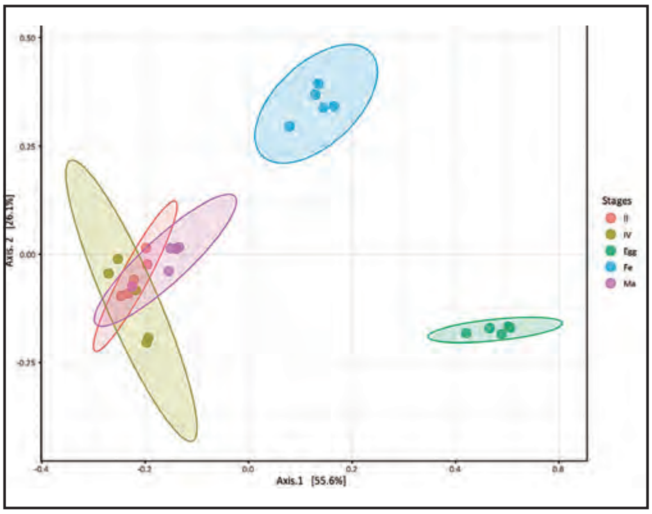


Fig. 7.2 Principal coordinate analysis (PCoA) plot visualizes the beta diversity based on Bray-Curtis similarity index among developmental stages of *T. javanica* (ANOSIM, R=0.85354, P< 0.001). II refers to 2nd nymphal stage, IV- 4th nymphal stage, Fe- Female and Ma- Male nymphal stage)

Expansion of seasonality of litchi leaf roller and new flower feeder on litchi

Infestation of Webbers on litchi flowers was observed in litchi orchards of Jharkhand, India. The identified species were *Statherotis leucaspis* Meyr. (Tortricidae: Lepidoptera) and *Homona coffearia* (Tortricidae: Lepidoptera). Larvae of *S. leucaspis* and *H. coffearia* feed in inflorescences through webbing and feeding inside silken webs and tunnelling into immature fruits (Fig. 7.3). Florets of flowers and small-sized fruits were cut and carried in one place to make web balls. Larvae remain inside webs, and were observed to feed the florets and tunnel into immature fruits. The number of webs per inflorescence ranged from 1.58 to 2.05 at flowering to fruit setting phenophase of litchi. The percentage of panicle damage in experimental farms varied from 1.9 to 34.2% by *S. leucaspis*. The correlation analyses showed significant positive correlations ($p \leq 0.05$) with rainfall for the incidence of *H. coffearia*, and with temperature for the incidence of *S. leucaspis.*

Fig. 7.3 Webs and damage symptoms caused by the infestation of *Homona coffearia* and *Statherotis leucaspis.*

Utilization of major fruit seeds and Underutilised fruits for the development of functional food product

Sixteen underutilized fruits (collected from various places of WB, Assam and Bihar) were evaluated for their phenolics and flavonoids content. The total phenolic content ranged from 35 to 347 mg GAE/100g (FWB), with the highest levels found in Indian jujube (321 mg GAE/100g) and Barbados cherry (347 mg GAE/100g). A similar pattern was observed for total flavonoid content, which ranged from 11 to 130 mg CE/100g (FWB). The highest flavonoid content was recorded in Jamun (127 mg CE/100g) and Indian jujube (130 mg CE/100g).

Fig 7.4 Underutilized Fruits: Indian Jujube, Carambola, and Barbados Cherry

8 Vegetables

Evaluation of vegetable soybean for horticultural and nutritional traits

During the *Kharif* season of 2023, thirty-four germplasm lines of vegetable soybean, received from AVRDC-The World Vegetable Centre, Taiwan, were evaluated in a replicated trial. Among these lines, AGS-404 exhibited a graded green pod yield of 17.34 t/ha and a green seed yield of 8.77 t/ha. Similarly, AGS-402 achieved a graded green pod yield of 15.74 t/ha and a green seed yield of 7.80 t/ha. The aromatic line AGS-458 produced a graded green pod yield of 13.19 t/ha and a green seed yield of 7.26 t/ha. The released variety Swarna Vasundhara recorded a graded green pod yield of 12.71 t/ha and a green seed yield of 6.55 t/ha (Fig. 8.1). These four genotypes demonstrated superior performance in yield traits, and were comparable in terms of graded green pod yield. Notably, the high-yielding aromatic line AGS-458 was promising due to its early maturity and bold green seeds, with the green pods ready for the first harvest 61 days after sowing and a 100-green seed weight of 71.42 g.

Nutritional parameters were expressed on dry weight basis. The content of isoflavone ranged from 11.12 to 22.26 mg/100 g (Table 8.1). Total oil content ranged from 10.34 to 18.67 %. The maximum total oil content was found in AGS-190 (18.67%) followed by AGS-456 (18.60 %) and AGS-333 (18.40 %). Oleic acid was maximum in AGS-190 (52.10%) followed by HAVSB-1 (48.92%), AGS-337 (48.79%), AGS-333 (48.73%) and Swarna Vasundhara (48.61%). Linoleic acid was maximum in AGS-460 (51.76%). Linolenic acid was maximum and statistically at par in AGS-380, AGS-334 and Harit Soya. The minimum trypsin inhibitor activity was found in AGS-292 (17.50 TIU/mg) followed by AGS-610 (19.83 TIU/mg) and AGS-458 (22.50 TIU/mg).

In molecular diversity analysis of 34 genotypes of vegetable soybean, 120 SSR primers were tested, out of which 106 SSR primer pairs displayed polymorphism, resulting in the amplification of a total of 413 alleles, averaging 3.84 alleles per locus. The number of alleles per primer pair ranged from 2 to 7, with PCR product sizes spanning from 100 to 360 bp. The polymorphic information content (PIC) values ranged from 0.06 (Satt 707, Satt 546) to 0.72 (Satt 367), averaging 0.49. The 34 vegetable soybean genotypes were grouped into two primary clusters: Cluster I (22 genotypes) and Cluster II (12 genotypes). Cluster I further divided into two sub-groups, IA and IB, with 14 and 8 genotypes, respectively. Cluster II, with 12 genotypes, was also subdivided into two sub-groups, IIA and IIB, comprising 3 and 9 genotypes, respectively.

The genotypes from various geographic locations clustered together which suggests that their genetic composition is not influenced by their place of origin. This implies that genotypes from different geographic regions have the potential to introduce new genetic traits or diversity into breeding programs. The scatter plot generated through Principal Coordinate Analysis (PCoA) indicated that the 34 vegetable soybean genotypes were distributed across all four quadrants, underscoring their diversity. The presence of genotypes within the same quadrant in the PCoA plot corroborated the findings from the cluster analysis. The first three principal coordinates, particularly coordinate 1 and coordinate 2, explained 22.1%, 10.17%, and 6.60% of the total variation, respectively, based on Eigen values. In total, these axes accounted for a cumulative variation of 38.98%.

Table 8.1 Nutritional parameters (dry weight basis) recorded from shelled green seeds of 34 vegetable soybean lines

Nutritional parameters	Range	Mean
Isoflavone	11.12 - 22.26 mg/100g	14.33 mg/100g
Tocopherol (Vitamin E)	32.84 - 177.41 mg/100g	76.43 mg/100g
Total oil	10.34 - 18.67%.	15.41 %.
Trypsin inhibitor activity (anti-nutritional factor)	17.50 to 39.33 TIU/mg	30.84 TIU/ mg

AGS-404

AGS-458

AGS-402

Swarna Vasundhara

Fig. 8.1 Plant, pod and shelled seed of different vegetable soybean varieties

Evaluation of F_3 and F_4 segregants of French bean

Two hundred forty-five advanced generation progeny families of French bean (derived from IC632961×IC525260 and IC632961×HAFB 74) were screened against rust, anthracnose and angular leaf spot disease reaction under Jharkhand conditions during *Rabi* season. F_4-2-8 and F_4-69 and F_4-70 selected for multiple disease resistance/ tolerance under field condition (Table 8.2). All these progenies were recorded for their earliness, high vigour, determinate habit except $F_4$2-8 (pole type), green to dark green pod, round and flat podded with high-yielding and consumer preferred (Table 8.3).

Table 8.2 Selected progenies based on resistance or tolerance to diseases

Disease	Selected progenies for resistance/ tolerance
Rust	F_3 2-14, 2-18, 3-2-5, $F_4$2-8, F_4-11, F_4-35, F_4-69, F_4-70
Anthracnose	F_4 2-8, 2-14, 3-2-5, F_4-11, F_4-35, F_4-69
Angular leaf spot	$F_4$2-8, 2-14, F_4-11, F_4-35, F_4-70

Table 8.3 Selected progenies for horticultural traits and disease resistance

Bush type			Pole type		
Progenies	**Yield (t/ha)**	**Pod traits/ disease reaction**	**Progenies**	**Yield (t/ha)**	**Pod traits/ disease reaction**
2-2	11	Early, 14-15 cm long pod, round and dark green, high yielding	F_4 2-8	11	Early, 15-16 cm long, round green pod, multiple disease tolerance
3-16	12	Early, 12-14 cm long, round and dark green pod, high yielding	3-13	14	Extra early, 14-15 cm long, flat and green pod and high yielding

Bush type			Pole type		
Progenies	**Yield (t/ha)**	**Pod traits/ disease reaction**	**Progenies**	**Yield (t/ha)**	**Pod traits/ disease reaction**
$6F_1$-1-8	13	Early, 16-17 cm long, round, green pod, and very high yielding	4-9	10	Extra early, 14-15 cm long, round, green pod and high yielding
4-1-15	11	Early, 18-19 cm long and dark green pod, high yielding	4-1-23	13	Early, 15-16 cm long, round green pod, High yielding
F_4-11	7	Late, 16-17 cm long, round pod, multiple disease tolerance	5-1-6	18	Late, 14-15 cm long pod, flat, dark green, very high yielding
F_4-70	5	Late, 15-16 cm long, round green pod, multiple disease tolerance	F_4-69	11	Late, 18-19 cm long and green pod, multiple disease tolerance and high yielding

Among the germplasm, after subsequent screening for last three years, four genotypes of French bean, *viz.* RCFB 6, RCFB 14, RCFB 15 and RCFB 37 (Fig. 8.2), were validated as highly resistant genotypes to rust in spring-summer season and *rabi* season. These genotypes scored 0 on a scale of 0-5. Pod length ranged from 14.0 to 15.6 cm and colour from light green to dark green colour with stringless character. RCFB 6 was the highest yielding genotype with green pod yield of 5.5 t/ha in 90 days.

Fig: 8.2 French bean: a) pole type, progeny 5-1-6 for long green pod b) bush type, progeny $6F_1$-1-8 for very high yield c) RCFB6; round podded d) RCFB14; flat podded

Development of multiple disease resistant hybrids in Solanaceous crops

1. Brinjal

Six advance breeding lines of brinjal, developed from HAB-917×IC 261786, HAB× IC-545901 and HAB-917×HAB-901, were evaluated for fruit yield, fruit quality and bacterial wilt resistance (Table 8.4). Among them, RCBR-938/HAB-938 (Fig. 8.3) was submitted for multilocation testing under AICRP (VC) IET 2023.

Fig. 8.3 Advanced breeding line RCBR-938

Table 8.4 Promising BWR segregating germplasm of Brinjal

S. No	Entry name/ Pedigree	Days to 50% flowering	Yield (t/ha)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit Colour & shape	Calyx colour
1.	HAB-933/HAB-917 x IC-261786 (3-1) F_6	45	45.53	207.5	11.3	7.4	Purple Round	Green
2.	HAB-934/HAB-917 x IC-261786 (3-2) F_6	47	43.48	142.5	9.2	6.4	Purple Round	Green
3.	HAB-935/HAB-917 x IC-261786 (3-5) F_6	49	41.61	113	8.5	6.1	Dark Purple Round	Light purple
4.	HAB-936/HAB-917 x IC-261786 (4-2) F_6	43	50.48	186	12.0	6.2	Dark Purple Oblong	Green
5.	HAB-937/HAB-917 x IC-545901 (1-2) F_6	49	61.37	213.5	14.4	6.1	Dark Purple Oblong	Green
6.	HAB-938/HAB-917 x HAB-901 (1-1) F_6	45	55.44	192.5	9.5	7.6	Dark Purple Round	Light purple

2. Tomato

Evaluation of Bacterial wilt resistant germplasm in tomato

Evaluation of tomato crosses was carried out for successive 7th generation. The F_7 generation of the cross HADT-296×HAT-311 (RCDT-51) showed better resistance to bacterial wilt with high yield (80 t/ha). The line RCFT-54 has been submitted for multi-location trials under AICRP (VC) IET 2023 Bacterial wilt resistance trial

Development of multiple disease resistant hybrids in tomato

Fifty-five crosses of tomato were developed with eleven parents, *viz.*, Swarna Naveen, DT-7, HAT-296, RCDT-1608, Swarna Kanchan, RCDT-1116, RCDT-1128-1, HAT-311, HAT-310, HAT-159 and Swarna Lalima, in a half diallel fashion during 2022-23.

Evaluation of intergeneric grafted tomato for bacterial wilt resistance

The main objective of this study was to evaluate the performance of grafted tomato using different rootstocks for management of bacterial wilt. Grafting in tomato using rootstock of *Solanum torvum*, bacterial wilt resistant rootstocks of brinjal (HAB-901, HAB-921, HAB-928, HAB-930) and tomato (HADT-296), respectively was carried out using scion of tomato hybrid Swarna Baibhav under randomized replicated trial during 2022-23. The grafted tomato treatments were evaluated for yield and other characters (Table 8.5). Ungrafted Swarna Baibhav was used as the control. Percent plant survival against bacterial wilt indicated that *Solanum torvum* (HAB-901, HAB-928, HAB-930 and HAB-921) were the best rootstocks for management of wilt in tomato (Fig. 8.4 & 8.5). The technology of grafted tomato developed by this center has been commercialized through sale of grafted seedlings and technology transfer to entrepreneurs (Fig. 8.6 & 8.7). There is a huge demand for the saplings of grafted tomato every year.

Table 8.5 Evaluation of grafted tomato for bacterial wilt management

S. No.	Treatment	Plant height (cm)	Fruits per plant (no.)	Yield (t/ha)	% Survival against wilt
1.	T1 (ungrafted)	97	40.7	47.82	28
2.	T2(*Solanum torvum*)	110.67	138.2	193.04	92.5
3.	T3 (HAB-901)	92	149.1	182.20	100
4.	T4 (HAB-921)	103	135.4	164.79	92.3
5.	T5 (HAB-928)	106	124.9	151.65	97.4
6.	T6 (HAB-930)	91.67	116.8	132.17	97.4
7.	T7 (HADT-296)	109.33	70.6	84.31	89.7
	SE(m)	9.66	17.69	22.67	
	CV	16.51	27.66	28.76	

Fig. 8.4 Survival of grafted tomato against bacterial wilt

Fig. 8.5 Grafted tomato ready for harvest

Fig. 8.6 Sale of grafted tomato produced at the Centre

Fig. 8.7 Successful demonstration of grafted tomato in Entrepreneurs' field

3. Chilli

Twenty-one crosses of chilli, developed with seven lines (HC-75, HC-76, HC-77, HC-78, HC-79, Swarna Apurva, HC-80) and three testers (Swarna Praphulya, Swarna Arohi and HC-81) in L×T design, were evaluated for bacterial wilt resistance and yield related characters along with the parents in randomized block design with two replications (Table 8.6). Among them, five hybrids, *viz.*, HC-75×Swarna Arohi, HC-78×Swarna Praphulya, HC-79 ×Swarna Arohi, Swarna Apurva×Swarna Arohi and Swarna Apurva×HC-81 were found promising for fruit yield, fruit quality parameters and bacterial wilt resistance (Table 8.7). These hybrids were selected for further evaluation.

Table 8.6 Line × Tester analysis of 21 Chilli hybrids

Characters	Range	SE(m)	CV	ANOVA for Combining ability	Genetic variance
Days to 50% flowering	33-51	2.10	7.57	F significant for Lines x Testers	Dominance
Yield (t/ha)	3.3-20.2	16.46	31.85	F significant for Lines	Additive
Avg. Fruit weight (g)	1.9-4.1	0.21	10.82	F significant for Lines & Lines x Testers	Dominance
Fruit Length (cm)	3.1-8.0	0.33	7.73	F significant for Lines & Lines x Testers	Additive
Fruit diameter (cm)	6.55-17.69	1.29	7.50	F significant for Lines & Lines x Testers	Additive

Table 8.7 Best crosses identified in chilli

Cross	Days to 50% flowering	Yield (t/ha)	Avg Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit color
HC-75 x Swarna Arohi	39	18.25	2.49	6.25	7.23	Green
HC-78 x Swarna Praphulya	36	14.6	4.09	7.1	9.40	Dark green
HC-79 x Swarna Arohi	42	13.45	2.97	6.18	8.04	Dark green
Swarna Apurva x Swarna Arohi	39	20.2	3.58	7.54	7.99	Light green
Swarna Apurva x HC-81	39	19.0	3.50	7.25	7.97	Light green

Evaluation of Bacterial wilt resistant germplasm in chilli

Twelve germplasm of chilli (IC-214965, IC-214966, IC-410423, EC-378632, EC-390029, EC-566920, EC-599969, IC-447065, IC-561622, IC-561626, HC-82 and HC-83) were found resistant to bacterial wilt under wilt sick plot conditions (Fig. 8.8). These resistant genotypes will be utilized in resistance breeding programme.

IC-447065 EC-599969 HC-82

Fig. 8.8 Bacterial wilt resistant germplasm identified in Chilli

Genetic Resource Management in Vegetable crops

Evaluation and characterization of Pointed gourd germplasm

Forty-six germplasm of pointed gourd were evaluated for fruit yield and fruit quality traits in a randomized design with three replications (Table 8.8). Swarna Alaukik recorded the highest fruit yield (23.73 t/ha) followed by HAP-79 (20.61 t/ha). ANOVA revealed substantial variations in both fruit yield and quality traits among the genotypes. Important traits like the number of fruits per plant, harvest frequency, pulp seed ratio and total phenol content showed significant positive correlations with total fruit yield (t/ha) at both genetic and observable levels (Fig. 8.9). Selection based on characteristics such as the number of fruits per plant, pulp weight and pulp seed ratio are expected to enhance yield significantly. Promising genotypes including Swarna Alaukik, HAP-79, HAP-70 (for yield-related attributes) and HAP-106 (for quality traits) were identified and recommended for cultivation in the Eastern Plateau and Hill Region.

Table 8.8 Characterization of pointed gourd germplasm for fruit yield and quality traits

S. No.	Character	Range	CD	SE(m)	CV
1.	Fruit yield (t/ha)	4.07-23.73	2.09	0.75	10.21
2.	Fruit weight (g)	15.75-49.01	3.85	1.37	7.69
3.	Fruit length (cm)	4.90-10.24	0.69	0.25	5.77
4.	Fruit diameter (cm)	2.62-3.90	0.28	0.09	5.13
5.	Fruit volume (cm^3)	21-61.67	3.59	1.28	5.53
6.	Pulp weight (g)	12.54-41.61	3.27	1.16	8.16
7.	Seed pulp ratio	2.76-5.76	0.50	0.18	7.41
8.	Days to first harvest (days)	79.67-120.67	2.81	0.99	1.70

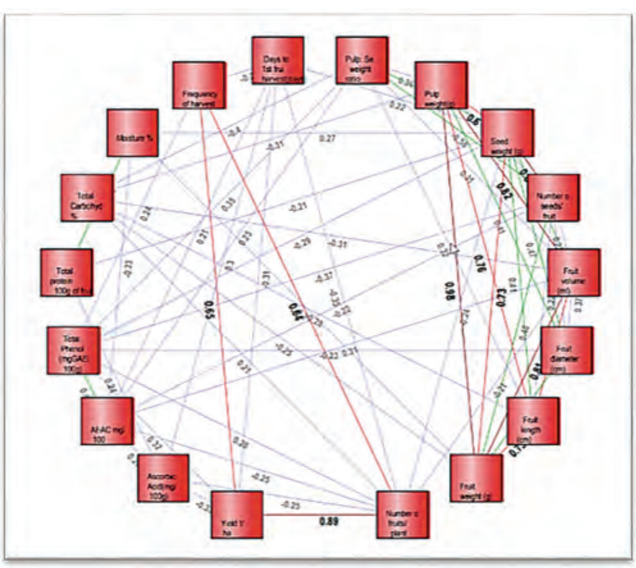


Fig. 8.9 Genotypic correlations among yield and its component traits in pointed gourd

Clustering analysis using 15 ISSR markers grouped 46 genotypes into two main clusters with HAP-76 in one cluster and remaining 45 into another cluster. The sub-cluster again divided into two clusters with the cultivated varieties (3) in one sub-cluster and remaining 42 in another sub-cluster (Fig. 8.10).

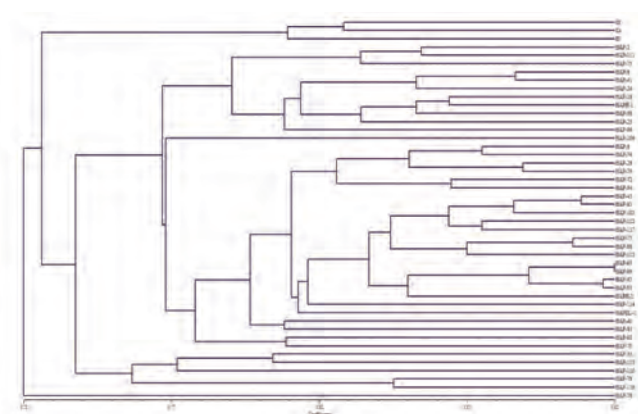


Fig. 8.10 Cluster analysis using 15 ISSR markers in pointed gourd

Biofortification of edible podded pea

To develop anthocyanin-pigmented edible podded peas, hybridization was performed between green snow pea and red podded pea (EC598581) (Fig. 8.11). The F_1 hybrids had dark red pods with parchment layers and medium height. In the F_2 generation, 272 progenies were evaluated for various traits, revealing duplicate gene action for flower and stipule color and incomplete dominance for pod pigmentation and other traits. Sixteen promising progenies were selected for advanced studies based on pod traits, seed sweetness, and yield. Three progenies (RCSP-74, RCSP-124, and RCSP-125) were identified for their vigorous growth and high pod yield, making them potential donor parents for future breeding programs.

Fig. 8.11 Edible pea a) F_2 segregants of snow pea × red colour wild pea (EC598581), b) sweet seeded pole type pea c) Dark red podded d) greed pod, sweet seeded with >250 pods in single plant e) partial pigmented edible pea

All India Coordinated Research Project (Vegetable Crops)

Solanaceous vegetables: Tomato, Brinjal, Chilli, Capsicum

A total of 11 trials were conducted in solanaceous vegetables under AICRP (VC). Five trials were conducted in tomato during 2022-23. All entries died due to bacterial wilt in Tomato Varietal (Indet) AVT-II and Hybrid (Det) AVT-I. Under Cherry Tomato Varietal AVT-I, 2021/TOCVAR-2 was highest yielding (78.25 t/ha) among the six entries. Under Tomato (Det) Hybrid AVT-II, 2020/TODHYB-2 was promising with yield 65.32 t/ha among the seven entries. Among the six entries, 2021/TODVAR-4 was high yielding (16.17 t/ha) under Tomato (Det) Varietal AVT-I trial. 2020/BRLHYB-1 (79.25 t/ha) among the six entries under Brinjal Long Hybrid AVT-II was found promising during 2022-23.

Entries 2022/CHIVAR-5 (20.5 t/ha) among ten entries under Chilli Varietal IET, Entries 2021/CHIVAR-7 (20.08 t/ha) among fourteen entries under Chilli Varietal AVT-I and 2020/CHIVAR-2 (20.25 t/ha) among thirteen entries under Chilli Varietal AVT-II were found promising during 2022-23. 2022/CAPVAR-6 (35.0 t/ha) among nine entries under Capsicum Varietal IET and 2021/CAPVAR-3 (37.33 t/ha) among seven entries under Capsicum Varietal AVT-I were found promising during 2022-23.

Cruciferous vegetables and root vegetables: Cabbage, Cauliflower and Carrot

Two trials in cabbage and three each in cauliflower and carrot were conducted during 2022-23. Entries 2022/CABHYB-4 (47.92 t/ha) under Cabbage Hyb IET and 2021/CABHYB-5 (47.25 t/ha) under Cabbage Hyb AVT-I, 2022/CAUMHYB-2 (75.08 t/ha) under Cauliflower Hybrid (Mid) IET, 2022/CAUMHYB-3 (17.42 t/ha) under Cauliflower Hybrid (Early) IET and 2021/CAUMHYB-7 (56.0 t/ha) under Cauliflower Hybrid (Mid) AVT-I were high yielding. Entries 2022/CARTRVAR-6 (88.29 t/ha) under Carrot Tropical IET, 2022/CARTRVAR-6 (69.43 t/ha) under Carrot Temperate IET and 2021/CARTHYB-6 (70.6 t/ha) under Carrot Hybrid Tropical AVT-II were found promising during 2022-23.

Cucurbitaceous vegetables

A total of twelve trials were conducted in cucurbitaceous vegetables under AICRP (VC) during 2022-23. Trials under

Musk melon Varietal IET and Hybrid IET failed due to high incidence of Fusarium wilt. Few promising entries identified under different AICRP trails are shown in Table 8.9.

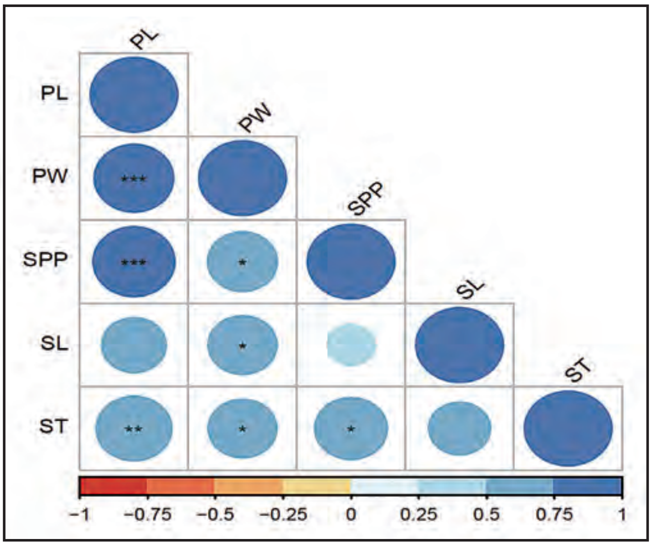
Table 8.9 Promising entries identified under different AICRP trials

Sr. No.	Name of the trial	No. of entries	Promising entry	Yield (t/ha)
1	Cucumber Varietal AVT-I	7	2021/CUCUVAR-3	21.50
2	Cucumber Hyb IET	6	2021/CUCUVHYB-1	22.96
3	Cucumber Hyb IET	6	2022/CUCUVHYB-2	22.90
4	Ridge gourd Var AVT-I	7	2021/RIGVAR-2	18.10
5	Sponge gourd Varietal IET	8	2022/SPGVAR-1	7.60
6	Sponge gourd Varietal AVT-I	6	2021/SPGVAR-5	8.20
7	Sponge gourd Varietal AVT-II	7	2020/SPGVAR-3	11.78
8	Summer squash Varietal IET	-	2022/SSQVAR-6	28.70
9	Pumpkin Varietal IET	-	2022/PUMVAR-2	13.00
10	Pumpkin Varietal AVT-I	-	2021/PUMVAR-7	14.06

Genetic enhancement of selected vegetable legumes for Eastern India

Identification of trait specific germplasm in yardlong bean

144 genotypes of yardlong beans were evaluated for yield, yield-related traits and disease resistance. Notably, IC-284862, IC-273191, IC-626143, and IC-630413 exhibited extra-early flowering characteristics, blooming within 40-45 days compared to the early check variety Arka Mangla, which typically flowers in 50 days. Pod length was longest in IC-560919, while IC-630390 and IC-626159 showed highest yield per plant, outperforming the high-yielding check variety YB-7. Fig. 8.12a illustrates correlation among yield-contributing traits, showing a strong correlation between pod length, pod weight per plant and seeds per pod.



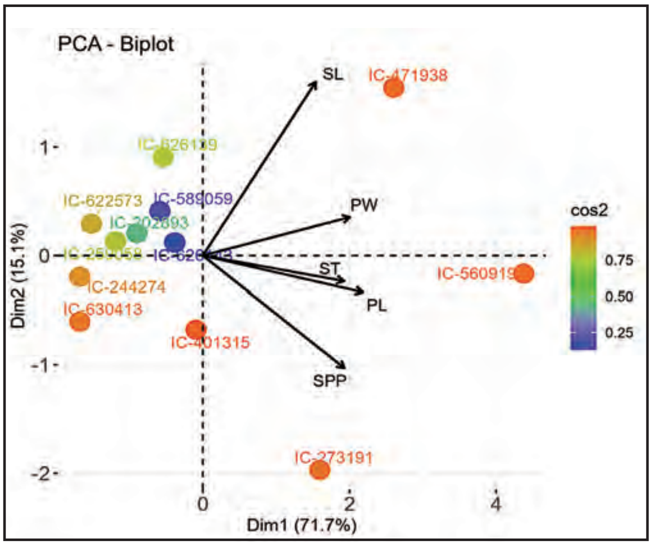


Fig. 8.12a and 8.12b Correlation studies and principal component analysis of yardlong bean genotypes for yield and yield related traits.

Principal component analysis (PCA) was conducted to confirm the associations between traits, providing a clear and concise graphical representation of trait profiles for different genotypes. The first principal component (PC1) explained 71.7% of total variance, while second principal component (PC2) explained 15.1% of variance (Fig. 8.12b). The PC1 was strongly and positively influenced by pod length, pod weight per plant and seeds per pod confirming their association with yield.

Evaluation of Lablab bean lines

At ICAR-RCER, Patna, a total of 216 genotypes of lablab bean sourced from ICAR-NBPGR were subjected to comprehensive evaluation. Notably, among the pole-type genotypes, RCPD-15, RCPD-24, IC-397636, IC-427453, IC-411045 and IC-565937 demonstrated superior performance, particularly in terms of pod production, ranging from 52 to 117 pods per plant. Additionally, within the bush-type category, RCPD-1, RCPD-16, IC411093, IC556808 and IC427453 stood out for their exceptional characteristics. These varieties showcased an early picking window of 45 to 52 days, coupled with a dwarf growth habit. They exhibited high yield potential, averaging between 450 to 670 grams per plant. Moreover, their vegetable-type flattened pods, increased pod production per node and synchronized maturity further distinguished them.

Performance of Lablab Bean Lines at KVK, Piprakothi (East Champaran)

Among the Lablab bean lines evaluated at KVK, Piprakothi (Table 8.10 Fig. 8.13), several lines showed noteworthy performance across various traits. Notably, Arka Sambhram (check) and RCPD-16 exhibited balanced characteristics, making RCPD-16 well-performing options for cultivation in Eastern India. RCPD-16, characterized by its bush growth habit, offers a stable performance across various traits. With an average plant height of 54.70 cm, RCPD-16 exhibits early flowering like check at 45.00 days. Average single pod weight of RCPD-16 stands at 4.40 grams, providing a good balance between pod size and yield potential.

Table 8.10 Evaluation Summary for Lablab Bean Lines Screening at KVK, Piprakothi

S. No.	Lines	Growth Type	Plant Height (cm)	Days to 50% Flowering	Avg. Single Pod Weight (g)	Avg. Pods per Plant	Avg. Pod Weight per Plant (g)
1	Arka Sambhram	Bush	58.40	43.00	4.50	43.00	193.00
2	RCPD-1	Bush	62.00	45.00	4.00	38.00	152.00
3	RCPD-22	Pole	118.00	107.00	3.40	145.00	493.00
4	RCPD-15	Pole	14.60	112.00	6.40	134.00	857.60
5	RCPD-16	Bush	54.70	45.00	4.40	52.00	228.80
6	RCPD-14	Pole	102.00	90.00	6.80	127.00	863.60

Moreover, RCPD-14 and RCPD-15 demonstrate exceptional performance in terms of yield potential and pod characteristics. RCPD-14, a pole-type variety, exhibits tall plants with an average height of 102 cm and produces a substantial number of pods per plant (127.00), each with a commendable average weight of 6.80 g. Consequently, the average pod weight per plant for RCPD-14 is notably high (863.60 g). Similarly, RCPD-15, another pole-type variety, although shorter in stature (14.60 cm), compensates with an impressive average single pod weight of 6.40 g and substantial number of pods per plant (134.00), resulting in a remarkable average pod weight per plant of 857.60 grams. These two varieties, with their robust pod characteristics and significant yield potential, emerged as promising options for farmers seeking high productivity and quality in Lablab beans.


Fig. 8.13 Trial of promising Lablab bean genotypes at KVK, Piprakothi

Screening of yardlong genotypes for yellow mosaic

One hundred forty-four yardlong genotypes were screened for yellow mosaic disease reaction. No visible symptoms were observed in five genotypes (IC-626170, IC-630412, IC-20514, IC-20298 and IC-586954). A total of 14 genotypes (IC-622570, IC-622574, IC-626139, IC166140, IC-626143, IC-630388, IC-630390, IC-630391, IC-626163, IC-630413, IC-398083, IC-202893, IC-361502 and IC-471938) were found to be resistant with only a few leaves having mosaic symptoms (Fig. 8.14). The remaining genotypes were categorized as moderately resistant, moderately susceptible, susceptible and highly susceptible.


Fig. 8.14 Yardlong bean showing immune (left) and highly susceptible reaction (right)

Standardization of Organic Farming Practices for Middle Indo-Gangetic Plains

An experiment focused on standardizing organic farming techniques to improve productivity, sustainability and ecological balance in the region was initiated at ICAR RCER, Patna in *Kharif* 2023 (Fig. 8.15).

Fig. 8.15 Field view of organic farming experiments

The experiment features three vegetable-based cropping systems with different nutrient management approaches: (i) 100% Farm Yard Manure (FYM), (ii) 50% FYM + 50% Vermicompost (VC), and (iii) 50% FYM + 50% VC + Biofertilizer (BF) + Humic Acid (HA). Initial soil properties at a depth of 0-15 cm were recorded, showing available nitrogen (N) at 165.89 kg/ha, available phosphorus (P) at 40.23 kg/ha, available potassium (K) at 747.7 kg/ha, and organic carbon (OC) at 0.55%. To standardize the package of practices, different vegetable crops were selected and cultivated, with vegetable cowpea grown during the *Kharif* season and colored cauliflower, broccoli and cabbage grown during the *Rabi* season, each under different nutrient treatments.

Standardization of hydroponic technology for horticultural crops

- **Performance evaluation of lettuce in Nutrient Film Technique (NFT) structure:** Lettuce seeds were sown in oasis cube during January. The seedlings were ready for transplant within 20-25 days. Whereas in conventional method of growing in soil required approximately 30 days (Fig.8.16). For first picking under both condition leaves were ready for 71-78 days. Growing season of lettuce was 98 days in NFT, whereas for conventional system crop required approximately 110 days. In both systems, crop gives five harvests. Yield was 35% less in conventional systems compared to NFT systems.

- **Performance evaluation of coriander in NFT structure:** Coriander seeds were sown in media mixture during February. At horticultural crop maturity, plant reach to its height of 19-21 cm (Fig.8.16). Number of leaves was more in DWC method compared to NFT system. Average shoot fresh matter in NFT system was 22 g/plant, whereas average shoot fresh matter in DWC was 25 g/plant. Shoot-root ratio in NFT was 0.558, whereas shoot-root ratio in DWC was 0.664.

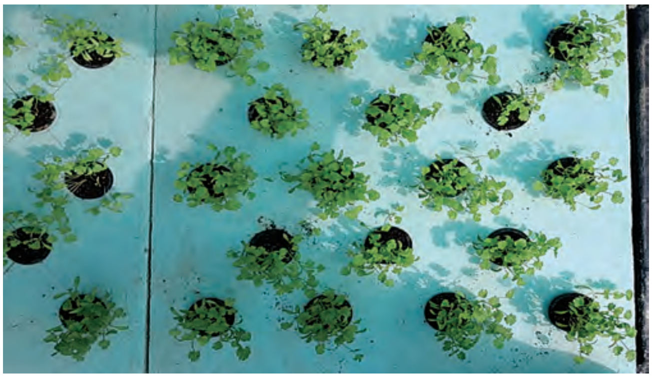



Fig 8.16 Growing of coriander in NFT and DWC system

9 Medicinal and Aromatic Plants

Development of Multipurpose trees and Medicinal plants-based Agroforestry Model

This research aims at screening of species of medicinal plants for their potential incorporation into an agroforestry model. In this experiment, growth performance of 23 medicinal plant species was assessed. Among these, Giloy exhibited the highest shoot-root ratio (15.75), followed by Shatavari (14.91) and Hadjor (12.75). Based on the growth performance, market value and availability of planting material, four medicinal plants, namely Giloy, Shatavari, Hadjor and Sarpagandha, were selected and planted for further evaluation in two different agroforestry (Teak-Karanj and Mahogany-Karanj) systems (Fig. 9a and Fig. 9b).

Fig. 9a. Teak + Karanj agroforestry system

Fig. 9b. Mahogony + Karanj agroforestry system

Photosynthetically Active Radiation (PAR) in both the agroforestry systems was measured and represented graphically in the Fig. 9c. The figure illustrates the varying levels of PAR (%) between trees planted in each agroforestry system, indicating sufficient availability of light for medicinal plant growth as an intercrop.

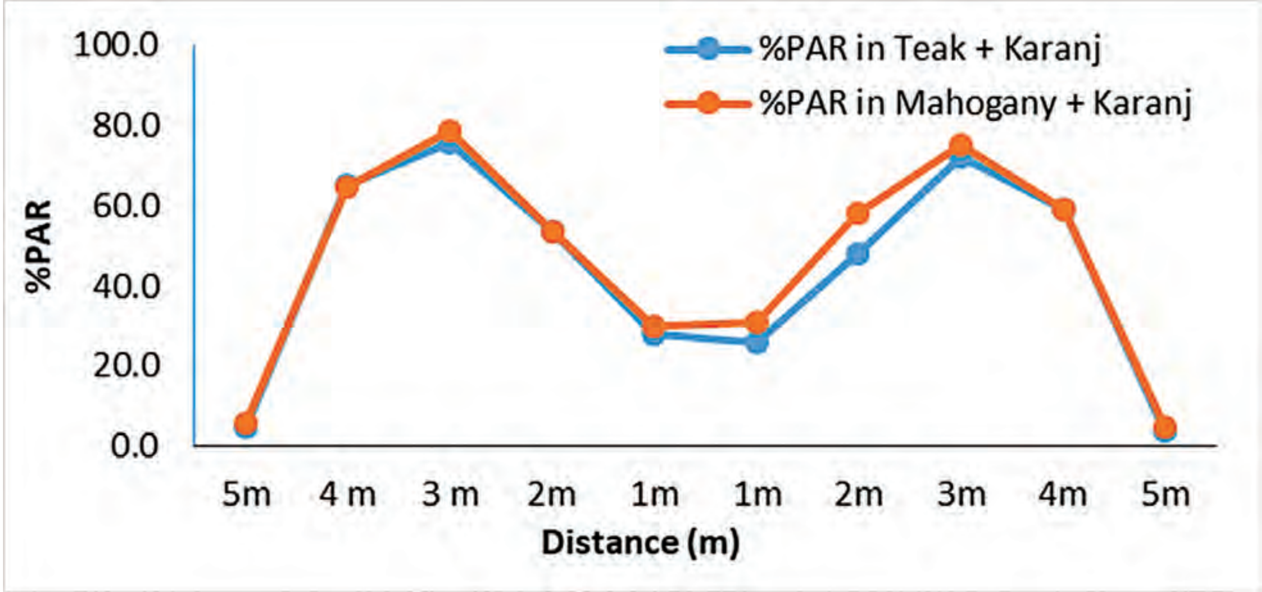


Fig. 9c Photosynthetically Active Radiation (PAR) percentage in selected agroforestry systems

Table 9.1 The growth performance of medicinal plants under rainfed condition

Species (Common Name)	Plant mortality (%)	Shoot-root ratio	Plant length/ height(cm)	Basal girth (mm)	Dry weight of stem (g)	Dry weight of root (g)
Anantmool	58.33	3.03	308±25	5.7±1.2	73±13	-
Aparajita	0.00	13.20	98±11	15.8±3.6	84±12	9±2
Ashwagandha	46.15	2.04	39±6	11.2±2.6	7.1±2.3	1.1± 0.3
Bhringraj	46.32	3.25	361±24	6.2±2.0	124±8	1±0.4
Bryophyllum	0.00	8.63	75±17	11.7±3.3	13±2	8±3
Gandh Prasarini	83.33	7.46	553±43	7.3±2.5	110±12	3±1
Giloy	0.00	15.75	474±32	7.24±2.0	99±8	0.04
Hadjor	6.67	12.75	152±8	90.1±5.9	7±1	0.01
Hathikan/ Hathisura	8.33	8.60	69±10	39.3±6.8	51.78±4	33.05±06
Insulin	0.00	6.81	89±7	25.8±3.0	57±3	3.5± 0.2
Indian pennywort	46.67	4.61	28±8	8.4±2.1	9±2	-
Kali Haldi	0.00	2.47	79±14	32±8.1	2.3± 0.5	29±8
Spearmint	91.67	3.48	43±4	7.7±1.5	17±4	0.8±0.4
Punarnava	91.00	4.93	48±6	6.4±2.3	3±1	0.1±0.03
Vasaka (Ram)	0.00	9.40	146±14	21.5±6.0	201±33	56±7.1
Sadabahar	0.00	9.32	63±7	11.5±3.8	50±8	4±1.2
Sarpagandha	83.33	6.57	110±18	26.9±3.6	100±26	33±6.1
Shatavari	0.00	14.91	142±21	13.4±3.5	19±4	66±7.3
Tulsi	0.00	8.88	138±28	15.8±3.5	257±28	188±17.9
Van Kapas	33.33	8.00	159±24	20.8±5.1	206±20	42±6.0
Vana Tulsi	0.00	7.51	85±15	12.1±4.0	60±12	10±3.3

10 Conservation Agriculture

Effects of long-term conservation agriculture (CA) on crop productivity of rice-based production system in irrigated agro-ecosystem

A long-term field experiment has been initiated as a part of Phase I of the CSISA (Cereal Systems Initiative for South Asia) Project since 2009 (*Rabi* season), focusing on CA-based rice-wheat systems at ICAR Research Complex for Eastern Region, Patna (Fig. 10.1). Following the seventh year of experiment, CA-based ZTDSR-ZT mustard-ZT maize system encountered a severe infestation of rice mealybugs. Consequently, the field was divided into four equal plots: ZTDSR, CTDSR, PTR, and UPTR. After two years of conventional tillage (CT), these plots were reverted back to the ZTDSR production system. By 14th year, ZTDSR yielded the highest rice production (5.55 t/ha), comparable to CTDSR (5.03 t/ha) and TPR (5.02 t/ha) (Table 10.1), with similar trends observed in total biomass production.

Table 10.1 Rice yield as influenced by different tillage-cum-crop-establishment methods in long-term CA-based rice production system under irrigated agro-ecosystem (Mean data of *Kharif* 2022: After 14th years of experimentation)

Crop scenario	Crop establishment	Grain yield (t/ha)	Straw yield (t/ha)	Residue load (t/ha)	Root biomass (t/ha)	Total biomass (t/ha)
S1: TPR-CTW-Fallow	Random transp.	5.02^{bc}	6.71^{a}	-	0.75^{c}	12.48^{ab}
S2: CTMTR-ZTW-ZTM	Machine transp.	5.03^{b}	3.09^{bcd}	3.09^{ab}	0.83^{b}	12.04^{abc}
S3: ZTDSR-ZTW-ZTM	Zero-till/ZT	5.55^{a}	3.14^{bc}	3.12^{a}	0.93^{a}	12.74^{a}
S4: ZTDSR-ZTMu-ZTMa	Zero-till/ZT	4.66^{d}	3.25^{b}	2.05^{c}	0.66^{d}	10.62^{d}
CD (*P*=0.05)		0.31	0.38	0.19	0.06	0.94

Mu: Mungbean, Ma: Maize

Fig.10.1 Performance of rice under long-term CA-based rice-wheat system at ICAR RCER

Evaluation of Natural Farming module in Eastern Plateau and Hill Region

The experiment aimed to evaluate natural farming (NF) and conventional farming (CF) methods across different cropping systems in EPHR (Fig. 10.2). This evaluation included aspects like crop productivity, soil fertility, plant protection, nutritional quality, system productivity and economic viability. Using a split-plot design, the main plots were assigned to CF and NF practices, while the sub-plots featured four cropping systems. Each treatment had four replications, comprising 32 plots of 20 m^2 area each. The four cropping patterns *viz.* paddy-lentil, black gram-niger, finger millet- mustard & cow pea- chick pea, were evaluated under the principles of NF and CF.

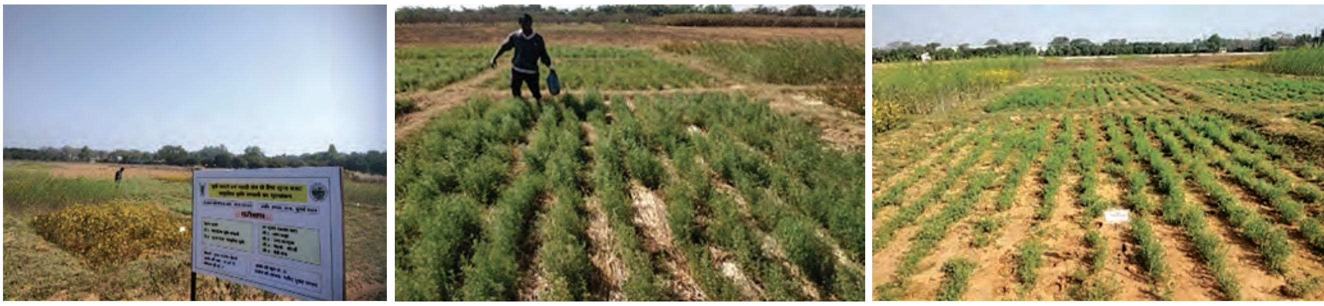


Fig. 10.2 Field view of the expriments on natural farming

The cultivation practices included application of FYM @ 10 t/ha and recommended fertilizer dose (NPK 25:50:25) in black gram, chickpea & lentil, finger millet (NPK 40:30:20), niger (NPK 20:20:20), mustard (NPK 50:25:20), cowpea (NPK 20:40:20) and paddy (NPK 80:40:40). The practice of NF had seed treatment by Bijamrita, basal application of Ghanjivamrit @ 10 t/ha followed by top drenching of Jivamrit @ 3500 liters/ha at the fortnightly intervals throughout cropping season with application of paddy straw mulch @ 5t/ha. Neemastra was applied as needed at 10 ml/litre of water on the standing crops. Soil properties like bacterial population, fungal population, actinomycetes population, dehydrogenase activity, Microbial biomass carbon were determined before the start of the cropping season (Table 10.2).

Table 10.2 Microbial count and biological properties of soils under natural and conventional farming

Treatment	Bacterial Population (10^6cfu /g soil)		Fungal Population (10^4cfu /g soil)		Actinomycetes Population (10^6cfu /g soil)		Dehydrogenase activity (ug TPF /g/d)		Microbial biomass carbon (µg/g)	
	NF	CF	NF	CF	NF	CF	NF	CF	NF	CF
Black gram - Niger	116	69.3	4.3	2	33	3	26.25	22.07	132.3	152.66
Paddy - Lentil	114.7	35.3	4.3	1	79	50.7	26.41	22.98	419.7	268.78
Cowpea - Chickpea	31	34.3	8.3	1.3	130.7	28.3	29.14	21.11	383.3	389.16
Finger Millet - Mustard	93.3	8.3	4.3	7	88	8	23.73	23.57	234.6	434.81
CD at 5%	44.2	NS	2	1.5	51.6	31.1	4.68	3.94	142.6	133.1

CF: Conventional farming, NF: Natural Farming

In case of *kharif* crops, natural farming-based treatments yielded higher pod yield of cowpea (94.5 q/ha) and finger millet (18.25 q/ha) compared to CF (87.13 q/ha and 17.13 q/ha, respectively). However, paddy and black gram yields were 19.2 and 23.2% higher, respectively, in CF. The rice equivalent yield (REY) of paddy-lentil (42.93 q/ha), finger millet-mustard (59.85 q/ha) and cowpea-chickpea (105.03 q/ha) was also higher under natural farming compared to conventional farming (Fig. 10.3).

For *rabi* crops, lentil and mustard exhibited higher harvest index (34.65 and 33.63%, respectively) and rice equivalent yield (27.78 q/ha and 29.4 q/ha, respectively) under natural farming compared to CF. Similar trends were observed for chickpea, although niger had a higher REY in conventional farming production system. Overall, natural farming treatments showed higher REY in all cropping systems except for black gram-niger. (Fig. 10.3). The cowpea–chickpea cropping system recored the highest REY of 133.3 q/ha in natural farming and 107.2 q/ha under conventional farming.

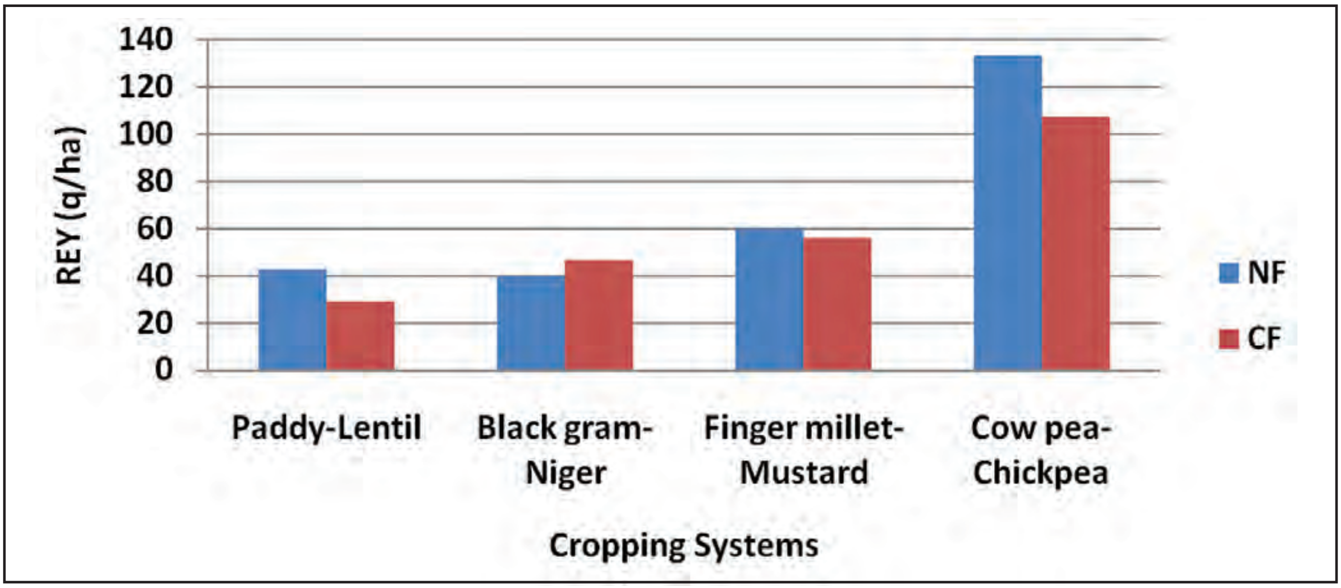


Fig. 10.3 Rice equivalent yield of cropping systems under conventional and natural farming methods

Studies on efficacy of natural farming and comparison with existing farming

An experiment was initiated to study the efficacy of natural farming and its comparison with existing farming practices at ICAR RCER Patna from July, 2022 with an objective to study the performance of rice-wheat-greengram system under different cultivation practices involving Natural farming (NF), Organic farming (OF), Integrated nutrient management (INM) and Conventional practices (CP). Standard package of practices of each farming method was followed. In case of natural farming a standard NF methodology was adopted in which seeds of rice, wheat and greengram (moong bean) were treated with *beejamrita* before sowing of seeds. Ghanjeevamrita was applied at the time of land preparation, *Jeevamrita* was applied at 15 days interval, Bio-mulch i.e. paddy straw/wheat straw was used to suppress the weeds. Application of Neemastra was done for pest and insect control. In case of other farming practices recommended dose of N, P, K (120:60:40 kg/ha) were applied. To fulfil the requirement of nitrogen, phosphorus and potassium FYM and vermicompost was applied in organic farming practices whereas in conventional practices Urea, DAP and MoP was added to the soil. In integrated nutrient management (INM) practices application of N, P, K was done through combination of both organic (50%) and inorganic fertilizer (50%). The initial status of experimental soil is sandy loam in texture with pH 7.72, bulk density 1.57 Mg/m^3, organic carbon 0.51% low in available Nitrogen (201 kg/ha), medium in available P (16 kg/ha) and available K (112 kg/ha). This experiment was conducted in strip-plot design (SPD) with three replications. The farming practices were in main plot i. e. strip while water management was in sub-plot. In case of water management, three treatment based upon IW: CPE *viz.*, 0.6, 0.8 and 1.0 i.e W1, W2 and W3 respectively were applied. Rice variety Swarna Shreya, wheat variety HD 2967 and greengram variety IPM 2-3 was grown during *kharif*, *rabi* and summer season, respectively.

Yield of all crops i.e. rice, wheat and greengram showed significant difference under different farming practices. Under integrated nutrient management (INM) practices maximum yield of rice (6.58 t/ha) was recorded followed by 5.56 t/ha under conventional system. Yield of rice under organic farming system (5.03 t/ha) was at par with that of conventional system. Natural farming practices produced 3.88 t/ha. In case of wheat and greengram yield obtained under organic and natural farming were at par with each other but lower than INM and conventional practices. Yield of wheat and greengram was converted to rice equivalent yield (REY) and both crops were higher under conventional and INM practices. Under organic and natural farming practices REY of both crops were at par with each other. Based on REY, system productivity of Rice-wheat-greengram of natural farming was recorded as 9.06 t/ha, organic farming as 10.13 t/ha, for conventional and INM practices 13.67 and 14.74 t/ha, respectively (Fig. 10.4). After completion of one crop cycle, total water productivity of rice-wheat-greengram system was 1.92 kg/m^3 under NF while it was maximum under INM practices (3.08 kg/m^3), followed by Conventional (2.96 kg/m^3) and Organic farming practices (3.08 kg/m^3) (Fig. 10.5).

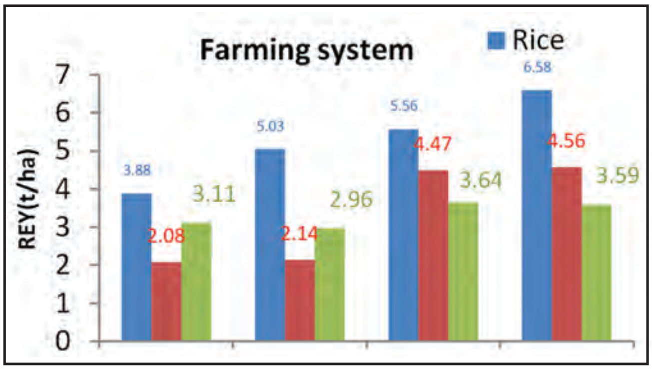


Fig. 10.4 Rice yield and Rice equivalent yield of wheat and greengram under different farming systems

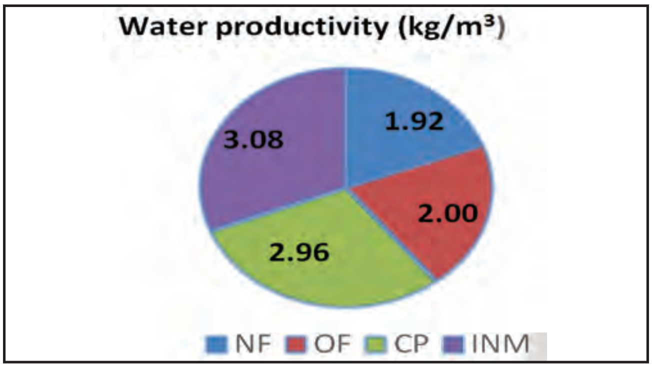


Fig.10.5Water productivity (kg/m^3) under different farming system

Soil Properties were estimated and under all farming practices available N content was lower than the initial value but no significant differences were found among treatments. Higher organic carbon was present in soil of organic farming plots (0.61%) followed by INM (0.58%) and natural farming (0.55%).

Table 10.3 Soil properties as influenced by different treatments after completion of one crop cycle

Farming Systems	N (kg/ha)	P (kg/ha)	K (kg/ha)	OC %	EC (dS/m)
Initial	201	16	112	0.51	
0-15 cm					
Conventional	171.96	22.90	140.35	0.50	0.24
INM	175.73	18.63	139.53	0.58	0.25
Organic Farming	182.20	15.87	135.82	0.61	0.25
Natural Farming	179.13	16.72	131.02	0.55	0.26
C.D (0.05)	NS	6.83	6.187	NS	NS
15-30 cm					
Conventional	172.27	20.99	128.73	0.38	0.24
INM	166.10	12.42	145.73	0.35	0.25
Organic Farming	148.96	25.88	132.05	0.48	0.24
Natural Farming	167.36	37.34	118.98	0.42	0.23
C.D (0.05)	NS	7.03	17.61	0.06	NS

During initial growth stages of rice and wheat crop, plants were 2-3 cm taller in natural farming but later on it was changed. Early maturity of rice and wheat was recorded in case of natural farming (3-5 days), followed by organic farming and delayed maturity was noticed in INM practices. It was also observed that due to heavy rain and wind, rice and wheat plants lodged under conventional practices followed by INM treated plots; however, there was no lodging under natural farming and organic farming plots (Fig. 10.6). Microclimatic condition of soil was studied and higher soil temperature was recorded under natural farming system followed by the organic farming system and lowest soil temperature was observed under the integrated nutrient management system followed by the conventional farming.

Rice under conventional cultivation

Rice under INM practices

Rice under natural farming

Rice under organic cultivation

Fig. 10.6 Different farming practices

11 Farming System Research

ICAR Research Complex has developed two integrated farming system models (Fig. 11.1) *viz*. one acre IFS model and Two-acre IFS model. In developed one-acre IFS model (Crop + Goat + Poultry + mushroom) and two-acre IFS model (Crop + dairy + fish), studies on nutrient dynamics, employment generation, energy budgeting, GHG emission and nutrient recycling were carried out. Nutrient/resource recycling under IFS is one of the important activities through which resource use efficiency could be increased due to repeated use of wastes of different components within system. Priorities given to those components whose by-product can be recycled within system or can be reused as input for another component to increase nutrient use efficiency on one hand and for decreasing cultivation cost and addition of organic forms to the system for its sustainability. Studies on nutrient recycling under one and two-acre IFS model revealed that 2.35 t of goat droppings (20 goats), 6.18 t of vegetable wastes, 1.72 t of poultry manure (700 nos.) and 5.4 t of crop straw from one acre IFS model and 16.8 t of cow dung from two cows, 10.2 t of vegetable wastes, 1.1 t of duck dropping and 2.2 t of green manure crops were produced during 2023 and upon recycling of these wastes into the systems, nitrogen (47.2 & 68.6 kg), phosphorus (36.8 & 52.7 kg) and potash (40.6 & 44.7 kg) were added into the soil. In monetary terms, these recycled nutrients had saved a sum of Rs. 4,108 & 5,297, respectively under one- and two-acre IFS models. (Table 11.1 & 11.2).

Fig. 11.1 Development of the Location Specific Integrated Farming System (IFS) Modules for Small and Marginal Farmers of Bihar

Table 11.1 Nutrient recycling pattern under one-acre IFS model (Crops + Goat + Poultry)

Sl. no.	Farm waste	Quantity produced (t)	Production/ use pattern (t)	Nutrient gain (kg)	Nutrient Gain (kg)	Saving by recycling (Rs.)	Fertilizer Saving (kg)
1.	Goat (20+ 1) droppings	2.35	1.72 (GM- 0.9) 0.63 (VC)	N- 15.3 P- 10.8 K- 14.6	N- 47.2 P- 36.8 K- 40.6	4,108/-	103.0 kg urea 230.0 kg SSP 68.0 kg MOP
2.	Vegetable waste	6.18	2.12 (VC- 0.83) 4.06- As fodder	N- 12.4 P- 10.2 K- 13.4			
3.	Poultry manure (700)	1.72	0.72 (whole quantity used in crops)	N- 16.3 P- 13.5 K- 10.6			
3.	RWMML Straw + cowpea	4.62 + 0.72	0.6 – Mush. 1.25- Mulch 2.62- Dairy 0.72- Soil	N- 3.2 P- 2.3 K- 1.8			

Another study on soil fertility build up was carried out for different integrations for 12 years continuously (2011-22) and it was found that percent increase from initial value (N 216.5, P: 27.2 and K: 226.5 kg/ha) in case of nitrogen in different combinations varied from 8.36 to 18.98 , in case of phosphorus 9.56 to 20.21 in case of potassium 8.52 to 12.63 while percent increase in organic carbon content was -3.39 to 11.86 at the end of Dec., 2023. *Percent* increase in case of nitrogen, phosphorus, potassium, and organic carbon was found maximum with crop + fish + poultry + dairy, crop + fish + goat, crop + fish + goat and crop + fish + poultry + dairy integration, respectively.

Table 11.2 Nutrient recycling pattern under two-acre IFS model (Crops + fish + livestock)

Sl. no.	Farm waste	Quantity produced (t)	Production/ use pattern (t)	Nutrient gain (kg)	Nutrient Gain from recycling	Saving (Rs.)	Fertilizer equivalent (kg)
1.	Cow dung (2 +2 calf)	16.8	FYM- 10.4) 2.0 (VC) 4.0- Pond	N-20.7 P- 20.2 K-12.3	N=68.6 P=52.7 K=44.7	Total: Rs. 5,297/-	149 kg urea 329.8 kg SSP 74.5 kg MOP
2.	Veg. waste	10.2	5.0 (VC-2.1) 5.2 As fodder	N- 31.5 P- 21.1 K- 22.6			
3.	Duck dropping (35)	1.10	As fish feed/silt	N- 8.4 P- 6.2 K- 5.6			
4.	Dhaincha/Moong	2.22	Incorporated in the soil	N- 8.0 P- 5.2 K- 4.4			

Further, an increasing trend in respect of NPK status and organic carbon content in the soil was observed for those plots where wastes were recycled along with calculated doses of chemical fertilizers (INM) over plots in which recommended doses of chemical fertilizers only were applied while organic carbon content declined with cereal cropping system with RDF (Table 11.3).

Table 11.3 Nutrient status of soil (kg/ha) under different IFS models (2011 and 2022)

Farming System	2011	2022				Increase %			
	Initial	N	P	K	O.C(%)	N	P	K	O.C
Cereal only + RDF	N 216.5	237.5	32.3	255	0.57	9.70	18.75	12.58	-3.39
Crop + Veg. + INM	P 27.2	234.6	29.8	245.8	0.65	8.36	9.56	8.52	10.17
Crop + Fish+ Pol.+ INM	K 226.5	240.2	30.5	246.4	0.59	10.95	11.13	8.79	0.00
Crop+Fish+Duck+ INM	O.C.	245.6	30.5	246.7	0.61	13.44	12.83	8.92	3.39
Crop+Fish+Goat + INM	0.59 (%)	253.4	35.4	255.1	0.62	17.04	18.15	12.63	6.08
Crop+Fish+Dairy+ INM		252.3	34.7	251.4	0.66	16.54	17.57	10.99	11.86
Crop+ Fish+Pol.+Dairy + INM		257.6	34.6	254.7	0.64	18.98	20.21	12.45	8.47
Crop+Mushroom+Goat+ INM		254.6	32.5	248.6	0.63	17.60	19.19	9.76	6.78

New initiation under two-acre IFS model has been taken where two numbers of Azolla ponds (115 sq. feet each) were created with an annual production of Azolla by 2.1 t. Azolla was fed to milch animals, fish, and ducks (Fig.11.2).

A Vertical Farming has been developed to use space above the pond's bank. Vertical farming was initiated in October, 2023 and first crop taken was Dolichos bean (sem).

Fig. 11.2 Newly established Azolla ponds under two-acre IFS model

12 Crop Diversification

Standardization of agro-techniques in nutri-cereals for enhancing productivity in eastern India

A long-term field experiment initiated in 2020 at the ICAR RCER Patna aimed to design a productive, profitable, and sustainable climate-resilient cropping system for eastern India. Experiment involved growing seven nutri-cereals (Jowar: CSV 15, Bajra: Proagro 9001) and five minor nutri-cereals (Ragi: RAU 8, Barnyard millet: VL 207, Foxtail millet: RajendraKauni, Proso-millet: TNAU 202, and Kodo-millet: JK 41) in three different planting windows, starting from onset of monsoon and at 10-day intervals thereafter. After first and second years of experiment, second planting window, up to July 15, resulted in better crop productivity. Among the nutri-cereals, Jowar and Bajra showed the highest productivity when planted on or before July 15, yielding 3.43 t/ha and 2.89 t/ha, respectively. Among minor nutri-cereals, Barnyard millet, Ragi, and Kodo-millet were identified as most productive, yielding 2.06 t/ha, 1.93 t/ha, and 2.05 t/ha, respectively, when planted by mid-July. Based on the local preferences, Bajra, Ragi, and Barnyard millet were selected for varietal testing. During subsequent years, promising varieties of Bajra (cv. Progro-9001), Ragi (cv. RAU 8), and Barnyard millet (cv. DHBM-93-2) were identified, showing improved productivity under rainfed conditions. Duringthe fourth year, an experiment was conducted to evaluate the effects of weed and nutrient management practices on the productivity of Bajra, Ragi, and Sawa. Among weed management practices, hand weeding at 25 and 45 DAS resulted in significantly higher yields of Bajra (3.08 t/ha), Ragi (2.29 t/ha), and Sawa (1.61 t/ha). Among the nutrient management, application of 100% recommended dose of nitrogen resulted in significantly higher yields of Bajra (2.83 t/ha), Ragi (2.25 t/ha), and Sawa (1.54 t/ha), comparable to 75% recommended dose of N applied as inorganic fertilizer combined with 25% dose through farmyard manure (Table 12.1& Fig. 12.1).

Table 12.1. Effect of weed and nutrient management on crop yields of nutri-cereals (Bajra, Ragi, Sawa) under rainfed agroecosystem of eastern India (Mean data of *Kharif* 2023)

Treatments	Bajra yield (t/ha)	Ragi yield (t/ha)	Sawa yield (t/ha)
Weed management practices			
Weedy check	1.86	1.38	0.68
2 Hand weeding (HW: 25 & 45 DAS)	3.08	2.29	1.60
Atrazine@0.50 kg/ha (PE) *fb* 1 HW (30 DAS)	2.79	2.21	1.52
Atrazine@0.5 kg/ha (PE) *fb* 2, 4-D@0.5 kg at 25 DAS (PoE)	2.36	1.81	1.21
CD (*P*=0.05)	0.29	0.084	0.098
Nutrient management practices			
100% RDN	2.83	2.25	1.54
75% RDN(IN)+25% RDN (FYM)	2.59	2.17	1.44
50% RDN(IN)+50% RDN (FYM)	2.21	1.49	0.90
50% RDN (IN)+25% RDN (FYM)+25% RDN (VC)	2.43	1.73	1.12
CD (*P*=0.05)	0.29	0.084	0.098

Fig. 12.1 Performance of nutri-cereals under different weed and nutrient management practices

Rice-fallow management through climate resilient agricultural practices

In *Kharif* 2023, flagship program "Rice-fallow Management through Climate-Resilient Agricultural Practices" commenced in Guleriyachak village, Bihar's Gaya district, under the stewardship of the ICAR RCER Patna, assigned by the Council. Firstly, it aimed to comprehensively assess and characterize rice-fallow areas to devise tailored interventions considering various factors like soil composition, climate dynamics, and resource availability. Secondly program sought to delve into socio-economic constraints and farmers' perspectives on rice-fallow system, crucial for crafting effective management strategies. Lastly, through an interdisciplinary approach, project aimed to develop location-specific management strategies to optimize the utilization of fallow lands. In its initial year, project focused on selecting target areas and gathering vital insights from rice-fallow farming community. It became evident that a significant challenge faced by farmers was the abandonment of land during *rabi* season due to inadequate irrigation. To tackle this, RCER initiated collaborative efforts to rejuvenate fallow lands through integrated crop management and conservation agricultural practices. To address this, selected farmers were provided with Arhar seed cv. IPA 203 for demonstration purposes, leading to its adoption in upland fields and bunds. The performance of Arhar in rainfed conditions showed promising results, hinting at its potential to boost agricultural productivity.

Simultaneously, pulses and oilseeds were showcased to farming households during Rabi, promoting the adoption of sustainable practices to greening rice-fallow areas. These demonstrations underscored a holistic approach towards rejuvenating fallow lands, emphasizing the importance of integrating climate-resilient agricultural practices. The details of supplied inputs for demonstrated at rice fallow farming community as mentioned below (Table 12.2 & Fig. 12.2).

Table 12.2 Crop and inputs distribution among rice fallow farming community at project site

S. No.	Crop	Variety	Quantity (kg)	Farmers (no.)	Area (acres)
1.	Arhar	IPA 203	100	15	12.5
2.	Lentil (ZT)	IPL 220	384	24	24
3.	Chickpea (ZT)	GNG 2299	896	28	28
4.	Mustard (ZT)	DRMR-150-35	50	25	25
5.	Mustard-FLD*	DRMR-150-35	30	15	15
	Total		**1460**	**107**	**104.5**

Fig. 12.2. Performance of nutri-cereals under different weed and nutrient management practices

Evaluation of crop establishment methods for improving productivity of rice-fallows system in eastern India:

A long-term field study was initiated during rainy season of 2016 at ICAR Research Complex for Eastern Region, Patna, Bihar, India tofind out the most suitable rice-winter cropping rotations; and appropriate crop establishment methods and residue management practices in rice-fallow system of eastern India (Fig.12.3). Treatment comprised of six levels of crop establishment methods-cum-residue management (CERM) practices: zero-till-direct seeded rice (ZTDSR), conventional-till-DSR (CTDSR), transplanted puddlerice (TPR), ZTDSR with rice residue retention (ZTDSRR+), CTDSR with rice residue retention (CTDSRR+), TPR with rice residue retention (TPRR+) and six post–rainy crops *viz.* chickpea (Pusa 3043), lentil (HUL 57), safflower (PBNS 12), mustard (Pro-agro 5111), linseed (T 397) and *toria* (TS 36) fitted in a split-plot design. After 8th year, rice yields werehigher in general under TPR. Rice productivity was 65.7 and 44.8% were higher with TPR (4.99 t/ha) compared to ZTDSR (3.01 t/ha) and CTDSR (3.45 t/ha) (Table 12.3). During 8th year of winter cropping, infestation of dry-root rot in lentil was severe in TPR followed by CTDSR. But more interestingly that yield of all post-rainy crops was higher in ZTDSR/CTDSR compared to TPR. However, TPR adversely impacted performance of all post-rainy pulses and oilseed crops.

Fig. 12.3 Performance of rice under different CERM and proceeding winter crops

Table 12.3 Rice yield as influenced by different crop establishment methods (CERM) and winter crops in long-term CA-based rice-fallow system (Mean data of *Kharif* 2022: After 8 years.

CERM		Rice yield (t/ha)						Mean
		Chickpea	Lentil	Safflower	Linseed	Mustard	*Toria*	
[ZTDSR-ZT] R-	CA	2.59[f]	2.62[ef]	2.90[ef]	2.78[ef]	2.86[f]	2.93[def]	2.78[f]
[ZTDSR-ZT] R+		3.19[cde]	2.95[de]	3.08[e]	3.55[cd]	3.36[de]	3.35[bc]	3.25[cde]
[CTDSR-ZT] R-	pCA	3.27[cd]	3.23[cd]	3.67[cd]	2.95[e]	3.42[d]	3.09[cde]	3.27[cd]
[CTDSR-ZT] R+		3.47[c]	3.52[c]	3.84[c]	3.81[c]	3.81[c]	3.34[bcd]	3.63[c]
[TPR-ZT] R-	FP	4.88[ab]	4.77[ab]	5.45[ab]	4.78[b]	5.28[ab]	3.74[b]	4.82[ab]
[TPR-ZT] R+		5.18[a]	5.15[a]	5.75[a]	5.17[a]	5.54[a]	4.21[a]	5.17[a]
CD (*P*=0.05)		0.36	0.43	0.34	0.47	0.38	0.41	

Effect of different irrigation and Biomass treatments on global warming potential (GWP) in rice-based production system.

A field experiment in *Kharif* with rice under different biomass (0, 25, 50, 75 and 100% incorporation) was conducted to evaluate its impact on yield and greenhouse gas emission. Results showed that under different biomass recycling ratios, highest GWP was in T5 (100% biomass incorporation) of 1115.32 kg (Table 12.4). During *rabi* three crops *viz.* lentil, mustard and chickpea were taken under four irrigation systems i.e. surface, drip, sprinkler, and no irrigation system. Fig. 12.4 &12.5 show emission flux during crop cycle, which indicates that methane flux was found to be higher in surface irrigation than in drip and sprinkler irrigation. Methane flux was more during tilleringand then at flowering stage due to plant active metabolism during these periods. Nitrous oxide flux was higher with fertilization and irrigation schedules. During *rabi* , Drip and sprinkler showed higher grain yield of mustard,chickpea and lentil 18.7, 17.3 37.2%, respectively over no irrigation (Fig. 12.6).

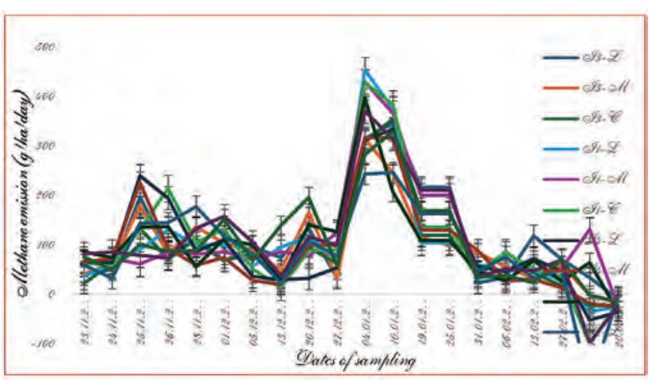


Fig.12.4 Methane flux from different irrigation system

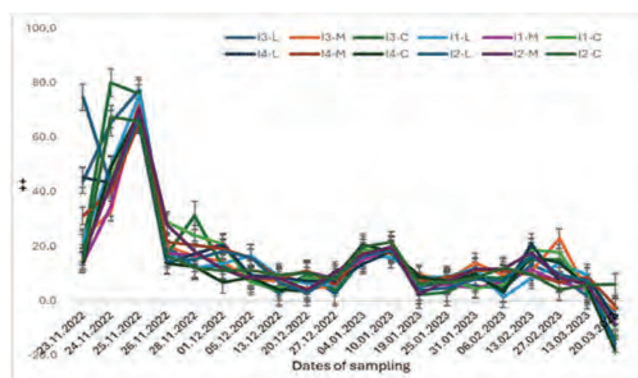


Fig.12.5 Nitrous oxide flux from different irrigation system (where I1: Surface irrigation; I2: Sprinkler; I3: Control; I4: Drip irrigation and L, M and C is lentil, mustard, and chickpea crop)

Table 12.4 Global Warming Potential under Different Irrigation Systems

	Methane emission (kg/ha)			Nitrous oxide (kg/ha)			GWP (kg CO_2 /ha)			TOTAL GWP
	Chickpea	Lentil	Mustard	Chickpea	Lentil	Mustard	Chickpea	Lentil	Mustard	
Surface	8.26	8.16	6.82	1.14	0.84	0.73	546.2c	454.3d	388.0c	**1388.58**
Sprinkler	4.28	5.3	6.9	0.78	0.81	0.75	339.4b	373.9c	396.0b	**1109.32**
Control	3	2.11	2.29	0.65	0.71	0.62	268.7a	264.3a	242.0a	**775.04**
Drip	3.05	3.22	4.05	0.68	0.7	0.72	278.9b	289.1b	315.8b	**883.8**

Fig.12.6 Field view of experimental field under kharif and rabi season

Irrigation and nitrogen management of diversified rice-based cropping system in middle Indo Gangetic plains

An experiment was conducted at main farm of ICAR-RCER, Patna comprised of three cropping systems i.e. Rice-wheat-greengram, Rice-cauliflower-spinach-greengram and Rice-broccoli- leafy onion-greengram; two methods of irrigation i.e. surface irrigation and mini-sprinkler irrigation with three methods of nitrogen application i.e. (i) Farmer's practice (100% Recommended dose of Nitrogen (RDN) through mineral fertilizer (ii) 75% N through mineral fertilizer + 1 foliar spray (FS) through Nano-urea and (iii) 50% N through mineral fertilizer + 2 FS through Nano urea. Short duration rice cv. Swarna Shreya was cultivated as *Kharif* crop followed by vegetables viz. cauliflower, broccoli, spinach, leafy onion and wheat variety HD 2967 as rabi crops, and green gram variety Samrat as summer crop. Nano urea was sprayed @ 4 ml/l at 20-25 and 40-45 days after sowing or transplanting.

After completion of second crop cycle (2022-23), system productivity of rice-cauliflower-spinach- greengram system was significantly superior (28.08 t/ha) over other cropping systems followed by rice-broccoli-leafy onion - greengram (21.81 t/ha).

In case of rice, application of 50% RDN+ two FS of nano-urea produced significantly lower yield than 75% RDN+ one FS of nano urea and 100% RDN through mineral fertilizer.Slight increase was observed in the yield of rabi vegetables when 50% recommended dose of nitrogen (RDN) through mineral fertilizer along with two spray of nano urea was given while in greengram it was opposite i.e. slight decrease under this treatment (Table 12.5).

The maximum water productivity was obtained under F1 (0.86 kg/m^3) followed by F2 (0.82 kg/m^3) and F3 (0.81 kg/m^3) (Table 12.6).

Table 12.5 Effect of different methods of irrigation and nitrogen application on yield and system productivity (t/ha) of diversified cropping system

Treatments	Rice yield (t/ha)	Rabi yield (t/ha)	Greengram yield (t/ha)	REY of rabi crop (t/ha)	REY of greengram (t/ha)	System Productivity (t/ha)
Cropping system						
Rice-Wheat-Greengram	4.29	3.94	1.50	4.10	4.77	13.17
Rice-Cauliflower-Spinach-Greengram	4.26	25.37	1.48	19.09	4.73	28.08
Rice-Broccoli-Leafy onion-Greengram	4.36	13.52	1.52	12.61	4.84	21.81
C.D (P=0.05)	NS	1.05	NS	0.95	NS	1.54

Treatments	Rice yield (t/ha)	Rabi yield (t/ha)	Greengram yield (t/ha)	REY of rabi crop (t/ha)	REY of greengram (t/ha)	System Productivity (t/ha)
Irrigation method						
Surface irrigation	4.29	14.40	1.51	12.03	4.80	21.12
Mini Sprinkler irrigation	4.32	14.15	1.49	11.83	4.76	20.91
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen application						
100% RDN (Mineral Fertilizer)	4.52	14.2	1.57	11.91	5.0	21.43
75% RDN+ one Nano spray	4.32	14.27	1.52	11.92	4.85	21.08
50% RDN+ two Nano spray	4.08	14.37	1.41	11.97	4.51	20.55
C.D (P=0.05)	0.26	NS	NS	NS	NS	NS

Table 12.6 Water productivity of different crops (kg/m^3) under various irrigation and nitrogen applications

Treatment	Wheat	Cauliflower	Broccoli	Leafy onion	Spinach	Greengram
I1F1	1.76	6.76	3.75	5.04	6.85	0.96
I1F2	1.58	7.03	3.83	4.94	7.16	0.92
I1F3	1.56	7.17	4.22	5.06	7.41	0.91
I2F1	2.10	8.13	4.26	6.61	9.44	1.20
I2F2	2.33	8.55	4.46	6.70	10.05	1.15
I2F3	2.69	9.03	4.88	7.09	10.32	1.16

13 Carbon Sequestration and Nutrient Dynamics

Soil carbon stock under different agricultural production systems in the eastern plateau and hill region

The ever-increasing level of greenhouse gases (GHG) has imposed a severe threat of global warming on the human population causing hindrance on agricultural activities, which further leads to the problem with regards to long-term food security and environmental sustainability. To reduce the atmospheric carbon dioxide, which is a major greenhouse gas, carbon needs to get stabilized in terrestrial ecosystem enriching the soil. Thus, adoption of the management practices facilitating carbon sequestration is the need of the hour. Different agricultural production systems comprising of uncultivated control (T_1), perennial napier grass (T_2), sole rice crop (T_3), tree-based production systems like mango + mahogany + rice (T_4), plum orchard (T_5), mango + mahogany + aonla + rice (T_6) and mango + mahogany + peach + rice (T_7) were evaluated in the acidic alfisols of eastern plateau and hill region of India for a period of 7 years.

The multitier systems with aonla filler trees had the highest total soil organic carbon (SOC) stock of 62.8 Mg ha^{-1} in the 0-60 cm soil depth. These systems also showed higher fractions and pools of SOC compared to rice crop and uncultivated control. The mango + mahogany + aonla + rice system had the highest very labile, labile, less labile, and non-labile carbon stocks (22.2, 15.5, 12.0, and 13.8 Mg ha^{-1}, respectively). The agro-silvi-horticultural system (T_6) recorded the highest active and passive carbon pools (37.6 and 25.7 Mg ha^{-1}), 49.5% and 41% increase over the control. The carbon management index (CMI) was significantly higher in multitier systems (T_6 and T_7), indicating better carbon rehabilitation capacity. SOC pools and fractions decreased with soil depth due to lete organic amendment addition. The Multitier systems exhibited significantly higher levels of organic carbon in the lower soil depth (30-60 cm) compared to control, sole rice, and napier-based systems, due to increased carbon addition from root biomass and rhizodeposition. The study found that multitier systems with filler trees (M+M+A+R and M+M+P+R) had higher organic carbon levels, fractions, pools, and CMI, indicating greater soil carbon stabilization. Therefore, adopting multitier systems over traditional rice-based systems can enhance carbon sequestration, improve soil fertility, and sustainability, and mitigate GHG emissions in the eastern plateau and hill region.

Leaching loss of nitrogen under different fertilizer management practices

Leaching loss of nitrate-nitrogen

The study examined leaching losses of NPK nutrients below the root zone of brinjal and maize crops using non-weighing lysimeters with four fertilizer management treatments: control (T_1), 100% inorganic (T_2), 100% organic (T_3), and integrated nutrient management (50% inorganic + 50% organic, T_4). Brinjal and maize received recommended NPK doses of 120:26:50 and 120:60:50, respectively. In the organic treatment (T_3), full doses of N, P and K for brinjal and full dose of N, P and 50% K in maize was applied through vermicompost. The nitrate-nitrogen leaching under brinjal was highest in T_2 (inorganic), ranging from 0.56 to 3.70 kg/ha, peaking at three days after transplanting (DAT)(Fig. 13.1). The T_4 treatment showed a lower peak value during the growing season and followed the same trend as the T_2 treatment. The next two nitrate leaching peaks were observed at 27th and 57th DAT, containing about 1.73 kg/ha and 1.85 kg/ha of nitrate-nitrogen, respectively. In T_3 and T_1, nitrate-nitrogen leaching remained relatively constant throughout the crop growth period.

Leaching of nitrate-nitrogen was also analysed for maize crop. The maximum amount of nitrate-nitrogen leaching (3.06 kg/ha) was observed in T_2 at 29 DAS, which then declined in later growth. In T_3 and T_1 treatments, nitrate-nitrogen leaching remained stable throughout the growth seasons, with slightly higher levels observed in the early stages (Fig. 13.1).

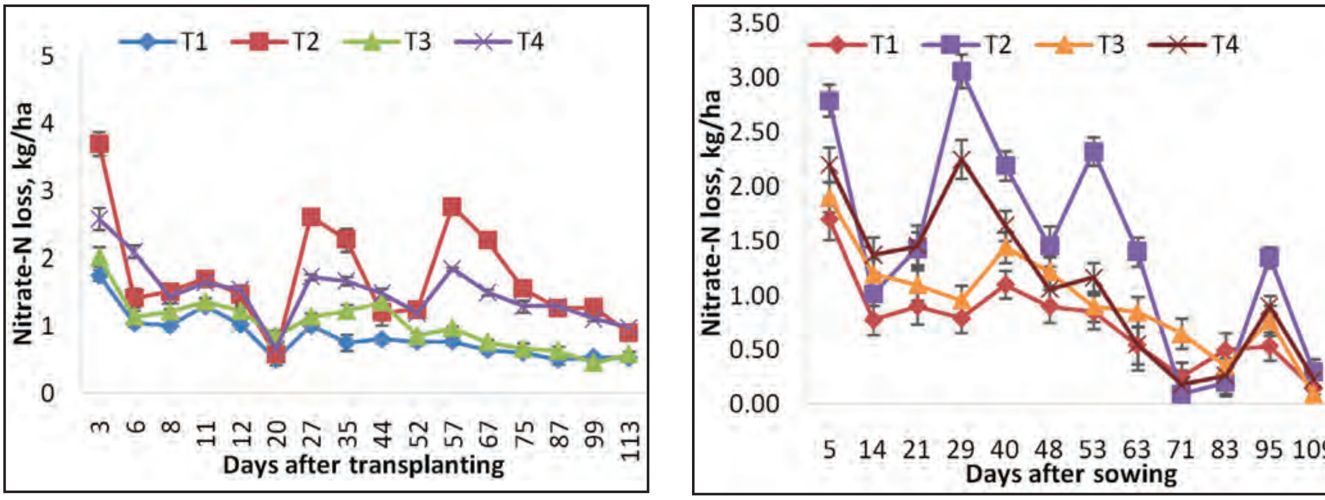


Fig. 13.1 Effect of different nutrient management options on the temporal variation of nitrate nitrogen (NO_3^--N) in brinjal and maize crop.

Leaching of ammonium-nitrogen

The ammonium-nitrogen loss in the T_2 treatment was highest and varied during the brinjal growing season, ranging from 0.09 to 0.84 kg/ha in the entire growth period. In the T_4 and T_3 treatments, the greatest ammonium leaching loss per period was 0.50 kg/ha and 0.45 kg/ha, respectively. At 3, 11 and 27 DAT, the T_2 and T_4 treatments showed high leaching loss. The highest ammonium-nitrogen loss in maize crop was observed in the T_2 treatment (inorganic). During the entire growth period, ammonium-nitrogen loss in the T_2 treatment varied from 0.04 to 1.15 kg/ha. In T_4 and T_3 treatments, the highest average ammonium leaching loss was 0.85 kg/ha and 0.65 kg/ha, respectively (Fig. 13.2).

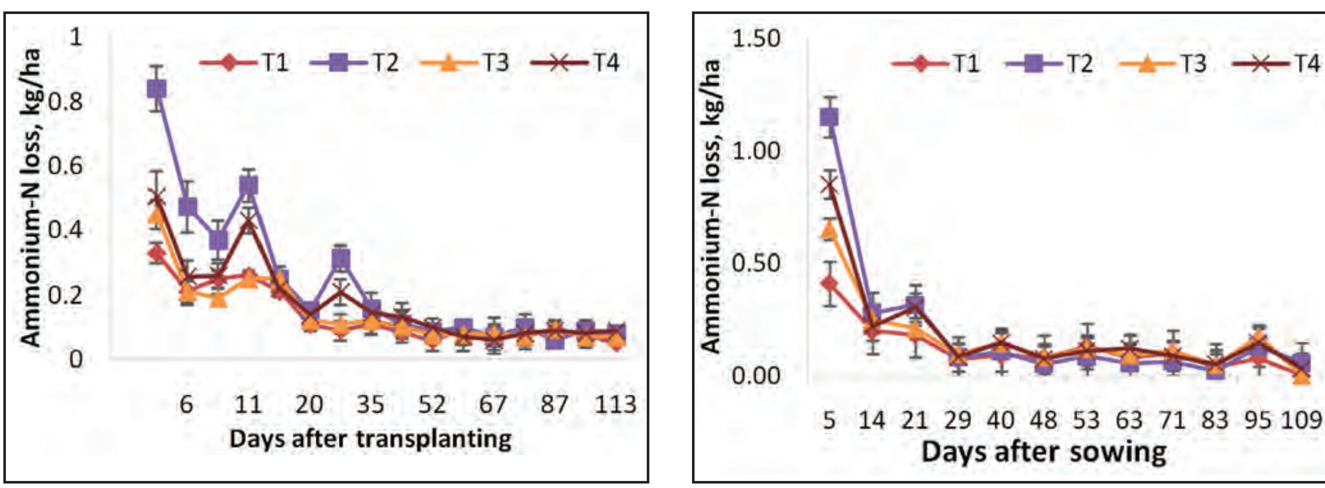


Fig. 13.2 Effect of different nutrient management options on the temporal variation of ammonium nitrogen (NH_4^+-N) in brinjal and maize crop

Organic Amendments for Phosphorus Mobilization in Acidic Soils

A field experiment was undertaken in maize and Frenchbean crops to identify organic amendments for phosphorus mobilization in acidic soils. The experiment was designed in RBD with nine treatments and three replications. The treatments included T_1 = Control (RDF), T_2 = RDF + lime (3 q/ha), T_3 = PSB (3 kg/ha), T_4 = PSB (5 kg/ha), T_5 = PSB (7 kg/ha), T_6 = Vermicompost (3 t/ha), T_7 = Vermicompost (5t/ha), T_8 = Vermicompost (7 t/ha) and T_9 = Green manuring (dhaincha). The nitrogen and potassium were applied to crops according to the recommended dose (RDF) in all treatments, while phosphorus application was excluded from treatments T_3 to T_9. PSB was applied by mixing with a fine powder of FYM@ 30, 50, 70 kg/ha in treatments T_3, T_4 and T_5, respectively.

The total phosphorus content among various treatments ranged from 516 to 801.5 mg/kg of soil. In treatments wherein the phosphorus application was omitted, the total phosphorus content decreased as compared to the initial levels, while treatments T_1 and T_2 showed an increase due to regular application of the recommended dose of phosphorus. Over two years, continuous cropping of maize and French beans led to depletion of both organic and inorganic phosphorus compared to the initial levels, which showed phosphorus mineralization for providing phosphorus nutrition to plants in treatments T_3 to T_9. Different forms of inorganic phosphorus found in all treatments were in decreasing order of Fe-P > Al-P >Saloid-P >Reductant Soluble-P > Ca-P > Occluded-P. The balance sheet (Table 13.1) of available phosphorus showed a net gain in treatments involving organic amendments, with the highest net gain observed in treatment T_5 with PSB @ 7 kg/ha and the lowest in the control group. The highest yield of French bean pods was observed in treatment T_8, which was comparable to T_2 and T_7. The maize cob yield was highest (8.92 t/ha) in treatment T_8, while it was lowest (6.24 t/ha) in the control treatment.

Table 13.1 Effect of organic amendments on soil P- balance in Maize -French bean cropping system

Treatment	Initial soil status kg/ ha(a)	Nutrient addition kg/ha(b)	Crop removal of P (kg/ha)(c)	Expected balance kg/ ha(a+b-c)(d)	Soil status at harvest kg/ha(e)	Net balance gain/loss kg/ ha(e-d)	Actual gain/ loss in soil kg/ha (e-a)
T1	20.1	140	26.62	133.48	22.5	-110.98	2.4
T2	25.34	140	34.4	130.94	27.6	-103.34	2.26
T3	22.13	2.25	27.1	-2.62	20.9	23.52	-1.23
T4	26.8	2.25	26.7	2.45	24.9	22.45	-1.9
T5	26.1	2.25	32.28	-3.83	25.4	29.23	-0.7
T6	24.9	9.9	28.16	6.64	22.2	15.56	-2.7
T7	24.3	16.5	33.48	7.32	22.6	15.28	-1.7
T8	25.1	23.1	38.2	10	24.6	14.6	-0.5
T9	24.2	8.2	31.54	0.86	23.1	22.24	-1.1

14 Soil and Water Conservation

Determining optimum decision variables for furrow irrigated system

The Kufri Jyoti variety of potato was sown on 26th Nov 2022 in furrow irrigated system in 0.30, 0.40 and 0.50% bed slope at a plant spacing of 0.50 x 0.25m. The furrow length of the field was 35 m. The cut-off ratio of irrigation applied as 0.85, 0.80 and 0.75 in the plot having slope of 0.30, 0.40 and 0.50% respectively (Fig. 14.1). Moisture content was measured using the gravimetric method at 15-day intervals throughout the growing season. The plot having 0.5% slope and 0.75 cut-off ratio recorded the highest yield of 11.9 t/ha and water productivity of 5.95 kg/m^3. However, this increase was not significantly higher than the yields from the other plots: 10.2 t/ha with a 0.30% slope and 0.85 cut-off ratio, and 11.4 t/ha with a 0.40% slope and 0.80 cut-off ratio.

(a) 0.3% **(b) 0.4%** **(c) 0.5% slope**

Fig. 14.1 Kufri Jyoti variety of potato grown on 0.3, 0.4, and 0.5% slope

Assessment of land use and land cover change for crop planning using remote sensing and GIS in East and West Champaran districts of Bihar

LISS III and LANDSAT images of the year 2000, 2011 and 2018 were collected, georeferenced, classified, and assessed for accuracy to generate maps and identify changes in the areas of rice, wheat, and maize cultivation over the past 18 years in East and West Champaran districts of Bihar.

The images were sourced from various websites, mosaiced, and organized according to the district boundaries of East and West Champaran. Using ERDAS IMAGINE 4.1 and ArcGIS 10.3, the images were georeferenced, classified, and used to generate maps for different land use and land cover (LULC) types in these districts. The change detection analysis showed an increase in the areas dedicated to rice, wheat, and maize cultivation from 2000 to 2018 (Fig. 14.2 & 14.3).

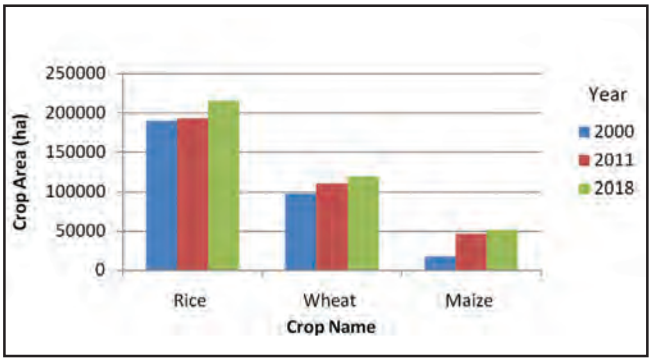


Fig.14.2 Areas of rice, wheat and maize cultivation in East Champaran for the years 2000, 2011 and 2018

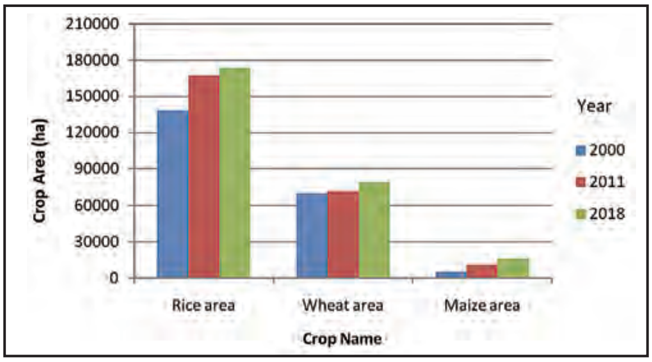


Fig.14.3 Areas of rice, wheat and maize cultivation inWest Champaran for the years 2000, 2011 and 2018

Retrieving and analyzing satellite-derived precipitation data in flood prone areas of north Bihar and its surrounding area

Flooding can occur in a river's catchment area when the river's capacity is exceeded and runoff overflows its banks. The primary source of this water is the precipitation over the catchment. Given that main rivers in north Bihar i.e. Gandak, Kosi and Mahananda are trans-boundary, understanding the spatial variation of precipitation across these catchments necessitates comprehensive precipitation data. While data for the Indian portion of north Bihar's river catchments can be sourced from the Indian Meteorological Department (IMD), obtaining comparable data from outside India presents challenges. To address this data gap, we utilized daily precipitation data from the Tropical Rainfall Measuring Mission (TRMM), with a resolution of 0.25^0 x 0.25^0, for the flood season (June-October) between 2000 and 2010. Codes in the open-source 'R' software were developed to produce georeferenced cumulative precipitation data for the flood season of 2000-2010 as well as to determine the average annual rainfall received by the river basins in and outside north Bihar from 2000 to 2010.

The average monsoonal rainfall received by pixels within the north Bihar and its surrounding during the period from June to October, spanning from 2000 to 2010, is illustrated in Fig. 14.4. Analysis reveals that the average monsoonal rainfall in the Gandak basin ranged from 319 mm to 1848 mm, with an average of 1282 mm. Similarly, for the Kosi basin, the range was from 402 mm to 1862 mm, with an average of 1124 mm, while for the Mahananda basin, it varied from 1213 mm to 2422 mm, with an average of 1685 mm. The annual variation of monsoonal rainfall across the basins is depicted in Fig. 14.5. Notably, the highest average monsoonal rainfall occurs in the Mahananda basin, followed by the Gandak and Kosi basins. The pattern of rainfall amounts received by the basins is largely similar, indicating that when there is a peak for a year in monsoonal rainfall in the Mahananda basin, the other two basins also exhibit a similar pattern. Furthermore, it is observed that the basin areas of the rivers outside Bihar receive more rainfall compared to the basin areas within Bihar state territory, as depicted in Fig. 14.6.

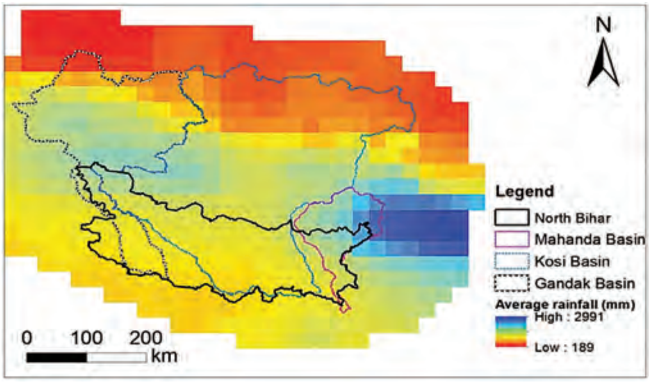


Fig. 14.4 Average monsoonal (June-October) precipitation received by pixels within north Bihar and its surrounding during 2000-2010.

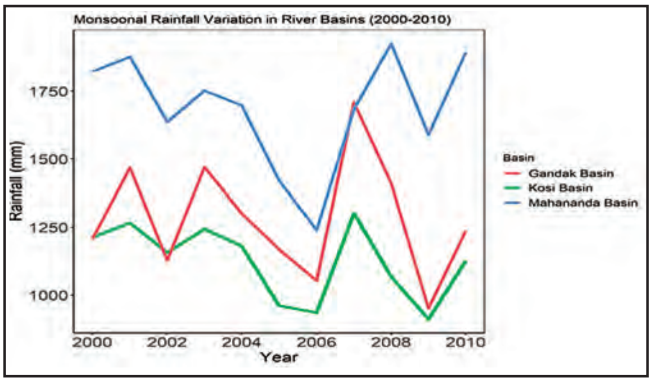


Fig. 14.5 Annual variation of monsoonal rainfall across the basins

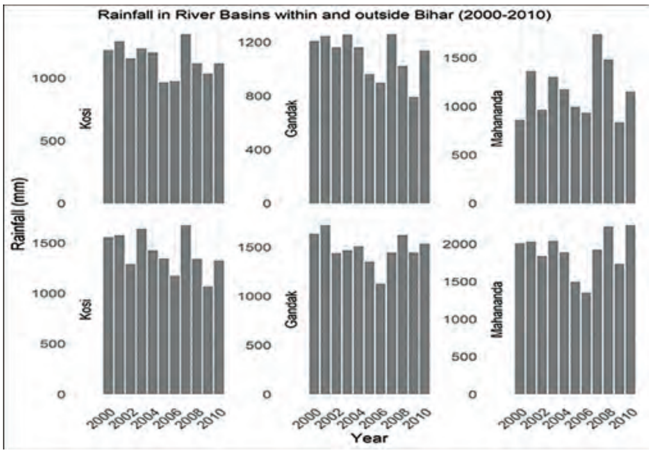


Fig. 14.6 Rainfall in monsoon season during 2000-2010 in river basins within and outside Bihar

Integrated modelling approach for developing drought management strategies in the Sakri river basin

This study was conducted in the Sakri River Basin of India, focusing on a spatio-temporal analysis of rainfall and temperature fluctuations over the past three decades (1991–2020), using a nonparametric test (Mann-Kendal test) and Sen's slope. Long-term rainfall analysis reveals an increasing trend in both annual and monsoonal rainfall, with the later contributing approximately 84% of the total annual rainfall. The annual rainfall in the Sakri basin ranged from 2.26 mm/year to 7.63 mm/year, with percentage changes varying from 0.84% to 2.27%. After examining monthly maximum temperatures, a significant increasing trend was observed in the monsoon month of September at all stations except Koderma, and in the pre-monsoon month of April at all stations except Giridih (Fig. 14.7).

This study also prioritizes sub-watersheds for the Sakri basin using multivariate geomorphometric approach. The basin resulted in the formation of 11 sub-watersheds. The quantitative measurements of morphometric analysis, including basic and derived (linear, relief, and areal), were considered, and 17 morphometric characteristics were chosen to rank and prioritize sub-watersheds. Two efficient and time saving techniques such as morphometric and PCA were used to rank and prioritize sub-watersheds based on highly correlated morphometric parameters. Based on the results of morphometric analysis and PCA, the sub-watersheds were classified as low, medium, and high. Among the sub-watersheds SW3, SW5, SW6, SW8 and SW9 has been identified as high priority, which covers approximately 46.82% of the basin area, suggesting those areas are at a higher risk of erosion. Sub-watersheds with high risk of erosion which requires instantaneous soil and water conservation measures for betterment of basin morphometry and to minimize the drought like situations (Fig. 14.8).

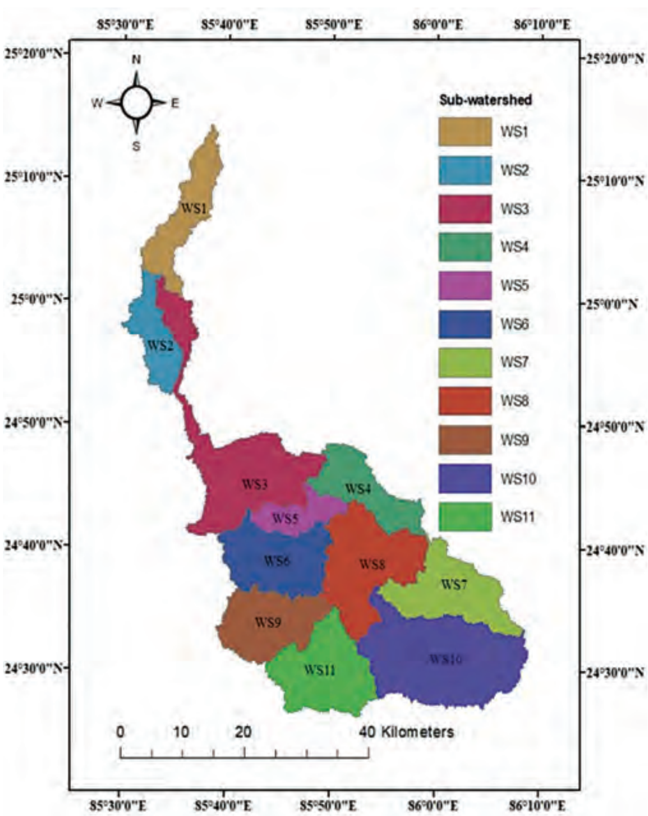


Fig. 14.7 Location of the study area with sub-watershed segments

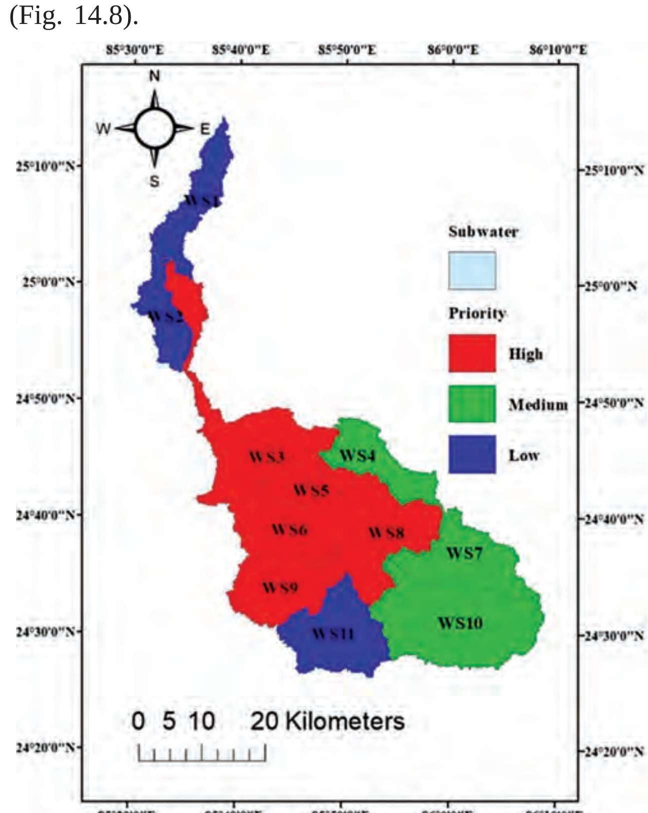


Fig. 14.8 Priority of sub-watershed based on morphometric analysis

Development of biodegradable pots for residue management in agriculture

Eco-friendly biodegradable plantable pots made from rice straw are organic, environment friendly and cost effective. These biodegradable planter pots have stable structure with less water infiltration property, which would result in good growth of plant by providing a favorable microclimate. The planter has good water absorption as well as drainage and air permeability; being completely biodegradable the pot enables direct transplant of plants into the ground, reducing the shock associated to this action. The developed planter is free from any kind of pollution, and does not require special technical knowhow for the preparation and development of the plantable pots (Fig. 14.9).

Fig. 14.9 Biodegradable planting pot

15 Livestock Health and Production

Characterization of lesser-known germplasm of farm animals in Eastern region

Field study was conducted in Kaimur district of Bihar to characterise and identify the uniqueness of farmer owned livestock germplasms, the nature of their integration in to production in systems, and the husbandry practices adopted by the farmers. It was observed that the native chicken reared by the farmers had unique plumage patterns, varying from solid golden colour to varied colours (Fig. 15.1). A total of 63.8% of birds had golden plumage, while the rest had varying coloured plumage. The birds were smaller in size but possess large earlobes. All the birds had single combs devoid of any tube or ridge like structures. The combs and wattles were pink, whereas the colour of the shank was yellow in 91.6% of the birds. The birds started laying at 7 months of age and lays about 100 eggs per year. The egg shells were brown and the average weight of an egg was found to be 42.38 ± 0.32 g. Generally, these birds were reared in free ranging system by the farmers. The chickens were let free in the early morning and were housed only at night. Apart from free ranging, they sometimes received household wastes to fulfill their nutrient requirements. A detailed study would provide more information about these chickens, which may pave the way for necessary documentation and registration.

Fig. 15.1 Chicken germplasm from Kaimur district of Bihar

Another study was conducted to describe the phenotypic characteristics, production performance and behavioural characteristics of selected populations of indigenous chickens in the Chotanagpur plateau region of India. A total of 736 adult chickens from Namkum, Bundu and Tamad blocks of Ranchi district were sampled and characterized for 17 quantitative traits and 438 adult chickens for 10 qualitative traits under field conditions. The study involved both questionnaire survey and a participatory group discussion. The average flock size ranged from 11 to 17. The dominant plum age colour in male was black & golden mix (38.88%) (Fig. 15.2a) followed by white and black mix (37.80%) plumage colour in males (Fig. 15.2b). In females, dominant plumage colour was white and black (34.60%), followed by brownish white to light brown (31.18%). The single comb was the dominant comb type in all localities, followed by pea comb. Hackle and saddle feathers of males are rich golden yellow, forming amala (*garland*) like shape with lacing plumage pattern. Predominantly, the native chicken possess white skin colour (73.28%), red earlobes (55.92%) and yellow shank (64.46%). The mean body weights of indigenous male and female chickens were 1.86±0.04 kg and 1.09±0.02 kg, respectively. The average values for body length (cm), back length (cm), wing span (cm), comb length (cm), shank length (cm) were 39.30±0.16, 27.22±0.13, 34.00±0.20, 5.76±0.18, 9.49±0.06, respectively. Flight distance and height was 40.14 ft and 8.35 ft, respectively. The territory radius of cocks was 122.69 ft. The results of the present study provides baseline data on phenotypic and performance traits of native chicken germplasms of Jharkhand.

Fig. 15.2a. Black & golden male with single comb and yellow shank colour

Fig. 15.2b. White & Black mix male with single comb and yellow shank colour

Network Project on Buffalo Improvement

Under Network Project on Buffalo Improvement (NPBI), a total of 93 Murrah buffaloes are maintained at the Experimental Livestock Farm of the Institute (Fig. 15.3). A total of 27 calves were born during the reporting year, including 15 males and 12 females. Calf mortality was restricted to 2.7 percent. The breedable buffaloes were inseminated using semen from 21 set of test bulls reared at five different semen stations. The Standard Lactation Milk Yield (SLMY) and the Total Lactation Milk Yield (TLMY) recorded during the year were 2488.54 and 2814.63 kg, respectively (Fig. 15.4). By utilizing the wastelands near the institute's boundary wall and in other locations, the area under fodder cultivation was increased by nearly one acre in order to support the green fodder requirements for the buffaloes. An MS Excel based Digital Information System developed in the project is being used to monitor the buffaloes which are nearing the estrus, pregnancy diagnosis and calving.

Fig. 15.3 Herd of breedable buffaloes of institute farm

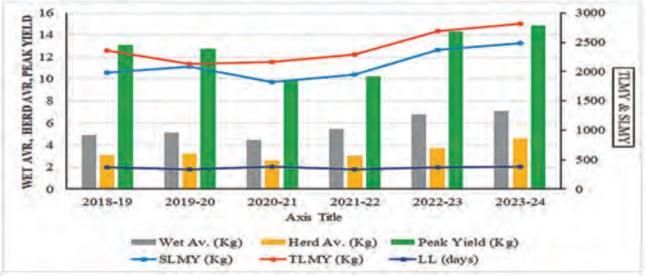


Fig. 15.4 Performance of buffalo under NPBI project

Development of egg and meat strains of ducks suitable for backyard system of farming

The presence of around 65%of India's total duck population in Eastern Region signifies the importance of duck rearing in Eastern India and its role in supporting the livelihood of farmers. To enhance the production and reproduction performances of ducks in the Eastern region, a crossbreeding program with native ducks (Fig. 15.5a) and White Pekin (Fig. 15.5b) was carried out for three generations. Subsequently, a selection process was applied to choose the best individuals under pre-defined characteristics. The results indicated 64.2% increase in the body weight of crossbred ducks over the native non-descript ducks.

Fig. 15.5a Native duck

Fig. 15.5b White Pekin duck

Assessing genetic variability in duck of Eastern states

Blood samples were collected from metatarsal vein of adult Indian Runner ducks, Khaki Campbell ducks, Chhattisgarh ducks, White Pekin ducks, Bihar ducks, Bengal ducks and Maithili ducks. After quality DNA extraction, a DNA library was developed using NEB Next Ultra™ II DNA Library Prep Kit. The whole-genome shotgun strategy was adopted to construct a 300 bp (2x150) library of DNA samples, which was sequenced on the Novaseq6000 platform (Illumina). We generated a total 3.4GB of raw sequence data. Raw reads in FASTQformat were processed for quality using Trimmomatic. The high-quality reads were mapped to the mallard (*Anas platyrhynchos*) reference genome (NC_009684.1) using SPADES version 3.13.0 and BLASTN version 2.2.30 to compare splicing with the *Anas platyrhynchos* reference genome. The assembly results of candidate sequences were determined based on the comparison. The gene structure was annotated with MITOS2 (http://mitos2. bioinf.uni-leipzig.de/index.py) by uploading the genome sequence and genetic code parameters for gene prediction. The results were deposited in GenBank and following accession numbers were obtained: Indian Runner duck (NCBI Accession No OQ561754), Khaki Campbell duck (NCBI Accession No OQ561755), Chhattisgarh duck (NCBI Accession No OQ561756), White Pekin duck (NCBI Accession No OQ561757), Bihar duck (NCBI Accession No OQ561758), Bengal duck (NCBI Accession No OQ561759), Maithili duck (NCBI Accession No OQ561760).

Exploring genetic basis of mastitis resistance in livestock

Milk of 308 animals (169 cows and139 buffaloes) from institute livestock farm and farmer's field were screened for sub clinical mastitis by California mastitis test (CMT). Out of these 308 animals, 116 animals (57 cows and 59 buffaloes) tested positive for subclinical mastitis. For transcriptome analysis, milk samples from three Murrah buffaloes suffering from subclinical mastitis and three healthy buffaloes were collected. RNA was isolated from milk somatic cell using standard protocol. The KAPA mRNA Hyper Prep Kit was used to prepare libraries for Illumina sequencing. The average number of raw reads, processed reads and mapped reads for six libraries were 51154816, 42049137 and 38995206, respectively. The mean mapping percentage against *Bubalus bubalis* reference assembly was 92.7%. The annotation of transcriptome count table was created using the Feature counts option of Rsubread package, using the gene transfer format (GTF) as a reference. The assembled transcriptome expression was estimated using the DESeq2 package of R. Subsequently, further analysis was limited to only those differentially expressed genes that had a log2 fold change e" 2.0, p value d" 0.05 and False Discovery Rate (FDR) d" 0.05 to limit the number of DEGs and identify only those genes that has strong expression changes (Fig. 15.6). Differential gene expression analysis revealed that total 3,482 gene showed differential gene expression in animal suffering from subclinical mastitis (Fig. 15.7). Out of these, 2,147 genes showed significant up regulation, whereas 1,334 genes showed significant down regulation in animal suffering from subclinical mastitis in compared to healthy animals. IL12 B, SLA, CSF3R, CD177, THBD, ICOSLG, NCF1, SELPLG, IL3RA and CXCR2 are some of the important genes that showed significant up regulation in animals suffering from subclinical mastitis. In contrast, KRT24, PIK3C2G, LALBA, CSN2, CSN3, CSN1S1, CD36 and CD59 are some of the common genes that showed highest down regulation in animals suffering from subclinical mastitis.

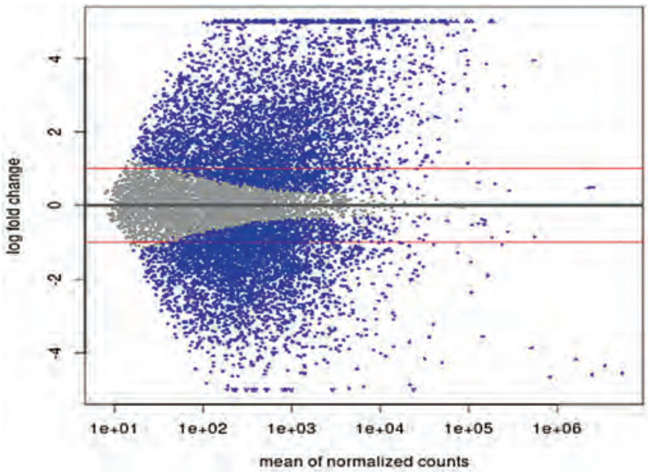


Fig. 15.6 MA Plot

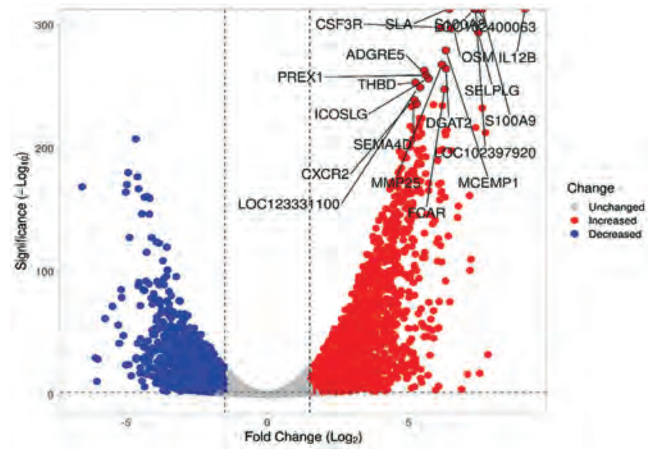
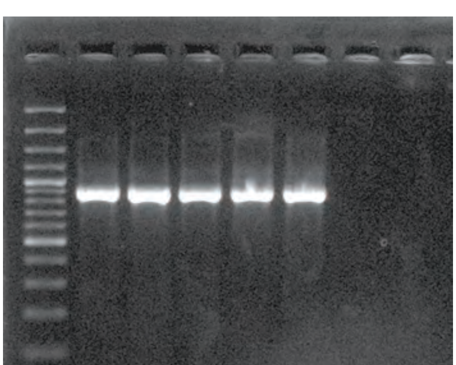


Fig. 15.7 Volcano plot of top twenty differentially expressed gene

Assessment of antimicrobial drug resistance in bacteria of animal origin

A total of 134 *E. coli* isolates were from fecal samples collected from cattle, buffaloes and poultry. Samples were identified based on staining, cultural, biochemical characteristics and PCR. Serotyping based on Somatic (O) antigen based revealed that the *E. coli* isolates belonged to different serogroups, namely O119, O101, O84, O135, O7, O20, O88, O111, O98, O2, O18, O76 and UT (Un typable). DNA was isolated from *E. coli* and *S. aureus* and was checked for ~~its~~ quality by electrophoresis in ethidium bromide stained agarose gels. All the 134 tentatively identified *E. coli* were confirmed by usp A gene PCR, producing an amplicon of expected size of 884 bp, as visualized under UV light-based Gel Doc system (Fig.15.8). Bacterial culture from 55 milk samples from cattle and buffaloes resulted in isolation of 27 *S. aureus* strains. They were identified and confirmed based on: colony characteristics, staining, biochemical characteristics and PCR. All 27 tentatively identified *S. aureus* isolates were confirmed by molecular test PCR, producing amplicon of 279 and 700 bp for thermonuclease and coagulase gene, respectively. All the bacterial isolates of *E. coli* and *S. aureus* have been preserved in glycerol for future use.

1000bp



884 bp

The Laboratory based antimicrobial sensitivity profile of *E. coli* isolates revealed that more than 40% were multidrug resistant strains and mostly resistant to commonly used antibiotic drugs. Out of 134 tested, 49 (36.5%) *E. coli* were phenotypically confirmed Extended Spectrum â-lactamases (ESBL) producer strains as tested by double disc synergy test.

In genotypic study, amr genes relevant for ESBL production, such as TEM, SHV and CTX, integrons and sulI were assessed in *E. coli* isolates. In the present study on ESBL phenotypes of *E. coli*, 113 (84.3%), 61 (45.5%) and 55 (41.1%) were positive for TEM, integron I and sulI, respectively (Fig. 15.9 a&b).

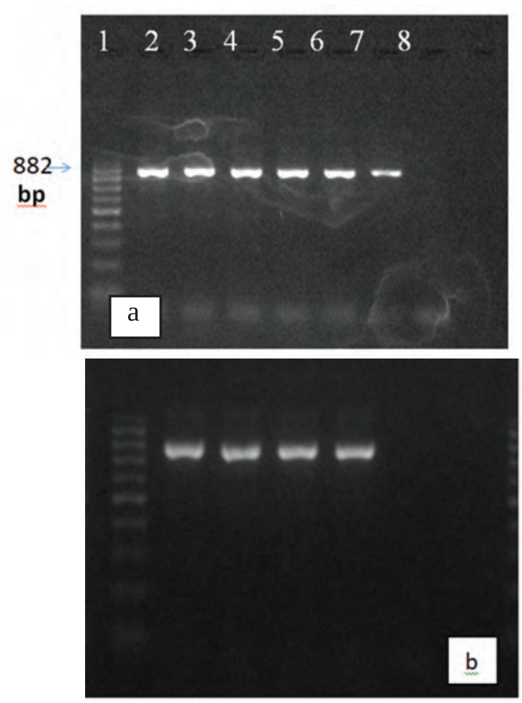


Fig.15.9 Agarose gel electrophoresis showing (a) PCR 882 bp amplicon for integron 1 and (b) sulI gene (779 bp) from *E. coli.*

Evaluation of diara land farming for sustainable food production

A study was undertaken to evaluate the sustainability of the food production system in diara land of Bihar. “Diyara” or “diara” denotes the flat, riverbank areas created by the accumulation of silt alongside riverbanks. These zones experience occasional flooding, which contributes to the enrichment of the soil with nutrients. In the present study, three sites of Ganga river (Buxar, Saran and Begusarai) and two sites of Gandak river (East Champaran and Vaishali) were selected. All diara land are broadly classified into two types *viz.* upland diara and lowland or riverbed diara (Fig. 15.10). Elevation analysis along the transect line has revealed that a mean elevations of riverbed diara and upland diara are about 49 m and 51 m, respectively in the Gandak river at Hajipur. In this study, we employed Google Earth data and Geographic Information System (GIS) techniques to quantify the extent of diara land along the Gandak River. The total diara land, including both riverbed and upland diara, in Bihar’s Gandak River basin was estimated to be 56,304 ha.

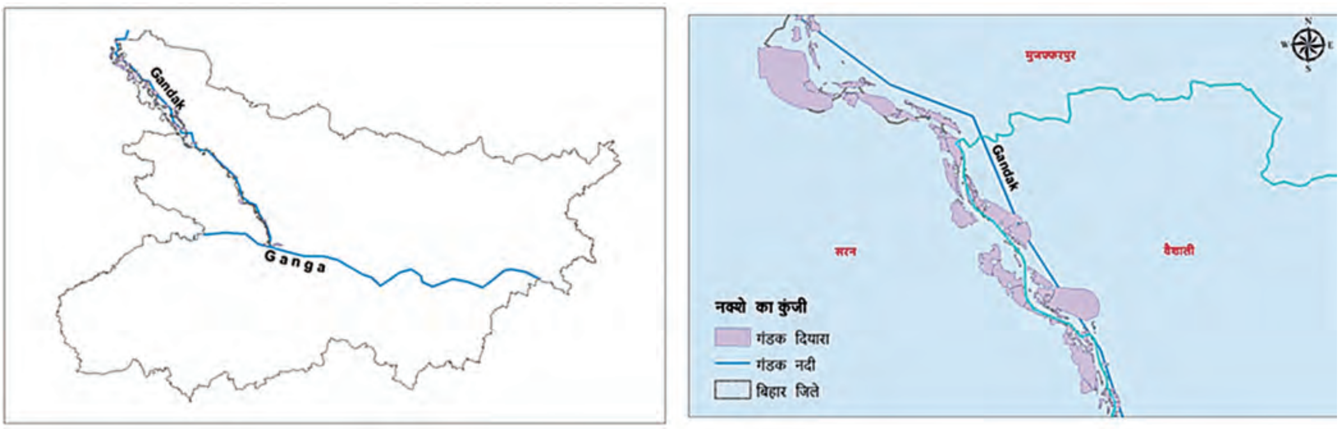


Fig. 15.10 The distribution of diara land along the Gandak river in Bihar

Unlike other cultivated land, agricultural activities in upland diara commence in early November, taking advantage of the river’s early water recession. Farming in the riverbed diara, however, begins after second fortnight of November. In the upland diara, wheat is the predominant crop cultivated by farmers, supplemented by other crops such as mustard, potato, and winter vegetables. Conversely, watermelon takes precedence in riverbed diara, accompanied by crops like sponge gourd and cucumber. The diara cropping season concludes in May or early June. To protect the crops from chilling winter in riverbed diara, farmers used to thatch the crop in east-west direction using dry khus grass (*Chrysopogon zizanioides*), which naturally grown on the river bank. It was observed that in riverbed diara, where the sand content is relatively higher, farmers prefer cultivating watermelons exclusively. In the upland diara, the initial irrigation is done using the water left in the abandoned river channels. Farmers who have irrigation facilities provide a second irrigation, while other farmers rely on residual soil moisture. In upland diara, farmer supplement the nutrition requirement of plant by adding Farm Yard Manure (FYM) and inorganic fertilizers.

Fig. 15.11 Traditional cultivation system along the Gandak river in Bihar

In the case of riverbed diara, farmers employ a unique technique to address water and nutrient requirements for crops. Due to the high sand content, crops are sensitive to water. Initially, when the plants are small, water needs are met through river water, and manual irrigation. Alongside each plant row, farmers dig a 10-15 cm deep channel, adding fertilizers (poultry manure and other inorganic fertilizers) mixing them with the soil. This encourage crop roots to extract nutrients and water from the channel (Fig.15.11).Since groundwater in riverbed diara is shallow, especially during the summer months when the groundwater level decreases, farmers deepen the channels and continuously add fertilizers, mixing them with the soil. This water and nutrient management process is labour-intensive.

All India Coordinated Project on Goat Improvement

All India Coordinated Research Project (AICRP) on Goat Improvement was initiated at ICAR Research Complex for Eastern Region, Patna in the year 2018-19. The centre continued its activities in five clusters in Bihar, namely East Champaran, Samastipur, Araria, Katihar and Jamui districts, selected based on the Bengal goat population density. A total of 925 households were adopted under the programme in 5 villages. During the year, the population growth in the selected villages expanded to the tune of 260.83% with the addition of breedable does and new births (Fig 15.12). A total of 22 improved Black Bengal breed of bucks were distributed among the farmers at 5 sites to improve the existing stock. The mortality rate was controlled within 3.19 % due to comprehensive efforts involving vaccination, de worming, timely therapeutic interventions and awareness program.

The average body weight (kg) at 3 and 6 months of age was recorded at 4.00 ± 0.01 and 6.75 ± 0.02, respectively. The body weight (kg) at 9 and 12 months of age was 9.11 ± 0.03 and 12.65 ± 0.07, respectively. The average lactation milk yield was 22.24 ± 3.88 kg over 90 days of lactation. A total of 2,969 does were available for breeding. The tupping percentage was 92.70, while breeding efficiency was 98.96% based on the numbers of does tupped. During the year under report, one training programme on goat management and 12 Goat Health Camps were organized. A total of 1,420 goats were vaccinated with PPR and ET.

Fig. 15.12 Multiple kids of Black Bengal goat

Evaluation of traditionally used growth promoters for pig

The study was conducted with 20 growing crossbred (T&D) piglets divided into four equal groups of five piglets each. Left-over fermented rice (LFR), dried under sun to 70% dry matter (DM) was used in diets for T&D growing piglets of 2-3 months of age. Pigs in group T1 were fed standard concentrate grower ration having 18.04% Crude Protein (CP) and 2.94 Mcal/kg of Digestible Energy (DE). This ration was replaced with wheat bran on dry matter basis with left-over fermented rice at 6%, 12% and 18% level in T2, T3, and T4, respectively. A measured quantity of feeds (concentrate mixture and dried fermented waste) was mixed thoroughly according to the experimental design and offered for libitum feeding (Fig. 15.13). The average daily gain in T_1, T_2, T_3 & T_4 were observed to be 266.89, 262.22, 253.22 and 251.44 g/pig/day, respectively.

Left-over fermented rice (LFR) after making Handia (Alcoholic drink)

Mixture of LFR and concentrate mixture

Pigs fed with LFR mixture

Fig. 15.13 Traditional feed used for pig fattening

Response of fodder oat to different nitrogen and zinc management practices

A field experiment was carried out in split plot design during *Rabi* 2022-23 to evaluate the efficacy of different nitrogen and zinc management practices in fodder oats. Three nitrogen management strategies *i.e.*, N_1: Recommended dose of nitrogen (RDN) through inorganic fertilizer (IN), N_2:75% RDN (IN) + Four foliar spray of Nano-N and N_3: 50% RDN (IN) + Five foliar spray of Nano-N were usedas main plot treatments. Meanwhile, three zinc management strategies *viz.*, Zn_0: Control (No Zn), Zn_1: Zinc @ 10 kg/ha (IN) and Zn_2: 5 kg Zinc (IN) as basal + Four foliar spray of Nano-Zn were assessed in sub-plots with three replications. Results revealed that application of N_1 treatment had higher total green fodder yield (36.7 t/ha) and total dry matter yield (6.23 t/ha) compared to rest of N treatments (Table 15.1). Furthermore, application of Zn_1 and Zn_2 (5.59 & 5.57 t/ha, respectively) equally improved total dry matter yield over Zn_0 (5.10 t/ha).

Table 15.1 Green fodder yield and dry matter yield of Oats crop as influenced by different N and Zn management strategies

Treatment	Green Fodder Yield (t/ha)				Dry Matter Yield (t/ha)			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
Zn_0	35.64	29.10	29.53	31.42	6.00	4.63	4.67	5.10
Zn_1	37.74	32.43	29.29	33.15	6.47	5.46	4.83	5.59
Zn_2	36.71	33.92	29.12	33.25	6.22	5.70	4.78	5.57
Mean	36.70	31.82	29.31		6.23	5.26	4.76	
	N	**Zn**	**N x Zn**		**N**	**Zn**	**N x Zn**	
SEm±	0.83	0.79	1.37		0.22	0.12	0.20	
LSD (P=0.05)	3.26	NS	NS		0.85	0.36	NS	

Fodder quality traits of Oats crop significantly influenced by different N and Zn management strategies (Table 15.2). The N_1 treatment being at par with N_2 showed highest total crude protein yield (TCPY; 997 kg/ha), total ash yield (TAY; 604 kg/ha), and total ether extract yield (TEEY; 185 kg/ha) compared to N_3. Further, Zn_1 and Zn_2 equally improved TCPY, TAY and TEEY compared to Zn_0.

Table 15.2 Fodder quality traits of Oats crop as influenced by different N and Zn management strategies

Treatment	Total Crude Protein Yield (kg/ha)				Total Ash Yield (kg/ha)				Total Ether Extract Yield (kg/ha)			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
Zn_0	865	798	745	803	571	424	403	466	177	134	121	144
Zn_1	1087	924	779	930	626	503	432	520	191	159	135	162
Zn_2	1038	962	790	930	614	528	426	523	186	167	133	162
Mean	997	895	771		604	485	421		185	153	129	
	N	**Zn**	**N x Zn**		**N**	**Zn**	**N x Zn**		**N**	**Zn**	**N x Zn**	
SEm±	28.9	36.1	62.6		32.5	11.2	19.5		6.0	4.1	7.1	
LSD (P=0.05)	113.5	111.4	NS		127.8	34.6	NS		23.6	12.7	NS	

Effect of Environmental Exposure of Arsenic in Animals of Bihar

Samples were collected from Chapar village (Samastipur), Maneer (Patna), Churamanpur, and Badka Rajpur village of Buxar district (Fig. 15.14). In Chapar village, the level of arsenic in water was 40.13±13.30 µg/L.Haemoglobin (gm/dl), PCV (%), total erythrocyte count(10^6/µl) and rectal temperature(^{0}F)in the goats were 7.54±.39, 22.22±1.16, 8.43±.14, 102.15±0.07, respectively. Plasma creatinine (mg/dl), urea (mg/dl), SGOT (IU/L) and SGPT (IU/L) were 1.17±0.12, 62.43±4.20, 156.28±4.32, 23.46±1.26, respectively, which were higher than those in goats from Nurichak, Udaypur, and Kachardiha villages in Nawada district(0.74±.10, 37±2.60, 110.4 ±4.6, and 14.6±1.4, respectively) where as arsenic in water, blood, and urine was at non-detectible levels. The elevated levels of these biochemical parameters may indicate a negative effect of arsenic on liver and kidney functions in arsenic affected animals.

Fig. 15.14 Sample collection for analysis of Arsenic

During 2023 a total of 7 Accession Number were received after submission at NCBI as given below in table 15.3

Table 15.3 NCBI submission from different project activities with details

S No	Accession Number	Year	Contributors	Details
1.	OQ561754	2023	Kumari, R., Prabha, R., Dayal, S., Ray, PK, Kamal, R., Chandran, PC., Kumar, J. and Dey, A.	*Anas platyrhynchos* isolate IR mitochondrion, complete genome.
2.	OQ561755	2023	-Do-	*Anas platyrhynchos* isolate KC mitochondrion, complete genome
3.	OQ561756	2023	-Do-	*Anas platyrhynchos* isolate CHH mitochondrion, complete genome
4.	OQ561757	2023	-Do-	*Anas platyrhynchos* isolate WP mitochondrion, complete genome
5.	OQ561758	2023	-Do-	*Anas platyrhynchos* isolate Bihar mitochondrion, complete genome
6.	OQ561759	2023	-Do-	*Anas platyrhynchos* isolate Bengal mitochondrion, complete genome
7.	OQ561760	2023	-Do-	*Anas platyrhynchos* isolate Maithali mitochondrion, complete genome

16 Fisheries Resource Management and Aquaculture

Performance of Different Manures on Fish Productivity

The fish productivity performance under different manure combinations, i.e., T1: Cattle + goat manure, T2: Cattle + duck manure and T3: Feed (3% body weight) was analyzed at Institute's fish farm. Three species of carps (Catla, Rohu and Mrigal) were used for the present study and stocked at a density of 7000/ha. All the water quality parameters such as temperature, pH (7.67-7.80), dissolved oxygen (7.49-7.82 mg/l), alkalinity (149.63-152 mg/l) and hardness (126.13-130 mg/l) were within the acceptable limit of fish culture in all the treatments (Fig 16.1 & 16.2). Likewise, other important parameters such as total ammonium, nitrite and phosphate concentration ranged between 0.10 to 0.13 mg /l, 0.05-0.06 mg /l and 0.03-0.05 mg /l, respectively.

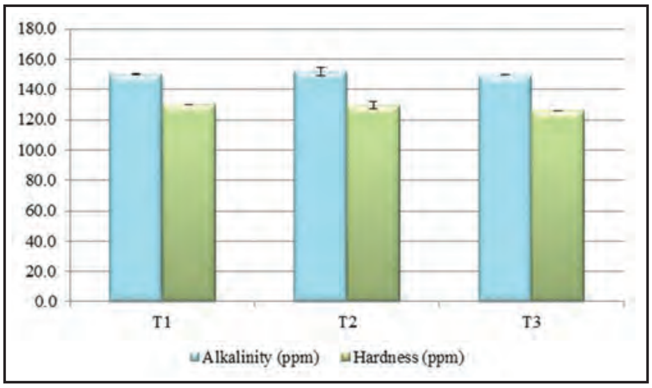


Fig. 16.1 Water alkalinity and Hardness

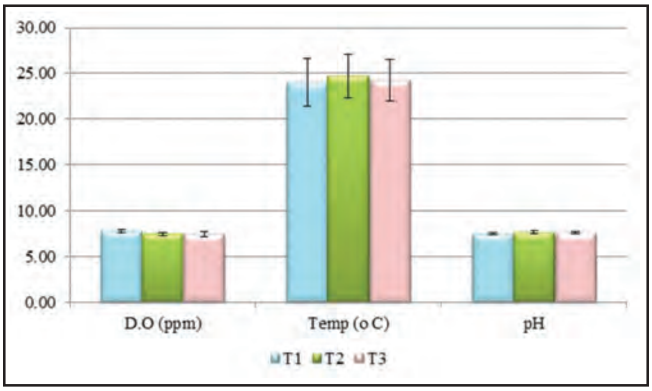


Fig. 16.2 Water quality parameters DO, Temp, pH

Maximum Gross Primary Productivity (GPP) was recorded in T1 (0.19 g C $m^{-3} h^{-1}$) followed by T2 (0.18 g C $m^{-3} h^{-1}$) and T3 (0.16 g C $m^{-3} h^{-1}$). No significant water quality deterioration was recorded when mixed manures were utilised in fish farming. The most abundant and frequently recorded planktonic organisms were Rotifers (*Branchionus falcatus* and *Keratela tropica*), Cladocerans (*Moina brachiata*, *Leydigia* spp), *Navicula* spp. *Diatoma* spp. *Scenedesmus* spp. Filamentous algae etc. A proliferation of zooplankton is generally associated with application of organic manure. Microbiological analysis of water and soil, including Total bacterial count (TBC), Total coliform count on MA (TCC) and Total *E. coli* count on EMB (TECC) of the fish pond under different treatments are depicted in Fig. 16.3 & 16.4. From the current study, it was observed that bacterial load in T1 integration was relatively high followed by T3 and T2. On the other hand, maximum *E. coli* count was found in T2 followed by T1 and T3.

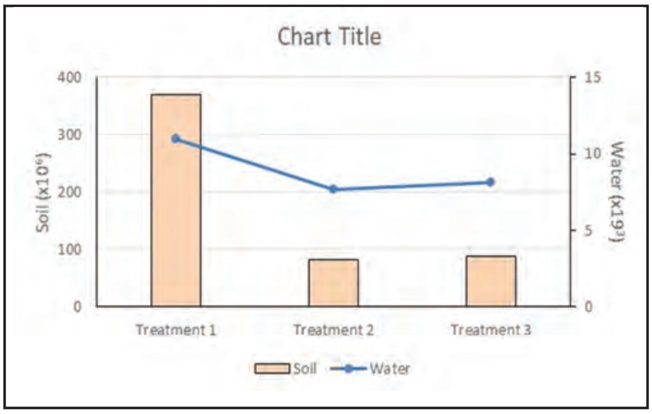


Fig. 16.3 Total bacterial count in water and soil

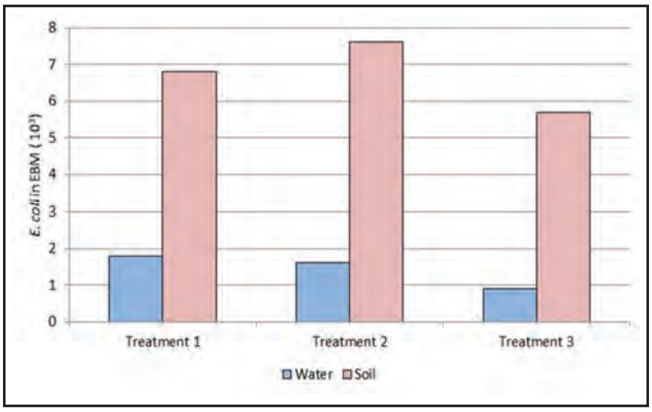


Fig 16.4. *E. coli* density in water and soil

Over the study period, highest average weight gain was recorded in Catla (700g) followed by Rohu (548.3g) (Fig.16.5). Overall, production was highest under the feed-based treatment and lowest in the T1. The survival rate in case of feed-based treatment (T3) was maximum (77.10%) followed by cattle-duck combination (T2). The lowest survival (69.03%) was recorded in case of cattle-goat combination (T1). The feed-based treatment showed highest fish production (3161.3 kg/ha), followed by cattle-duck combination (2980 kg/ha). The study revealed that the combination of Catla and cattle+duck manure was performed best in terms of production.

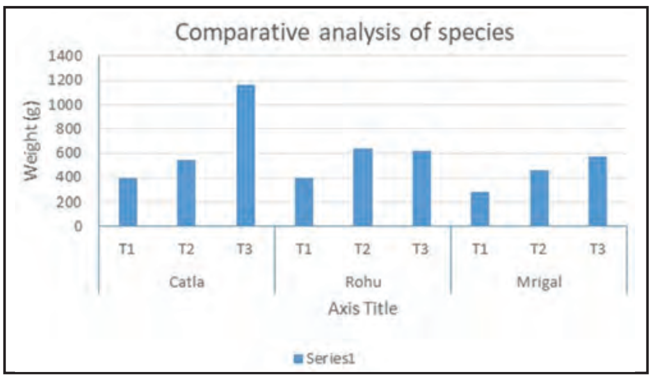


Fig. 16.5 Species-wise fish production under different treatments

Economic Feasibility of Integrated Prawn cum Fish Farming in Polyculture System in Eastern Region

An experiment on prawn in polyculture system was carried out in a 1000 m^2 earthen pond at the institute's fish farm. Prior to starting the experiment, the pond was sun-dried, then filled with water, limed (15 kg/0.1 ha), and manured using 100 kg of cow dung, rice bran (5 kg), arginine (100 mg), and DAP (0.5 kg). After 4-5 days of manuring, the plankton development was observed, and in April, fish and prawns were stocked. The stocking density of prawn was 20,000 nos/ha (0.098g) and Catla and Rohu was 250 nos/ 0.1ha (average145g). The starter feed,equivalent to 100% of the prawn's body weight, was fed until they reached a weight of 1 g, and floating feed amounting to 4% of body mass was given to Catla and Rohu. Monthly length-weight data were collected for prawn and fish health management and growth analysis. Water quality standards such as DO, pH, alkalinity, hardness, ammonia, nitrite, and phosphate were maintained within permissible limits(Fig. 16.6). At the end of the experiment (270 days), Catla, Rohu and Prawn attained weights of around1000 g, 800 g and 45g, respectively (Fig.16.7). Overall, Catla, Rohu, and Prawn produced 1980 kg/ha, 1680 kg/ha, and 688 kg/ha, respectively (Fig.16.8). Economic analysis revealed a profit of Rs. 215,104/ha in composite fish culture (without prawn), whereas it was Rs. 286,996/ha when cultured with prawn. Therefore, adding high-value fish to the polyculture system will allow an additional Rs. 71892 income (Table 16.3).

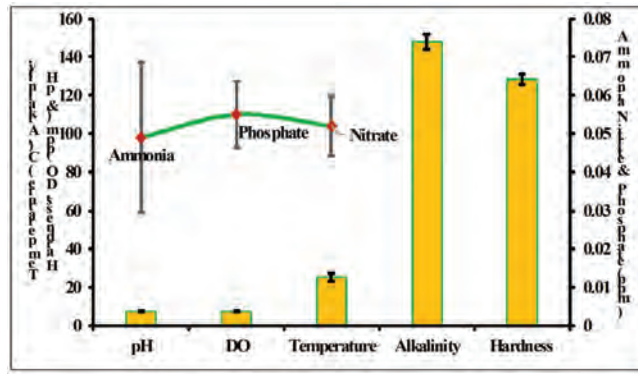


Fig. 16.6 Water quality parameters of cultured pond

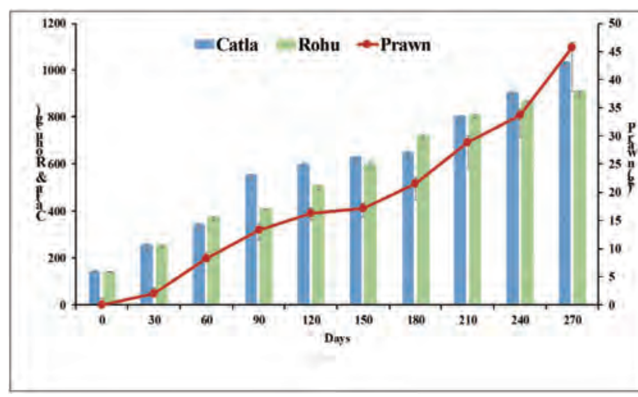


Fig. 16.7 Growth performance of Catla, Rohu and Prawn

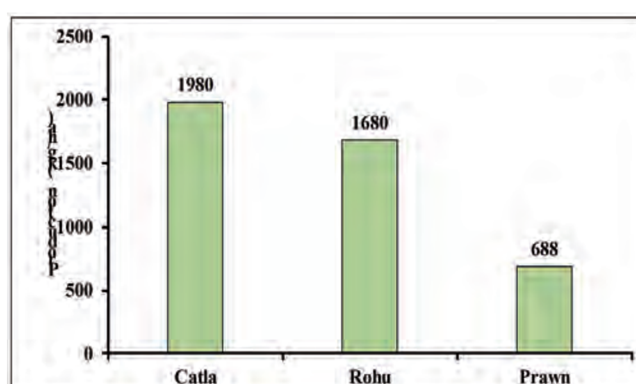


Fig. 16.8 Production of Catla, Rohu and Prawn in polyculture experiment

Table 16.3 Economics of prawn polyculture experiment for 1000 m^2 pond

Economic feasibility	Production/0.1 ha	Price/unit (Rs.)	Total Price (Rs)
Calta	198/Kg	160/Kg	31680.00
Rohu	168/Kg	160/Kg	26880.00
Prawn	68.8/Kg	400/Kg	27520.00
Gross income (Rs.)	86,080.00		
Expenditure (Rs.)	46,490.00		
Net profit/0.1 ha (Rs.)	39,590.00		
Net profit/1 ha (Rs.)	3,95,900.00		
Benefit-Cost Ratio (BCR)	1.85		

Ichthyofaunal biodiversity and biological studies of KasaraiyaDhar Maun

A total of 58 fish, 2 prawn and three mollusc species under 26 families and 14 orders were identified from the Kasraiya Dhar, with the majority species (20) belonging to Cyprinidae family. The Shannon diversity index was 3.072,3.313 and 3.498 for Monsoon, Post-monsoon and Pre-monsoon, respectively. The highest Shannon Diversity Index is associated with high number of individuals and vice-versa. Therefore, fish diversity in Kasaraiya Dhar has not declined, despite being a close type of wetland, it remains favourable for fish species. Simpson's diversity index (1-D) was highest in the Pre-monsoon (0.958), followed by Post-monsoon (0.950) and Monsoon (0.935). Pielou's Evenness Index (J') indicates the extent of the closeness of abundance of the species in an ecosystem, reflectingthe equality of numbers in a community structure. The maximum and minimum Pielou's evenness index (J') was found in the Pre-monsoon (0.894) and post-monsoon (0.875) seasons, respectively (Fig. 16.9). Based on the Bray-Curtis similarity cluster analysis, 2-D nMDS (nonmetric multidimensional scaling) plot was made to observe difference in species composition among the three seasons. nMDS analysis showed that there were significant differences in the species abundance among seasons, with the Pre-monsoon well-separated from both Monsoon and Post-monsoon at the stress of 0.1573 (Fig. 16.10). Analysis of similarity (ANOSIM) was conducted to confirm the results obtained from nMDS analysis.The results revealed significant differences in species composition among three seasons, with an ANOSOM statistic R of 0.8621 at a p-value of 1e-04.

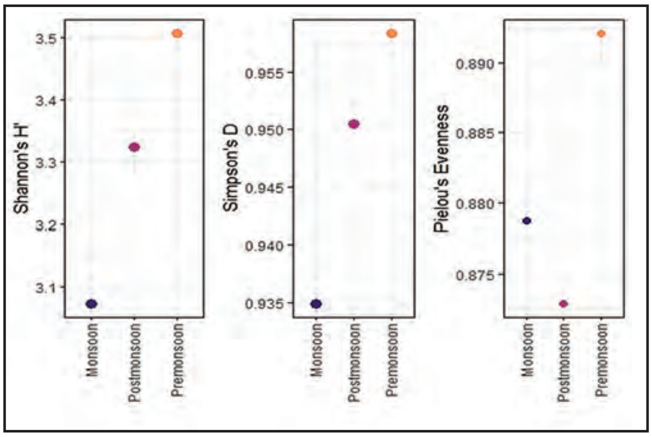


Fig. 16.9 Biodiversity index among three seasons at KasaraiyaDhar Maun

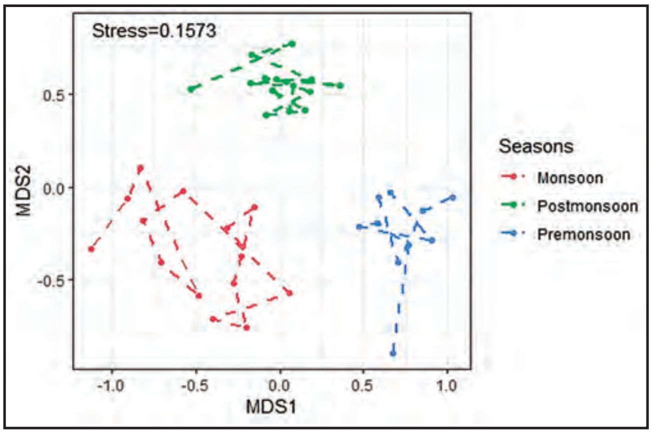


Fig. 16.10 (nMDS plot showing the grouping of species in three seasons based on species abundance in KasaraiyaDhar Maun

Biological studies of *Nandus nandus*, *Macrognathusaral*, *Mastacembalusarmatus* and *Mystus tengara of* Kasariara Dhar Maun were carried out. All four species are carnivorous and them on soon is their breeding season. The Gonado-somatic index was 6.32, 0.11, 1.68 and 1.64 for *N. nandus*, *M. Aral*, *M. armatus* and *M. tengara*, respectively. The relative fecundity (egg/ ovary weight) was estimated as 3744, 409, 1708 and 5052 for *N. nandus (*Fig. 16.11a), *M. aral*, *M. armatus* and *M. tengara (*Fig. 16.11b), respectively. The eggs of*M. armatus*were brown in color, while cream coloured eggs wereobserved in the ovary of *M. aral*

Fig. 16.11a *Nandus nandus*

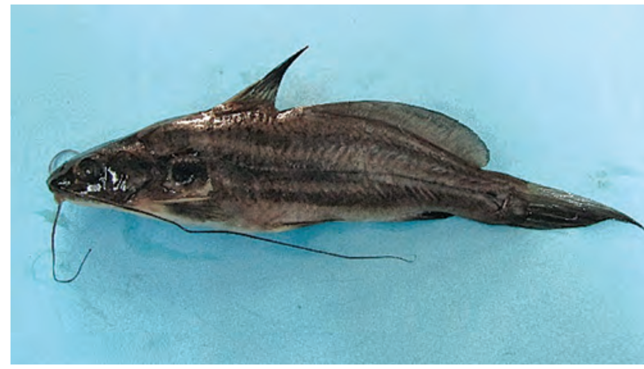


Fig. 16.11b *Mystus tengara*

Microplastics samplings and characterization from the Ganga River system

Microplastics are globally perceived as a severe problem affecting several ecological systems. Recently, much attention has been drawn to environmental issues such as land, water and public health due to microplastics. In this context, water, sediment, and fish samples were collected and analysed to assess the severity and prevalence of microplastics in different regions of the Ganga, Sone, and Punpun rivers in the eastern region (Fig. 16.12). The sediment samples collected from the Ganga River exhibited the high concentrations of microplastics, with an average of 553 particles per kilogramme. In comparison, the Punpun and Sone rivers recorded 376 and 301 particles per kilogramme, respectively (Fig. 16.13). Water sample analysis revealed that, Ganga River had an average concentration of 364 microplastics per litre, while the Sone and Punpun Rivers had concentrations of 223 and 180 microplastics per litre, respectively. Most of the microplastics were classified as films, pellets, beads, and fibres (Fig. 16.14).

Fig.16.12 Microplastic sampling from different locations and leftover plastic waste at river banks

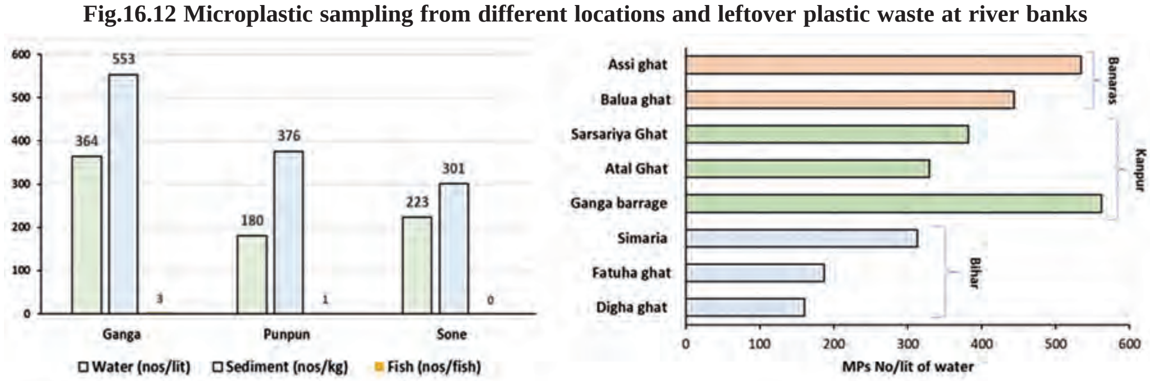


Fig.16.13 Microplastics concentration in water, sediment and fish of the Ganga river system

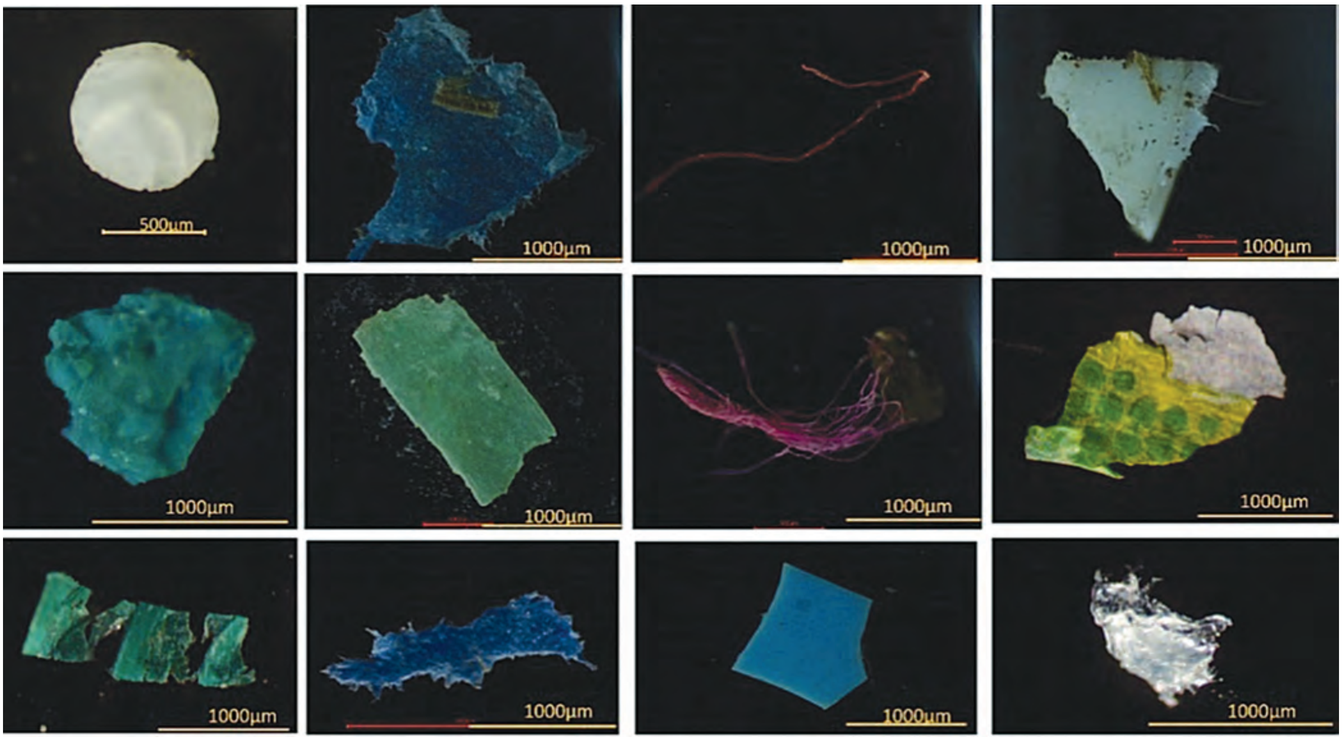


Fig. 16.14 Microscopics detected in different rivers of eastern region

Standardization of culture technique of *Ompok bimaculatus* (Pabda) for eastern India

Culture of high value fish Pabda was evaluated in the institute farm using three earthen ponds (1000 m^2). The experiment included three treatments asT1 (Polyculture)-Pabda and IMC with organic manure, T2 (Polyculture)-Pabda and IMC with commercial feed and T3 (Monoculture)-Pabda alone with commercial feed. Initially, the ponds were thoroughly sun-dried. Subsequently application of liming (10 kg/0.1ha), organic manure (10 kg/0.1ha of cow dung), and inorganic fertilizers (Urea: 300g/0.1ha and DAP: 50g/0.1ha) were done to each treatment. Carps and Pabda were stocked at 5000 and 20,000 nos/ha in polyculture (T2 & T3), respectively, while Pabda alone was stocked at 60000 no/ha in the monoculture system (T1). Feeding was carried out at 5% of body weight for the first few months and then reduced to 3% for both mono and polyculture systems (T2 & T3). The best growth performance was recorded in T1 (polyculture with organic manure), followed by T2 (polyculture with commercial feed) and T3 (pabda monoculture with commercial feed) (Fig. 16.15).

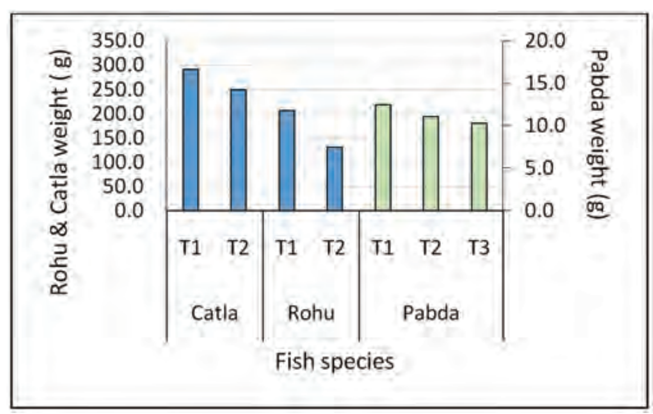


Fig. 16.15 Weight gain of fishes under different treatments

Morphology based body weight prediction algorithms for barred spiny eel (*Macrognathus pancalus*) (Hamilton, 1822)

In the present study, an attempt was made to evaluate the body weight of barred spiny eel based on morphological traits. Ten morphometric characters and five meristic counts were measured for 38 specimens, with standard length ranging from 77.8 to 149.6 mm and a weight 2.02 to 17.89 g.All the data sets were standardized using the z-transformation method. The Kaiser-Meyer-Olkin (KMO) test was performed to measure the sample adequacy level. The significance of the correlation matrix in all traits was tested with Bartlett's test of sphericity, which was found to be significant (Ç^2 = 793.360, *df* = 105, $P < 0.01$). Four of the fifteen principal components (PCs) explained around 85% of the total variation. The first principal component (PC1) contributed 57.52% of the total variation and was represented by significant positive high-loading factors for pre-dorsal (PDL), pre-anal (PAL), and standard length (SL). The second principal component (PC2) explained 10.90% of the total variation and was represented by significant positive high-loading factors for anal fin rays (AFR) and dorsal fin rays (DFR). The third and four principal components explained 9.26% and 7.41% of total variation and showed high loading factors for pectoral fin (PFR), and caudal fin rays (CFR), respectively. The estimated communalities ranged from 0.658 for eye diameter (ED) to 0.978 for pre-dorsal fin length (PDL). The species' body weight was predicted using stepwise multiple regression of interdependent morphometric traits and four extracted PCs. Stepwise multiple regression reveals that a combination of three interdependent variables such as pre-dorsal length (PDL), body depth (BD), and post-orbital length (POL), were best predictors of the body weight of species (r^2 = 93). Therefore, the study confirms that the species' body weight is the function of the three interdependent variables rather than orthogonal variables.

Reproductive parameters of the barred spiny eel *Macrognathus pancalus* (Hamilton, 1822) from river Ganga, India

Information on the reproductive parameters of fish species is a prerequisite for conservation andsustainable utilization. In this region, this species has commercial importance and fetches high market prices due to its delicious taste. Fish specimens were collected monthly from two sampling sites of Ganga River, where fish were mainly caught using traditional fishing gear. Analysis showed that the species has sexual dimorphism in body weight and size, with females were significantly longer and heavier than males. Females show positive allometric growth, whereas male exhibit isometric growth. Male attain maturity at a smaller size than females. Based on gonadosomatic index, the species has bimodal spawning periodicity with a prolonged spawning season from February to October. The hepatosomatic index has a positive correlation with the gonadosomatic index. Fecundity reveals that the species has a low fecund, which appeared to increase with fish weight (r = 0.84) rather than length (r = 0.77). The sex ratio does not statistically deviate from the hypothetical ratio of 1:1, indicating a homogeneous population. These reproductive parameters will be helpful for stock assessment models, which will eventually assist the eel fishery to be sustainable for future generations.

Principal Component Analysis of Morphological Traits in Bagridae Catfish *Mystus cavasius* (Hamilton, 1822)

Principal component analysis (PCA) was performed on eighteen morphological traits of *Mystus cavasius* to assess the phenotypic correlation among them and identify the components that construct relevant clusters of features for the characterization of the species. Trait data were recorded for sixty-six fresh specimens, withtotal lengths and total weights range from 8.89 to 18.36 cm and 4.403 to 31.943 g, respectively. The recorded data of traits were standardized using the z-transformation method. The adequacy of sampling was evaluated using Kaiser-Meyer-Olkin (KMO) test, which is found to be marvellous result of 0.947 and Bartlett's test of sphericity, which was significant ($Ç^2$ = 2255.43, df = 153, P<0.001). Phenotypic correlations among body dimensions were positive and highly significant (P<0.001, r = 0.368-0.984). The communalities of each trait are above 0.70 except for snout length (0.530) and inter orbital length (0.607). Based on the Kaiser criterion and eigenvalue (>1), two principal components (PC) were extracted, which explained about 86.263% of the total variance. The first component (PC1) explained for 78.188% of the total variance and was represented by significant positive high-loading of head length, caudal peduncle depth, and pre adipose fin length. The second component (PC2) explained 8.075% of the variance, with high loading factors of outer mandibular barbel length, inner mandibular barbel length, and maxillary barbel length, respectively.

Principal Component Analysis of Morphological Traits in Bagridae Catfish *Mystus tengara* (Hamilton, 1822)

Principal component analysis (PCA) was performed on fourteen morphological traits of *Mystus tengara* to assess the phenotypic correlation among them and identify the components that construct relevant clusters of features for the characterization of the species. Trait data were recorded for fifty-six fresh specimens; their total lengths and total weights range from 5.76 to 10.51 cm and 3.07 to 12.74 g, respectively. The recorded data of traits were standardized using the z-transformation method. The adequacy of sampling was evaluated using Kaiser-Meyer-Olkin (KMO) test, which yielded a marvellous (0.902), and Bartlett's test of sphericity is significant ($Ç^2$ = 868.639, df = 91, P<0.000). Phenotypic correlations among body dimensions were positive and highly significant (P<0.05, r = 0.293-0.929). Communalities of each trait are above 0.60 and it is found maximum for fish body weight (0.94). Based on the Kaiser criterion and eigenvalue (>1), two principal components were extracted, which explained about 76.13% of the total variance. The first component explained for 68.69% of the total variance and was represented by significant positive high-loading of fish body weight (0.889), pre ventral length (0.825), and body depth (0.816). The second component explained 7.44% of the variance, with high loading factors of nasal barbel length (0.787), outer mandibular barbel length (0.771), and inner mandibular barbel length (0.745), respectively.

Morphometric relationship of fish and sagittal otolith of few commercial important fish species from the Ganga River system

This study analysed the morphometric relationships between fish and otoliths of three economically and nutritionally significant freshwater species, namely *Jhonius coitor*, *Gudusia chopra*, and *Mystus cavasius*. A total of 297 specimens of *J. coitor*, 183 of *G. chapra*, and 205 of *M. cavasius* were collected at monthly interval from the Ganga River (Fig.16.16). An analysis was carried out on characteristics of fish and otolith, including length-weight relationships (LWRs), length frequency distribution, condition variables, and otolith aspect ratio. The LWRs of all these species showed positive allometric growth (b>3). A strong positive association was found between morphometric parameters of fish and otolith, including LWRs, length frequency distributions, condition factors, and otolith aspect ratios. The condition indices for this species showed that the environmental conditions in the Ganga rivers were extremely favourable to their survival and presence. These links are crucial for managing fisheries and can be utilised in future time series research on food, stock structure, environmental changes, and conservation initiatives.

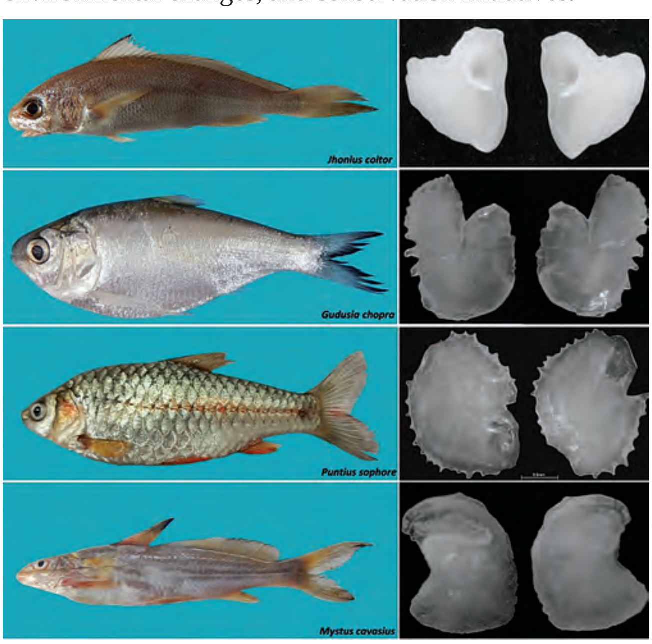


Fig. 16.16 Fish species and their otolith morphology

Performance of the *Channa striata* (striped snakehead) fry in cement tanks

Channa striata (striped snakehead) brood stock was collected from nature and maintained in the institute earthen pond (Fig. 16.17). Natural breeding was stimulated by manipulating fertilization and optimum feeding from February 2023 onwards.

Fig. 16.17 Advance fingerling of *C. striata*

During the rainy season (July) fishes were breed naturally. A total of 300 advanced fry (53.6±1.57 mm & 1.17±0.20 gm) were collected from the pond in the month of August 2023 and stocked in the cemented tanks (5 × 5 m^2). Before stocking the fish, the cement cistern were layered with about 10 cm soil bed to provide a natural environment for the fish. Water depth was maintained at about 0.5 m throughout the rearing period and slowly increased as the fishes grew. The experimental fish fries were fed daily in the morning at 5% body weight with formulated feed (20% crude protein) along with chopped chicken waste and trashed fish up to *ad-libitum* level. The monthly weight gain and mortality percentage of fish during the cultured period were recorded. Fish attained a weight of 124.36±1.94 mm (Fig. 16.18) after 132 days of rearing with 78% survival. The monthly water quality parameters like water temperature (16 – 30 °C), pH (6.35-7.5), ammonium ion (0.19-0.45 ppm), nitrite (0.04-0.11 ppm), phosphate (0.05-0.20 ppm), dissolved oxygen (7.4-8.0 ppm), alkalinity (94-232 ppm), hardness (132-284 ppm), gross primary productivity (015-0.38 gm C/L/hr) and net primary productivity (0.11-0.24 gm C/L/hr) were monitored.

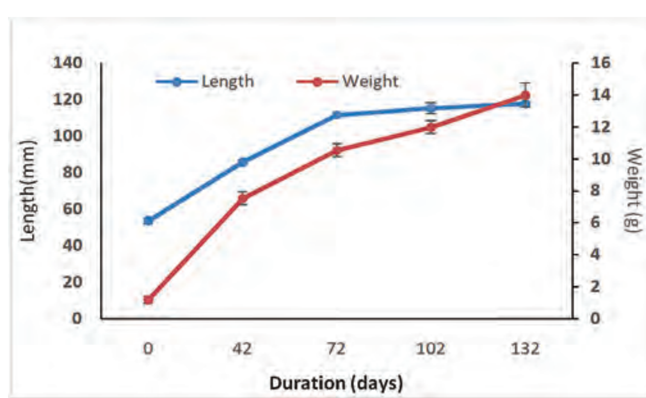


Fig. 16.18 Growth performance of *C. striata*

Rearing of potential candidate species for aquaculture

Two species of minor carp *viz.Cirrhinus reba*and *L. Calbasu* (Fig. 16.19) were collected from natural habitats and maintained in the institute ponds for production of potential breeding stock. Mixed wild Spawn of *L calbasu* was collected from the Gaighat of river Ganga. After the collection, they were stocked in a circular tank to assess the growth pattern for 150 days. Pelleted feed was provided in the morning and evening. Growth was assessed at 15 and 30 days interval. The average weight of the *L. calbasu* during stocking was 1.42±0.08g. At the end of experimental period, the final body weight, body weight gain percentage, and specific growth rate were significantly higher in *L. calbasu*. Furthermore, fingerlings of *L calbasu* (24.16±1.50 g) was cultured at four different stocking densities with a 5% feeding rate (protein level: 32%) of the total biomass. At the end of the 90-day experimental period, final body weight at 1, 2, 3, and 4 per square meter were 99.67, 87.32, 72.00, and 62.94 g, respectively (Fig. 16.20). The percentage of body weight and specific growth rate were decreased with the increasing stocking densities. Additionally, a large number of species were collected and identified from the Ganga river system as shown in Fig. 16.21.

Fig. 16.19 Growth and body weight gain of *L calbasu* under different treatments

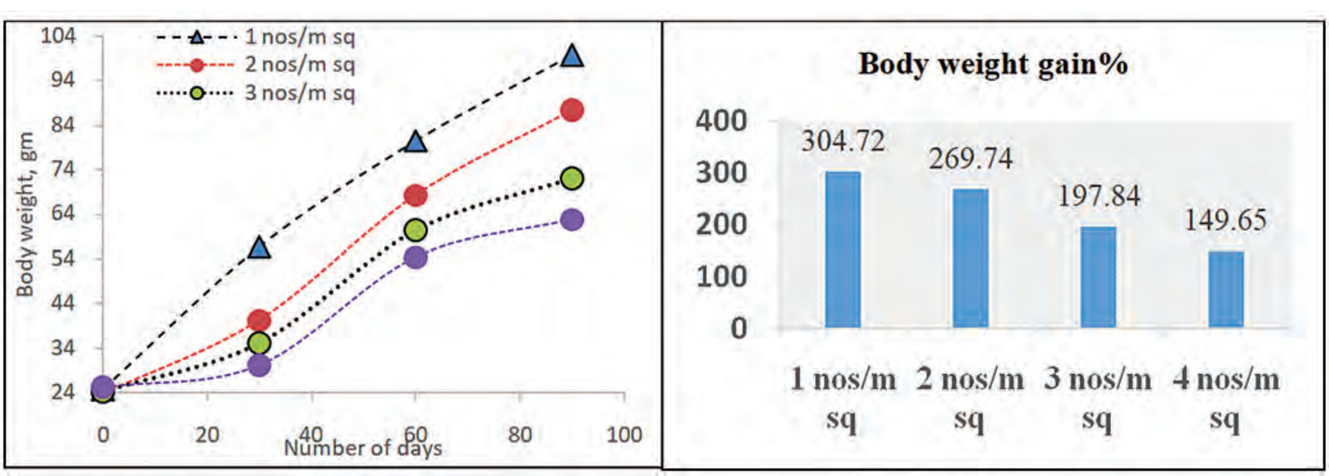


Fig. 16.20 Growth performance and body weight gain of *L. calbasu*

Fig. 16.21 Biodiversity from Ganga river system

17 Farm Mechanization

Design and development of solar operated hold-on type paddy thresher

A solar operated paddy thresher was designed and developed considering the portability and threshing requirements of medium scale farmers. The thresher was ergonomically designed so that a person with average height can operate it easily. The solar panels were placed such that it acts as a shade to the operator. Thresher is provided with a solid angle iron frame to provide the required strength and stability to the machine while in operation and is also provided with four wheels for easy mobility in fields (Fig. 17.1).

The thresher is equipped with two solar operated DC motors, one having 500 W capacity used to run the main threshing drum while the other small capacity DC motor (250W) drives the blower. The speed control of drum and blower fan was achieved through the use of potentiometric switches. The power requirement of the machine was met out using three solar panels each of 325w capacity, thus making the total panel capacity of 975Wp. Higher capacity of solar panels ensured the longer operation times from 10.00 am to 4.00 pm with total operation time of 6 h per day.

Fig. 17.1 Prototype of the solar operated paddy thresher

Performance of Solar Paddy thresher

Evaluation of paddy thresher at farmer's fields was carried out under three levels of straw and grain moisture contents (Fig. 17.2). The evaluation was done separately at different rotational drum speeds ranging from 400-800 rpm.

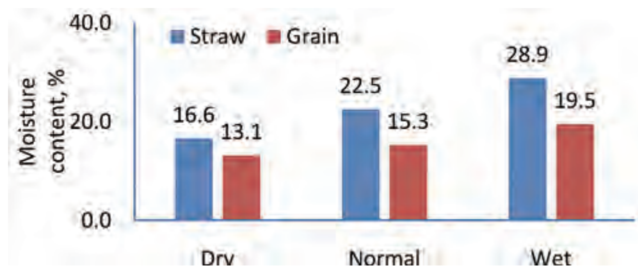
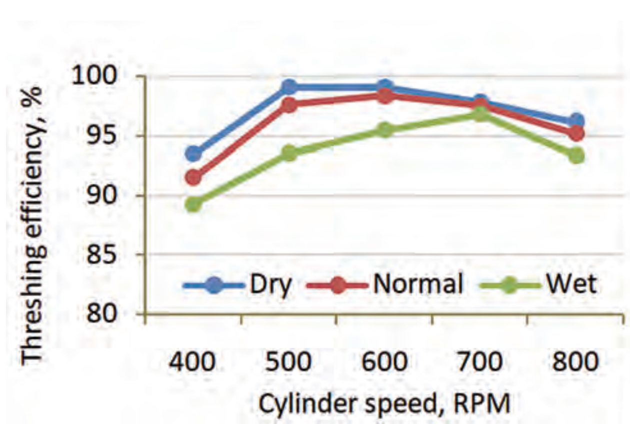
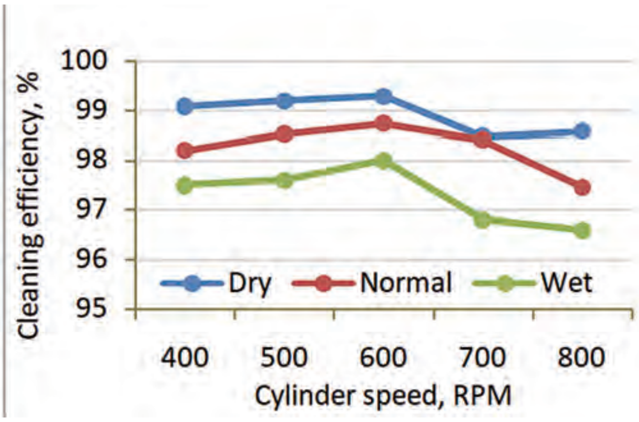


Fig. 17.2 Straw and grain moisture content under dry, normal and wet conditions of paddy straw

The threshing efficiency was maximum (99.1%) at the drum speed of 500 rpm for dry straw conditions. At relatively high straw moisture content (16-22%), the threshing efficiency was maximum (98.4 %) at 600 rpm (Fig. 17.3a). The threshing efficiency dropped at lower or higher speed of rotations and 500-600 was the optimal range to achieve higher threshing efficiencies. Under wet straw conditions, the threshing efficiency was lower at all the drum speeds. The cleaning efficiency of thresher was improved with the replacement of the centrifugal blower with axial flow fan blower. The cleaning efficiency was in the range of 98.0 to 99.0 for straw with lower moisture content (dry). At normal moisture content conditions of straw and grain, the cleaning efficiency was above 98 % for drum speeds up to 600 rpm; however, at higher drum speed the cleaning efficiency decreased under all the straw moisture levels (Fig. 17.3b).



(a) Threshing efficiency



b. Cleaning efficiency

Fig. 17.3 Threshing and cleaning efficiencies at different drum speeds

Highest machine capacity of 89.2 kg/h was obtained at drum speed of 600 rpm when the moisture content was in the normal range. At higher straw moisture levels (wet straw), the weight of the bundle was not easy to handle for the operator. Further, existence of stronger bond between grain and its pedicel, the time required to thresh a bundle was very long. Both these conditions led to reduced capacity of the machine. At 600 rpm, the machine capacity under wet, normal and dry straw conditions was 63.9, 80.2 and 89.2 kg/h (Fig. 17.4), respectively. The optimal range of threshing drum speed was worked out to 550 to 600 rpm.

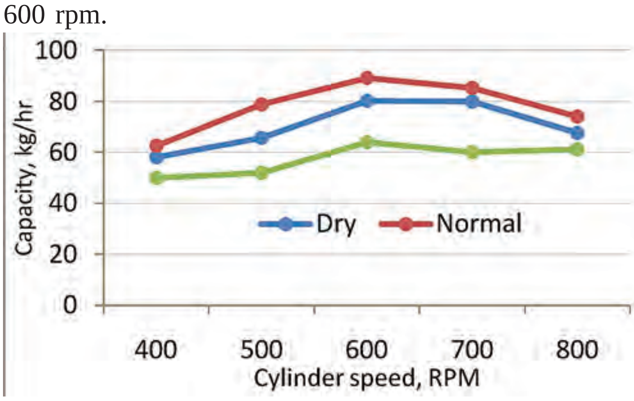


Fig. 17.4 Machine capacity at different drum speeds

The developed paddy thresher having capacity of 5-6 q/day is very effective in threshing and cleaning of paddy. The portable thresher can relive drudgery involved in manual paddy threshing with the use of clean and eco-friendly energy.

Design and development of Solar operated hybrid insect trap

A solar operated hybrid insect trap was designed and developed which operates on dual principle of insect attraction. It uses combined effect of pheromone and light for attracting flying insects. The tapping of insects is based on the principle flight interruption and impact injury. The flight of the insect attracting towards the trap gets interrupted by the transparent baffles (three panels placed at 120 degree) placed vertically partitioning each light bulb (Fig. 17.5). The insects get injured by the collision with these baffles and fall in the collecting hopper below. The injured insects sliding down the hopper gets drowned in the soap solution kept below the collecting hopper. The trap is provided with telescopic height adjustment system to increase or decrease the height of the trap as per the crop height. The trap is provided with three LED lights to develop the sufficient light to attract insects from a distance of 40-50 m. Therefore, 4-5 traps per hectare are sufficient to make effective insect catch. The trap is equipped with a 10A 12 V charge controller to avoid the overcharging of the battery and stabilize the voltage output. Trap uses a light sensor to make or break the electric circuit as per the set light intensity which puts the lights ON during dusk time and switches it OFF during dawn time. The 30Wp solar panel size was selected so that it can meet the charging requirement of the 15Ah battery in six working hours.

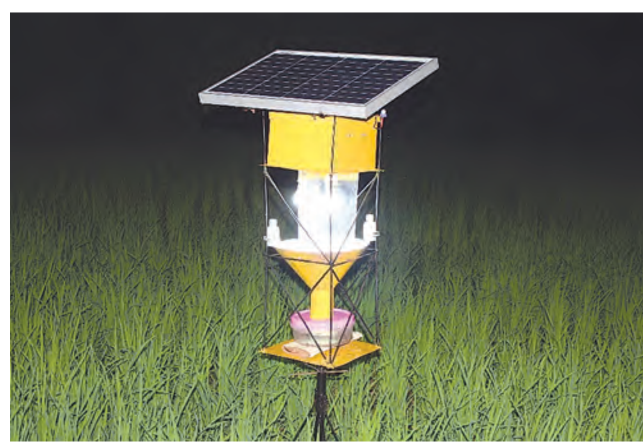


Fig.17.5 Modified insect light trap with pheromone and transparent baffles

Performance of Solar Operated hybrid insect trap

The traps were evaluated at different maturity stages of paddy (grain filling stage), tomato (early fruiting stage), litchi (Non fruiting season October), brinjal (late fruiting stage). The trap was installed in the crop fields during the flowering stages of the crops, as this was the period of increased insect activity. The traps were placed at 50 m apart to avoid the interference of lights (Fig. 17.6). The traps automatically switched 'ON' on complete dark and switch 'OFF' at the dawn time.

Fig. 17.6 Evaluation of the trap in field

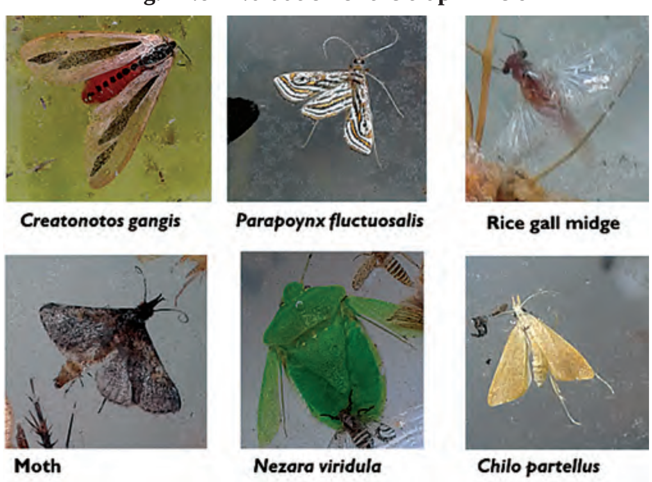


Fig. 17.7 Different types of insects trapped in the paddy fields

The solar operated insect trap woks effectively over wide range of species in different crops. In case of litchi, it was observed that the trap could effectively attract about 5 numbers of major insects of litchi. Similarly, in case of paddy, tomato and brinjal, a total of 14, 12 and 7 types of insect species were effectively trapped by the solar light trap (Fig.17.7). The sensor based solar insect trap is very effective in catching wide range of insect species over wide range of fruit, vegetable and grain crops. The eco-friendly trap has potential to reduce chemical use in agricultural production systems.

Energy use pattern and greenhouse gas emission of winter vegetables: insights from Chhotanagpur Plateau region, India.

The study investigated energy use efficiency (EUE) and greenhouse gas (GHG) emissions for winter vegetable production in India's Chhotanagpur Plateau region, focusing on garden peas and potatoes. Data from vegetable growers revealed that garden peas required 6564.29 MJ/ha, primarily from human energy (25.56%), farmyard manure (21.33%), seed (20.15%) and diesel (12.22%). For potatoes, the energy requirement was 40,282.29 MJ/ha, with fertilizer (42.30%), chemicals (24.43%), and seed (16.98%) major contributors. EUE was 9.80 for garden peas and 1.11 for potatoes. GHG emissions were 718.32 and 369.69 kg CO_2 eq./ha for garden peas and potatoes, respectively. Promoting small farm machinery and optimizing resource management could enhance energy efficiency and reduce GHG emissions. Sustainable farming practices are crucial for mitigating energy use and GHG emissions in the region's vegetable production, urging further research for effective strategies.

Energy input–output analysis and greenhouse gas emission in okra and tomato production in Chhotanagpur plateau region of India

The information on greenhouse gas (GHG) emission and energy use patterns from vegetable production in the Chhotanagpur plateau region of Jharkhand state is minimal. The study analyzed the energy input–output and GHG emission and their relationship with the productivity of two critical vegetables grown in the region, viz. summer season okra and tomato. In this regard, data were collected from 30 vegetable farmers of the region in a pretested questionnaire through personal interviews. The results showed that the overall energy input used in the okra production was 8828.71 MJ ha^{-1} of which human energy (27.62%), petrol (27.31%), farmyard manure (13.59%), and animal energy (13.22%) contributed the primary inputs. The total energy required for tomato production was 4798.66 MJ ha^{-1}, where petrol (25.13%) contributed the highest, followed by fertilizer (16.94%), diesel (14.67%), electricity (12.06%), farmyard manure (12.03%), and human energy (11.65%), respectively. The energy ratio (energy output to energy input) for okra and tomato was estimated at 2.85 and 7.58, respectively. The benefit cost ratios for tomato and okra production were 7.87 and 1.71, respectively showing that the cultivation of both the vegetables is remunerative in the region, with tomato being more remunerative than okra. The total GHG emission was 875.41 and 322.75 kg CO_2eq. ha^{-1} for okra and tomato, respectively. The economical use of inputs could help reduce GHG emissions in vegetable production.

18 Socio-economic Studies and Transfer of Technology

Climate Resilient Agriculture Programme (CRA Programme)

The CRA Programme funded by Government of Bihar is being implemented by ICAR RCER, Patna along with Bihar Agricultural University (BAU), Sabour; Dr. Rajendra Prasad Central Agricultural University (RPCAU), Samastipur and Borlaug Institute of South Asia (BISA), Samastipur. Five villages each in Gaya (Rasalpur - Manpur, Rasalpur Nagar, Rupaspur, Takeya and Rahimbigha) and Buxar (Harikisanpur, Dalsagar, Churamanpur, Ramobariya and Balapur) district has been chosen for implementation of project activities. A total of 2938 acres area were covered for technological demonstrations at farmers' field during 2023-24. Out of this, 1468 acres were at Gaya and 1470 acres were at Buxar. Both districts have achieved the target area during *Summer*-2023, *Kharif*-2023 and *Rabi*-2023-24 (Table 18.1). A total of 2885 beneficiaries benefited from this programme which comprised 1477 and 1408 farmers from Gaya and Buxar, respectively.

Table 18.1. Area coverage and beneficiaries under CRA Programme during 2023-24.

Seasons	Area covered (Acre)			No of beneficiaries		
	Gaya	Buxar	Total	Gaya	Buxar	Total
Summer - 2023	250	250	500	256	261	517
Kharif - 2023	595	595	1190	567	418	985
Rabi - 2023-24	623	625	1248	654	729	1383
Total	**1468**	**1470**	**2938**	**1477**	**1408**	**2885**

Evaluation of crop productivity under CRA interventions

All CRA interventions found to increase the crop productivity in both districts when compared to non CRA villages. During *kharif* season, Direct Seeded Rice (Var. Rajendra Sweta) gave 18 and 8.7% increased yield over conventional farming in Buxar and Gaya, respectively (Fig. 18.1 & 18.2). The yield level of paddy in Buxar (53.40 q/ha) was higher as compared to Gaya (44.17q/ha). Raised bed Maize (DMRH 1301), introduced as one of the CRA interventions, had achieved 19.48 and 17.6% higher grain yield over flatbed method and profitability of Rs 83,889 and Rs 76,580/ha, which were 19.32 and 23.02% higher over traditional farming in Buxar and Gaya respectively (Fig. 18.1 & 18.2).

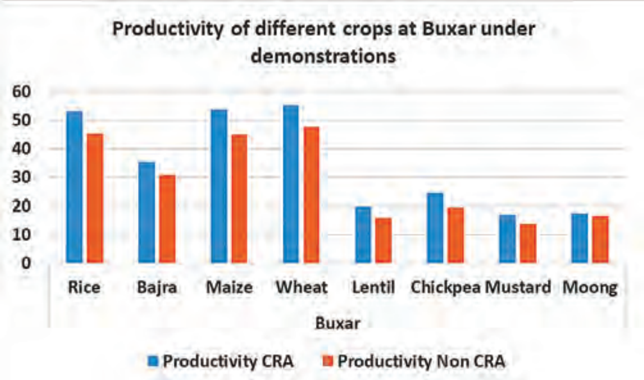


Fig 18.1 Productivity under CRA interventions at Buxar

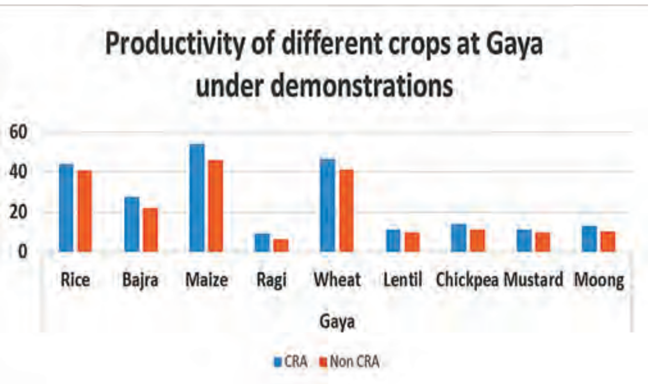


Fig 18.2 Productivity under CRA interventions at Gaya

Millets are important for diversification of existing cropping system. Bajra found a great choice among the farming communities, as this crop can thrive well in drought conditions also acting as fodder for animals. Line sowing of Bajra (Var. NU 7799, PHB 13) had received very good yield of 35.4 and 27.24 q/ha in Buxar and Gaya, which were 15.45 and 21.4% higher over conventional broadcasting cultivation. Line sowing Ragi (Ragi 376) was also introduced in Gaya, where it recorded 9.23 q/ha grain yield. The demonstration of Line sowing bajra had increase of profitability to the extent of 32.53 and 26.15% over broadcasting method (Fig. 18.3 & 18.4).

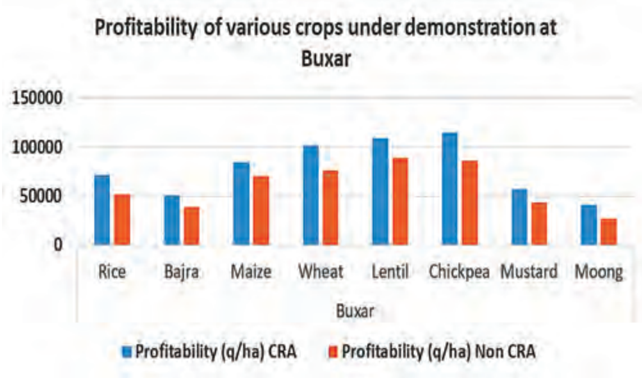


Fig. 18.3 Profitability under CRA interventions at Buxar

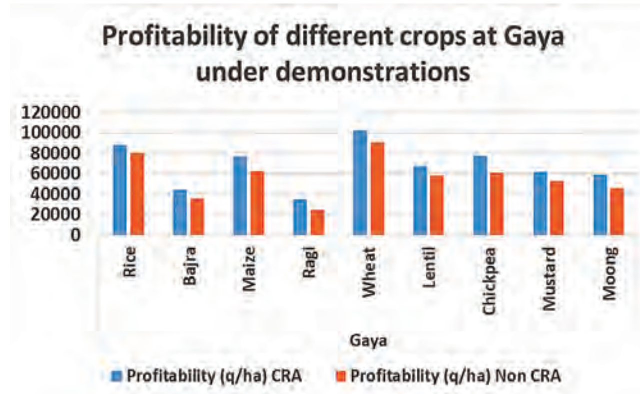


Fig. 18.4 Profitability under CRA interventions at Gaya

Zero tillage (ZT) in *rabi* crops (wheat, lentil, chickpea and mustard) gained more popularity, due to low fuel, less labour consumption and saving of time as well as money. Zero tillage wheat (var. HD 2967) obtained 55.35 and 46.7 q/ha of grain yield which were 15.86 and 13.3% higher over traditional broadcasting method. Likewise, the grain yield of lentil (IPL 220) chickpea (Pusa 3043) and mustard (PM 30) under ZT demonstration were 15-26% higher over conventional broadcasting method. ZT summer moong (Samrat, IPM 2-14) were harvested with grain yield of 17.25 and 13.27 q/ha in Buxar and Gaya, those were 4.92 and 26.7% higher over local methods, respectively. Among the interventions of rice, direct seeded rice was found slightly higher productivity over un-puddled transplanting and alternate wetting and drying system. In wheat, sowing under ZT gave 31% higher yield as compared to happy seeder. Results indicated that zero tillage wheat had increased the profitability by 34.34 and 13.21% in Buxar and Gaya with net return of Rs 101667 and Rs 102,740/ha, respectively.

Under crop diversification during 2023, the mean area coverage by other field crops (other than rice and wheat) at non CRA villages compared to CRA villages were 10, 12.5, 17, 13, 18 and 30% in RB maize, RB Bajra, ZT chickpea, ZT lentil, ZT mustard and ZT moong, respectively. This shows nearby farmers were taking interest to introduce CRA interventions in their fields. As far as the best cropping pattern is concerned rice-wheat-moong was best combinations both in Buxar and Gaya. Highest profitability was recorded under rice-wheat-moong cropping system i.e. Rs 210,236 and Rs 135,172/ha in Buxar and Gaya district respectively.

Capacity building on climate resilient agriculture

Capacity building is a crucial part of CRA programme. A total of 3121 and 3260 beneficiaries participated under various capacity building programs in Gaya and Buxar (Fig. 18.5). This included 3910, 1217 and 1254 beneficiaries under training programs, field days and exposure visits respectively. A total of 80 training program, 16 field days and 18 exposure visits were conducted at both locations. Out of total participants, 11% in Gaya and 19% in Buxar were female. Moreover, 46 quintals of biochar and 34 tonnes of straw bales were also produced. Custom hiring centers were developed in both KVKs with a total income of generation of Rs 212110/- during the year 2023.

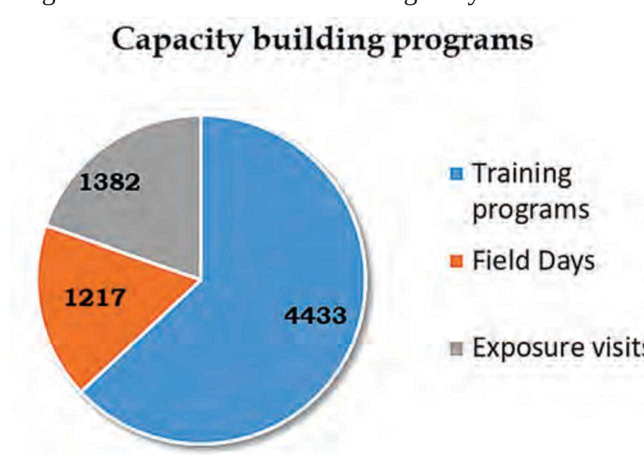


Fig 18.5 Capacity building activities organized under CRA

Impact of e-NAM on Improving Marketing of Agricultural Produce in Eastern India

Electronic National Agricultural Market (e-NAM) scheme has been operational in the country since April, 2016 and the journey have several milestones. During the year 2023-

24, the study was conducted in Jharkhand state. Data was collected from stakeholders for two e-NAM - APMC mandi i.e Ranchi and Hazaribagh. Meeting and Discussion with Mandi Secretary, traders was done to find out major issues in implementation of scheme in Jharkhand.

Farmers' registration on e-NAM platform: In terms of number of farmers registration on e-NAM platform in different districts of Jharkhand, Pakur district ranked first with 34,000 farmers registered contributing 13.2% of total farmers registered in Jharkhand. It was closely followed by Hazaribagh district having almost 29,000 farmers registered with contribution of 11.2%. Dhanbad (8.9%), Garhwa (6.45%), Ranchi (6.18%) and Giridih (6.11%)

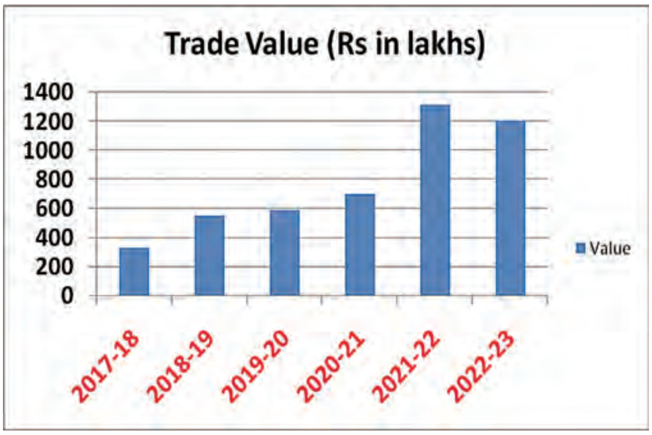


Fig.18.6 Yearwise value of e-NAM trade in Jharkhand

It was observed that among all, Hazaribagh topped in e-NAM trade contributing 35% of total trade in Jharkhand. Deoghar was second highest contributor in e-NAM trade in the state with 15.45% share in total trade. Among many districts, Ranchi and Hazaribagh are performing well in e-

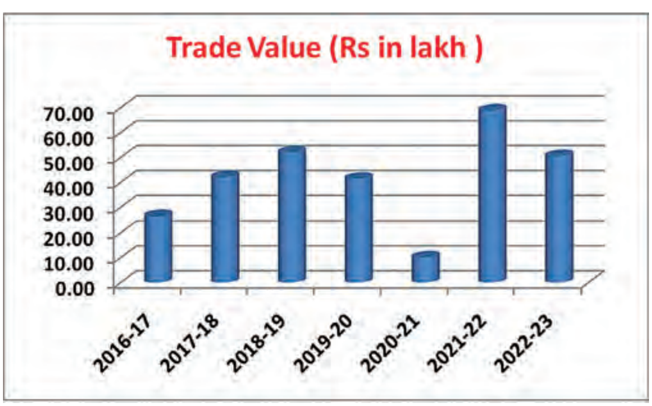


Fig. 18.8 Trade value of e-NAM trade in Ranchi

Among cereals, paddy, wheat, maize and ragi were the most traded commodity on e-NAM platform in Jharkhand. Paddy was the highest traded commodity with 65,555 quintals worth Rs 1035.8 lakhs followed by wheat with 40,696 quintals trade worth Rs. 784.8 lakh. Among

were other important districts contributing to farmers registration on e-NAM with 15 to 23 thousand farmers registration.

Trends in e-NAM trade :Volume of e-NAM trade in terms of Rs in lakhs was studied for whole Jharkhand from 2017-18 to 2022-23 and depicted in Fig. 18.6. Since its inception in April, 2016; electronic trade through e-NAM has increased continuously from Rs 332 lakh in 2017-18 to Rs 1,315 lakh in the year 2021-22. During year 2022-23, slight decrease in trade was observed. District wise volume of proportionate share in trade was also studied since beginning of e-NAM and top five districts can be seen in Fig. 18.7.

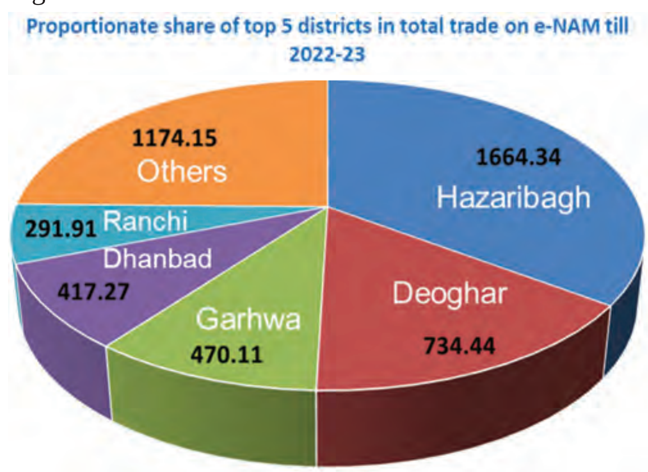


Fig. 18.7 Top districts in e-NAM trade in Jharkhand

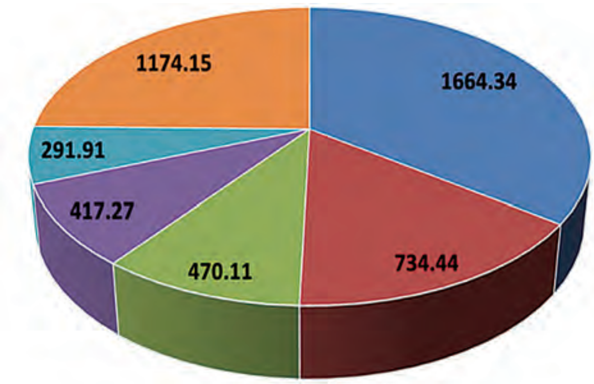
NAM and trade through e-NAM. It was observed that a total of 15,600 quintals of produce was sold at Ranchi APMC worth Rs 292 lakhs till March, 2023. In Hazaribagh, a total of 95000 quintals of produce was sold worth Rs 1665 lakhs till March, 2023 (Fig.18.8 & 18.9)

Fig. 18.9 Trade value of e-NAM trade in Hazaribagh

vegetables, potato topped the list with trade quantity of 2,3577 quintals followed by tomato, brinjal and onion. Banana and watermelon were most preferred fruits traded through e-NAM platform by farmers of Jharkhand.

Model based inference on agricultural crops for food security in Eastern India

Rice yield growth estimation using nonlinear model



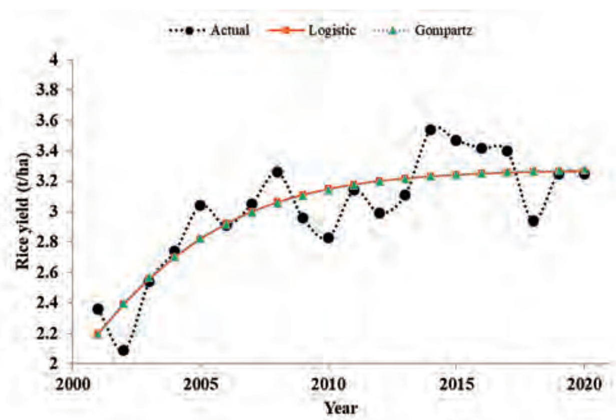


Fig. 18.10 Actual and estimated rice yield (t/ha) prediction of Malda, West Bengal, India

yield by logistic, Gompertz and monomolecular growth model (Fig. 18.10) found that yield is much closer to the actual yield as estimated by both the Gompertz and logistic model in comparison to monomolecular model. It was observed that the yield growth rate will increase in the future but slow rate as depicted by the logistic and Gompertz model. The ten years ahead yield forecast is presented by logistic and Gompertz model for the period 2021 to 2030. The land use cover and land use pattern of Malda district using open source QGIS 3.12 software revealed total geographical area, 2920.30 km^2 under crop land, 7.20 km^2 under forest, 257.80 km^2 under orchard, 133.60 km^2 under river, 365.10 km^2 under rural settlement, 38.50 km^2 under urban settlement, 7.90 km^2 under water bodies and 2.60 km^2 is under swamp (Fig. 18.11).

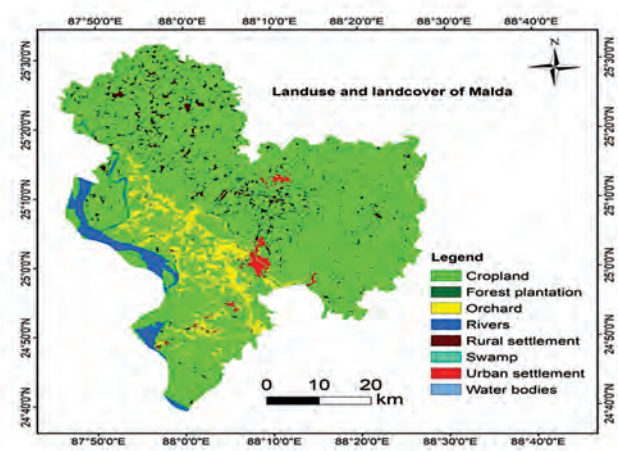


Fig.18.11 Land use and land cover of Maldah district, West Bengal

Resource Inventorization in Flood Plain Wetlands in Eastern India

The survey was conducted in five villages *viz.*, Habibpur, Oltara, Manglapura, Maivita and Rajdal of Habibpur block of Malda district in West Bengal (Fig. 18.12). Randomly 97 farmers were surveyed using interview schedule. The farmers (average age 43 years) were dominated by schedule caste (45%) followed by schedule tribes (42%) and 8% other backward caste, and only 5% belongs to general category. Around 28% farmers were connected to agricultural officials or farmers producers' organisation. Agriculture was primary occupation for all the farmers. Their average size of land holdings was 0.62 hectare and maximum size of land holding was 2.1 hectare. Average agricultural income was Rs 27,380 per hectare/year and average total annual income was found to Rs 118,441. The average rice productivity was 3.91t /ha. The maximum rice yield was observed to be 5.12 t/ha while minimum was observed as 3.0 t/ha. The variation in rice productivity among the surveyed farmers was found to be 0.72t/ha. The rice-mustard / maize/vegetables is the major cropping pattern in the area. The differences in rice productivity observed due to crop management practices by the farmers. Traditional rice cultivars have been replaced by some new varieties. Farmers grow rice varieties like, Swarna, MTU1010 and other varieties like BB11, Gaurab, Niranjan, etc. in the medium lands of surveyed area. Swarna is the most widely grown variety in medium lowland. In deep low-lying flood prone areas, farmers are growing traditional rice varieties. Annual income from vegetables is observed to be Rs 25,000- 28,000/ha. Around 85% population rear livestock. The annual income from livestock is around Rs 18, 000/ -. The annual expenditure per family is around Rs, 85,000-

Fig. 18.12 Farmers scientist interaction during field visit in Habibpur, Malda, West Bengal

Agri-Business Incubation Centre

The ABI centre of ICAR-Research Complex for Eastern Region, Patna has two operational units located at Patna and Ranchi. ABI centre is actively working to create favourable ecosystem for start-ups and to facilitate entrepreneurship development in different sectors of agriculture. Major focus of the ABI centre is to support operations on business projects as a measure of enhancing the foundation for new technology-based industries. The center is providing technology backstopping and capacity building on the aspects of capital raising, entrepreneurial setup, inventory and human resource management, collaborations, production, packages, marketing and market led extension of the products. During 2023, a total of 5 incubatees were admitted to ABI as mentioned in Table 18.2.

Table 18.2 Incubatees admitted to ABI center during 2023

S. No.	Incubatee Name	Address	Area specification	Date of MoA
1	Mrs. Albina Ekka	Vill- Kharsidag, Namkum Ranchi, Jharkhand	Value Addition in Agricultural Products.	26.12.2023
2	Mr. Bishun Murmu	Mr. Bishun Murmu, Vill-Sarwaha, P.O-Charhi, Hazaribagh, Jharkhand	Nursery Production in Polyhouse	20.12.2023
3	M/s Phal Udyog Nursery	Mr. Shrawan Kumar Gupta, Aara, P.O- Mahilong, Tatisilway, Ranchi	Vermicomposting and Nursery Production	19.12.2023
4	Aahaarsetu Techonolgy Pvt. Ltd	Amit Prakash & Kumari Lovely, Digha, Dinapur Cum Khagaul, Patna	Geo-tagging of poultry birds	03.10.2023
5	M/s Homekhet Agritech Pvt. Ltd	Seemab Ahmed, Chandwara, Muzaffarpur, Bihar	Modular Farming (Mushroom, Fishery, Livestock)	15.09.2022

Farming to Entrepreneurships: Success stories

Albina Agri and Ayurvedic Products

Residing in suburban village of Ranchi, Ms Albina Ekka, a tribal farmer, used to earn her livelihood from minimal farm land that she and her husband used to cultivate. Struggling to meet the ends, she started an ITK based ayurvedic formulation medicinal oil to nearby villages. Due to her engagements with our center, she came to know about ABI and became an incubatee of the ABI center. With her linkage to ABI center, she developed the skills and insights to run a business. The center assisted her to get a brand name 'Epil Ranu Sunum' which has recently been renamed as 'Albina Agri & Ayurvedic Products'. Starting from scratch, she out scaled her small-scale medicinal oil production activities in to a successful start-up. She has diversified product portfolio which include LED bulbs, mushroom, digestive medicines, pain relievers, hair oils etc. She has set an example of successful entrepreneurship in the village and others are willing to follow the suit (Fig. 18.13 & 18.14).

Fig. 18.13 Ms Albina Ekka showcasing her products to Dr Himanshu Pathak, Secretary DARE & DG ICAR, New Delhi at ICAR NISA, Ranchi

Fig 18.14 Ms Albina Ekka interacting with Hon'ble Governor of Jharkhand and ICAR Dignitaries during Farmers Fair at Ranchi

Homekhet Agritech Pvt. Ltd.

A young entrepreneur Mr Seemab Ahmed from Muzaffarpur, Bihar became incubatee of ABI center with an innovative idea of 'Modular Farming' for urban areas (Fig.18.15). With the assistance of ABI center, he has now developed the insights into the concept of modular farming and registered his start-up as 'Homekhet Agitech Pvt. Ltd'. His start-up received a 'Start up India certificate' from Dept. for Promotion of Industry and Internal Trade, Ministry of Commerce & Industry, Govt of India (Fig.18.16). He assembled his prototype of Modular Farming at ICAR RCER, Patna and planning to produce it on a commercial scale.

Fig.18.15 Prototype of Modular Farming at ICAR RCER, Patna

CERTIFICATE NO:
DIPP115904

#startupindia

CERTIFICATE OF RECOGNITION

This is to certify that Homekhet Agritech Private Limited incorporated as a Private Limited Company on 10-02-2022, is recognized as a startup by the Department for Promotion of Industry and Internal Trade. The startup is working in 'Agriculture' Industry and 'Agri-Tech' sector as self-certified by them.

06-12-2022
DATE OF ISSUE

09-02-2032
VALID UPTO

Fig.18.16 Recognition from Ministry of Commerce & Industry, Govt of India

Activities under SCSP project

The institute is undertaking a flagship SCSP program to improve the livelihood of the SC farmers. It aims at providing the need based infrastructural and knowledge support to SC communities of the region for livelihood upliftment and to address the emerging problems of the farmers to provide better return. Under this project, battery

Fig. 18.17 Kisan Gosthi and input distribution under SCSP at Ranchi

operated sprayers were distributed to 06 SC farmers of Dhara, Kalyanpur, Chani, Lawalong and Kadeh in Lawalong block of Chatara. A Kisan Goshti (Fig. 18.17) was also organised under the SCSP program of AICRP on Vegetable crops. In this program, the seeds of improved varieties of bitter gourd, chilli, Amaranthus, tomato and cucumber were distributed to 20 farmers of Baru village in Tamad block of Ranchi district.

IP Management and Technology Commercialization

Patents filed

The institute has developed three innovative technologies. Two of these technologies pertain to solar operated farm machines and one deals with development of biodegradable pot preparation using paddy straw. The institute has successfully filed the patents with Indian Patent Office (IPO) as per the following details (Table 18.3).

Table 18.3 Details of the patents filed during 2023

Name of Innovation	Patent application No.	Date of Filing/ Registration
Solar operated hold-on type paddy thresher- winnower	TEMP/E-1/43773/2023-DEL	03.06.2023
Hybrid solar light- Pheromone insect trap	TEMP/E-1/39843/2023-DEL	18.05.2023
Eco-friendly biodegradable plantable pot	2023310610868 A	11.09.2023

Varieties identified for release and notification

Three vegetable varieties developed at Ranchi center of the institute have been identified for release and notification during the 30th meeting of Central Sub-Committee on Crop Standards, Notification and Release of varieties for Horticultural Crops held on 21.02.2023 (Fig. 18.18 a,b,c).

SWARNA PRAKASH (Tomato)

- Swarna Prakash (RCDT-1314) when tested at different farmers' fields of Jharkhand proved its worthiness because of its bacterial wilt resistance (88.5% plant survival) and attractive fruits (Fig. 18.18.a)
- Vigorous growth, determinate growth habit, plant height (75-80 cm), TSS-3.0-3.8^{0}brix, Acidity (%)- 0.18-0.20, Ascorbic acid (10-15mg/100g fruit), slightly flattened fruits with attractive dark red colour at maturity and high yielding (45-50t/ha).
- Flowering starts in 25-30 days after planting.

Fig. 18.18.a Swarna Prakash

SWARNA APURVA (Chilli)

- Swarna Apurva (HC-70) is resistant to bacterial wilt (87% plant survival) and fruits are highly pungent (Total SHU 90194, Capsaicinoids 0.56g/100g dry weight) at green chilli stage (Fig. 18.18.b).
- Vigorous growth, high yielding (20-25 t/ha) and green pendulous fruits having good source of vitamin A (246.94 mg/100g dry weight) & vitamin C (135.2mg/100g fresh weight)
- Flowering starts in 35-40 days after planting.

Fig. 18.18.b Swarna Apurva

SWARNA AROHI (Chilli)

- Swarna Arohi (HC-69) is resistant to bacterial wilt (89.5% plant survival) and has highly pungent fruits (Total SHU 50431, Capsaicinoids 0.31g/100g dry weight) at green chilli stage (Fig. 18.18.c).
- Vigorous growth, high yielding (20-22 t/ha) and dark green upright fruits having good source of vitamin A (211.87 mg/100g dry weight) & vitamin C (112.5mg/100g fresh weight)
- Flowering starts in 35-40 days after planting.

Fig. 18.18.c Swarna Arohi

In addition to that two vegetable varities namely Swarna Vasundhra (veg. soyabean) and Swarna Tripti (field pea) were submitted for registration (Table 18.4).

Table 18.4 Registration of varieties

Registration No.	Name of Innovation/Technology/ Product/ Variety	Date of Filing/ Registration	Application Granted/ Registered**
REG/2017/1389	Swarna Vasundhra (Vegetable Soyabean)	07.12.2020	Annual fees submitted on 19.10.2023
REG/2016/942	Swarna Tripti (Field Pea)	10.10.2019	Renewal fees and Annual fees submitted on 19.10.2023

Commercialization of technology

The institute is actively involved in technology commercialization. For this purpose, some MoUs have been signed with scientific and academic organizations which are listed below (Table 18.5).

Table 18.5 Memorandum of Understanding (MoU) signed

Name of Technology/Know-How/ServiceProvided	Name of ContractingParty	Date of Signing MoU
MoU for development of academic link of CIMP in the field of science and education that are related to agriculture	Chandragupt Institute of Management Patna (CIMP), Mithapur Institutional Area, Patna	16.01.2023
Collaboration for promotion of students training and quality Postgraduate research.	Jharkhand Rai University, Ranchi	07.08.2023
Entrepreneurship development in agriculture	a-IDEA, Centre for Agri-Innovation, ICAR-NAARM, Hyderabad (Fig.18.19)	23.08.2023

Fig. 18.19 Signing of MoU with a-idea, ICAR-NAARM

‘ Several Material Transfer Agreement (MTA) has also been signed for research and development purpose which is given below (Table 18.6).

Table 18.6 Material Transfer Agreement with other organizations

S. No.	Name of Technology/ Know-How	Name of Contracting Party	Date of Licensing
1	Germplasm Swama Yamini (Bitter gourd)	Dr. Prasanth K, College of Agriculture, Kerala Agricultural University, Vellanikara	27.08.2023
2	Germplasm Swarna Sawani, S. Manjari (Ridge gourd), S. Prabha (Sponge gourd), S. Yamini (Bitter gourd), S. Sneha (Bottle gourd), S. Amrit (Pumpkin), S. Kanchan (Tomato), S. Shyamali, S. Pratibha (Brinjal)	Dr. Mangaldeep Sarkar, Hill Millet Research Station, Navsari Agriculture University,Waghai	02.06.2023
3	Germplasm (One variety and 6 germplasm of Bitter gourd)	Nalanda College of Horticulture, Noorsarai, Nalanda	27.05.2023
4	Germplasm of S. Shree,S. Mani, S. Shyamali, S. Prathibha, S. Shobha, S. Abhilamb, S. Shakthi, S. Mohit, S. Ajay, S. Neelima (Brinjal)	Dr. YSRHU College of Horticulture, Anantharajupeta	17.04.2023

Technology Certification by ICAR

During 2023, ICAR, New Delhi started to certify institute technologies following standard procedure of application and evaluation. The selected technologies were certified under concerned subject matter division. ICAR RCER also applied for technology certification under different categories and a total of 13 technologies were certified by the council during year 2023. Following is the list of certified ICAR RCER technologies (Table 18.7).

Table 18.7 List of ICAR RCER technologies certified by ICAR, New Delhi during year 2023

S. N.	Title of technology	Lead Developer
1.	Solar Irrigation Pump Sizing Tool	Dr. Santosh S Mali
2.	Integrated Farming Systems for different ecologies of Eastern India	Dr. Sanjeev Kumar
3.	Multitier cropping system for rainfed uplands of Eastern India	Dr. M.K. Dhakar
4.	Sustainable intensification of rice-wheat cropping system with summer greengram using resource conservation technologies in Eastern India	Dr. Rakesh Kumar
5.	Carbon stock quantification models for important fruit trees of Eastern India	Dr. S K Naik
6.	Modified drip fertigation technology for vegetable production in Eastern India	Dr. B K Jha
7.	Innovative Millet-Based Climate Resilient Cropping System for Eastern India	Dr. Rakesh Kumar
8.	Design and development of Solar operated hold on type paddy thresher	Dr. Santosh S Mali
9.	Seed based technology delivery model through Farmers Producer Organization (FPO)	Dr. Anirban Mukherjee
10.	Policy measures for Tenant farmers of Bihar	Dr. Ujjwal Kumar
11.	Socioeconomic status scale for farmers of Bihar and Jharkhand	Dr. Virendra K. Yadav
12.	Developed a method for serological diagnosis (Indirect ELISA) of *Theileriaannulata* using recombinant spm2 antigen	Dr. Pankaj Kumar
13.	Identification of CCL8 and CXCL10 as early pregnancy biomarker in buffaloes:	Dr Rajni Kumari

Collaboration and linkages

The institute and its centre are involved in many collaboration and linkage with national and international organization in order to complete its research, extension and educational activities. Following is the list of organization with areas of collaborations (Table 18.8).

Table 18.8 International and national level collaborations and linkage

Research areas	Collaborating institutes
Conservation Agriculture	CIMMYT
Climate resilient cropping systems	CIMMYT
Improving water use for dry season agriculture	CIMMYT
Sustainable and resilient farming system intensification for EIGP	CIMMYT
Development of submergence tolerance rice varieties for flood plain and flood prone areas of eastern region	IRRI
Development of drought tolerance rice varieties for eastern region	IRRI
Restoration of degraded lands, water congested areas and carbon sequestration	World Agroforestry Centre
Developing suitable pulse varieties of lentil, grass pea and pigeon peafor drought tolerance in eastern states	ICARDA
Small ruminants improvement and production system	ILRI
Development of Solar Irrigation Pump Sizing Tool	IWMI, New Delhi
Integrated Farming System	IVRI RC, Kolkata; IISWC RC, Koraput; IARI RS, Pusa (Bihar); CIFRI; CPRS RS, Patna, IIFSR, Modipuram, MGIFRI, Motihari and NBSS&LUP
Tribal Farming System	IISWC RC, Koraput, Odisha, and NBSS&LUP
Quality brood management, fish seed, enclosure culture and wetland rehabilitation	CIFA; CIFRI; CRRI; NRC (Pig); AAU and CTCRI
Livestock & Avian Production System	IVRI; NRC (Pig); NDRI; AAU; UBKV; BAU (Bihar); BAU (Ranchi) and CARI
Seed production of agri-horti crops including production technology	DSR, Mau; IARI RS, Pusa; BISA (CIMMYT) Pusa; CRRI; BAU (Bihar & Ranchi); RAU, Pusa; IIVR; CTCRI; CHES; NRC, Litchi; CSISA; DMR; CPRS-RS, Patna & UBKV.
Impact evaluation of watershed development projects	National Bank for Agriculture and Rural Development, Ranchi
Economic development of aspirational districts	Grant Thornton Bharat LLP, Hazaribagh, Jharkhand

19 Krishi Vigyan Kendra

ICAR Research Complex for Eastern Region is having two Krishi Vigyan Kendras, one at Buxar, Bihar and another is at Ramgarh, Jharkhand.

Krishi Vigyan Kendra, Buxar

Krishi Vigyan Kendra (KVK), Buxar plays a pivotal role in advancing agricultural research and extension activities within the district, Buxar. Its primary functions relates to organizing various field-level activities for disseminating innovative agricultural practices and technologies directly to farmers through On-Farm Trials (OFTs), Frontline Demonstrations (FLDs), Cluster Front Line Demonstration (CFLDs), Training, Exposure visits, etc. Some of the activities and achievements are summarized below.

Training Program

KVK, Buxar organized various training programs to enhance the skills and awareness of practicing farmers, rural youth and extension functionaries on modern agro-techniques to optimize yields while minimizing costs. A total of 82 training programs were organized, catering to 2193 participants in total, with 73 trainings to practicing farmers, 5 trainings for rural youth, and 4 trainings for extension functionaries (Table 19.1). Below are the comprehensive details of the oraganized training programs:

Table 19.1 Summarized Discipline wise Training Program for Practicing Farmers

Sl. No.	Topic	No of training	No of beneficiaries		
			Male	Female	Total
A.	Training program for Practicing Farmers				
	a) Agronomy	6	110	41	151
	b) Soil and Water Conservation	26	607	65	672
	c) Plant Breeding	16	323	81	404
	d) Plant Protection	25	633	67	700
	Total training program for Practicing Farmers	**73**	**1673**	**254**	**1927**
B.	Training program for Rural Youth	**5**	144	44	188
C.	Training program for Extension Functionaries	**4**	**73**	**5**	**78**

Fig. 19.1 Glimpse of training programs organized at KVK, Buxar

Cluster frontline demonstration on Pulses and Oilseeds (CFLD)

Cluster front line demonstration on Pulses (funded by National Food Security Mission) and oilseeds (funded by National Mission on Oilseeds and Oil Palm), were conducted to promote the adoption of scientific management practices for pulses and oilseed crops among the farmers to enhance their productivity. The details are given in Table 19.2.

Table 19.2 Details of Cluster Frontline Demonstration on Pulses and Oilseed crops

Sl. No.	Crop	Technology	Area (ha)	No of beneficiaries			Village covered
				Male	Female	Total	
01	**Green gram**	IPM 2-3 + seed treatment with FIR+foliar spray of micronutrient agromin @1 ml/l water before flowering and management of white fly by using Thiamethoxam 5g / 15 l water or Acetamiprid 15 g/15 l water	10	186	10	196	Mahdah, Sondhila, Diwan ka badka gavn, Jagdishpur, Badki Basouli, Hukha, Parmanpur
02	**Pigeon pea**	IPA 203 + seed treatment + micronutrient (MO and B) agromin @ 2 ml/l of water before flowering and management of Legume pod borer (*Maruca vitrata*)	20	47	0	47	Tilak Rai ka hata, badki Basouli, Dafa Dehri, Pawani, Rampur, Chousa, Dullahpur, Chakrahasi, Sonpa
03	**Chickpea**	Pusa 3043 + seed treatment with FIR + foliar spray of micronutrient agromin @1 ml/l water before flowering and management of gram pod borer by using bioinsecticides	20	65	5	70	Kulhariya, kathrai, majhariya, dhenuadih, mahila, sonpa, chotki basouli, Kushrupa
04	**Lentil**	IPL 220 + seed foliar spray of NPK (19:19:19) @ 10g/l of water before flowering + drenching with *Trichoderma viride* @ 5g/l of water at 45 DAS	20	58	4	62	Sonapa, Lodash, Pandey Patti, Pawni, Dafa Dhehri, Kankpura, Rahthuwa
05	**Mustard**	Line sowing of Var. Pusa Mustard 30 with seed treatment	60	186	10	196	Basav Khurd, Majhariya, Indoor, Jagdishpur, Mahila, Dafa Dehri, Sondhila, Khatiba, Badka Rajpur
		Total	**130**	**542**	**29**	**571**	

Table 19.3 Details of Front-Line Demonstration conducted and their coverage

Sl. No.	Crop	Name of the technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase
					Demo	Check	
01	Paddy	Rajendra Sweta	52	20	43.3	38.2	13.35
		Rajendra Sweta *(under SCSP)*	22	5	42.5	38.2	11.25
		Sampurna (KP 108) with DSR *(under CRA Prog)*	27	8	49.31	41.62	18.47
		Line sown of BPT-5204 *(under CRA Prog)*	139	138	53.66	49.21	9.0

Sl. No.	Crop	Name of the technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase
		Line sown of Sampurna (KP 108) *(under CRA Prog)*	20	16	54.51	50.55	7.83
		Line sown of Rajendra Sweta *(under CRA Prog)*	20	16	48.23	45.97	4.91
02	Pearl millet	Hybrid (NU7799)	17	7	27.20	24.8	9.67
		Seed drill sown of Hybrid (NU7799) *(under CRA Prog)*	82	32	35.16	30.55	15.18
03	Kharif Maize	Raised bed planting of DMH-1301 *(under CRA Prog)*	58	20	52.78	48.80	8.15
04	Rabi Maize	Raised bed planting of DXC 4244 *(under CRA Prog)*	8	1.2	48.91	43.51	12.4
05	Wheat	ZT sown of DBW 187*(under CRA Prog)*	210	60	55.16	51.88	6.33
		ZT sown of HD 2967*(under CRA Prog)*	332	100	54.36	50.12	8.45
06	Mustard	Seed drill sown of PM 30 *(under CRA Prog)*	68	20	16.31	12.35	32
07	Pigeon pea	Raised bed planting of IPA-203 *(under CRA Prog)*	27	8	17.59	14.22	26
08	Lentil	Seed drill sown of IPL 220 *(under CRA Prog)*	155	40	24.56	20.84	17.85
09	Chickpea	Seed drill sown of GNG 2299 *(under CRA Prog)*	65	12	27.46	22.15	23.97
		Seed drill sown of Pusa 3043 *(under CRA Prog)*	100	16	26.46	22.15	19.45
10	Okra	Kashi Lalima	21	1	92	80	15
11	Vegetable Pea	Azad Pea-3	12	1	82	71.5	14.68
12	Potato	Raised bed planting of Kufri Bahar *(under CRA Prog)*	35	1.2	283.46	244.15	16.1
13	Gram Green	Seed drill sown of IPM-205-7 *(under CRA Prog)*	259	100	7.66	6.10	24.75
14	Bajra	NU 7799	99	39	35.16	30.55	15.00
15	Kharif Maize	DMH-1301	58	20	52.78	50.80	3.89
16	Rabi Maize	DXC-4244	8	1.2	48.91	43.51	12.41
17	Poultry	Vanaraja*(under SCSP)*	65	1000 (Nos.)	2.5 kg	2.1 kg	19.04
		Total	1959	682.6 ha & 1000 Nos.	—	—	—

Fig. 19.2 Glimpse of Front Line Demonstrations (FLDs)

On Farm Trials conducted

A. Assessment of fungicides for the management of Sheath blight disease of Rice	
Problem diagnosed	Sheath blight has become a serious threat to rice cultivation because the disease affects the sheath and leaf of rice, causing direct economic loss to farmers
Final recommendation for micro level situation	Spray of Thifluzamide 24 SC @ 1 ml /l of water (45 days after transplanting) given higher yield per ha
B. Assessment of chemical fungicides for the management of False Smut in Rice	
Problem diagnosed	False smut is a serious threat to rice cultivation because the disease affects the grain development and cause direct economic loss to the farmers. The pathogen converts the grain into powdery mass of spores and causes sterility of neighboring spikelets, leading to both quantitative and qualitative losses
Final recommendation for micro level situation	Spray of Fluopyram 17.7 + Tebuconazole 17.7 SC @ 96.5 g a.i. / ha (formulation 550 g/ha) at 50 per cent flowering stage with seed treatment can control false smut in rice field
C. Management of Fall Army Worm *Spodoptera frugiperda* in Maize	
Problem diagnosed	Fall army worm has become a threat to maize production, damaging the crop in both the early and later stages of growth
Final recommendation for micro level situation	Application of sand followed by one spray of Emamectin Benzoate 5 SG @ 0.4 g/l, and a second spray of thiamethoxam 12.6 % + lambda-cyhalothrin 9.5% can control the infestation of fall army worm
D. Effect of zinc and bio fertilizer application on yield and yield attributes of Maize	
Problem diagnosed	Low yield of maize is due to unbalance use of nutrients; zinc sulphate and Azotobacter play a vital role to enhance vegetative growth, development and grain quality
Final recommendation for micro level situation	The recommended dose of NPK (NPK100:60:40 Kg/ha) + 1% foliar application of zinc sulphate at 30 days resulted in significant increase in the number of cobs/plant, test weight and grain yield (4.80 t/ha) with a cost-benefit ratio of 1.30 as compared to that of farmers' practice
E. Assessment of different crops establishment method on yield of lentil in Rice-Lentil cropping system	
Problem diagnosed	Delayed sowing due to excess moisture in the fields
Final recommendation for micro level situation	Zero tillage practice was found to be significant for increasing the numbers of branches/plant, test weight, grain yield (1.35 t/ha) and the benefit-cost ratio compared to farmers' practice (0.88 t/ha)
F. Assessment and performance of quality protein maize varieties during *kharif* season in Buxar district	
Problem diagnosed	Traditionally grown maize varieties are deficient in protein and minerals content
Final recommendation for micro level situation	*Shaktiman 5* produced maximum grain yield (6.6 t/ha), which was 36.78% higher than that of the farmers' practice (4.83 t/ha), with the net return of Rs.97,440/- and a BCR of 3.40

Fig. 19.3 Glimpse of OFTs

On Farm Trial conducted under KVK-CSISA Project

On farm trial were conducted for comparative study of yield performance of cultivars recommended for timely sowing with cultivars recommended for early/late sowing.

Table 19.4 Effect of dates of sowing and cultivar on grain yield of rice and wheat crops

Trial Name	Area covered (ha)	Variety name	Duration (in Days)	Method of planting	Sowing	Grain yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	BCR
Kharif										
Long duration varieties	8	BPT-5204	135-140	Line Transplanting	15-20 June	50.11	43568	125462	81894	2.88
	8	BPT-5204	135-140	Line Transplanting	20-25 June	49.9	41568	117676	76108	2.83
Rabi										
	8	HD 2967	135-140	Zero Tillage/ Line sowing	1-10 Nov	52.3	32500	132888	100388	4.09
	8	HD 2967	135-140	Zero Tillage/ Line sowing	11-20 Nov	49.1	32500	123658	91158	3.8
	8	HD 2967	135-140	Zero Tillage/ Line sowing	21-30 Nov	42.2	31900	107645	75745	3.37
Short duration varieties	8	PBW 373	110-125	Zero Tillage/ Line sowing	21-30 Nov	36.6	29800	90405	60605	3.03
	8	PBW 373	110-125	Zero Tillage/ Line sowing	1-15 Dec	32.1	29000	80873	51873	2.79
	8	PBW 373	110-125	Zero Tillage/ Line sowing	16-31 Dec	29.9	29000	74968	45968	2.59

Result: In *Kharif* season, sowing of long duration rice variety during June 15-20 produced maximum rice yield (5.01 t/ha), with a higher net return (Rs 81,894) and BCR (2.88) than those of the same variety under late sown condition. In *rabi* season, long duration wheat variety sown during November 01-10 resulted in higher wheat yield (5.23 t/ha) with higher net return (Rs. 1,00,388) and BCR (4.09) than those of the same variety sown at later dates. For short-duration varieties, wheat sowing during November 21-30 resulted in higher net return of Rs. 60,605 with a BCR of Rs 3.03.

Extension activities on oilseeds, pulses and cereal crops

Four field days, three Kisan Gosthi and eight training programs on different pulses (pigeon pea, chick pea and lentil), oilseed (mustard) and cereal (rice) were organized at farmers' fields to popularize the demonstrated technology among farmers. In each field day, scientific staff, technical staff, social workers, members of FPOs, progressive farmers and farm women participated, and learned about the demonstrated technology on different crops.

Table 19.5 Details of the Field days/ Kisan Goshthi and training programs

Activity	Date	Participants	Topic / area of programme
Field days / Kisan Goshthi	13/03/2023	105	Timely sown Mustard (Var. PM-30) and Kisan Goshthi at Churamanpur village under CRA Program
	14/03/2023	105	Timely sown Chickpea (Var. GNG 2299) and Kisan Goshthi at Harikishunpur village under CRA Program
	16/03/2023	105	Timely sown Lentil (Var. IPL-220) and Kisan Goshthi at Ramobariya village under CRA Program
	21/03/2023	104	Timely sown Lentil (Var.IPL-220) and Kisan Goshthi at Ramobariya village under CRA Program
Farmers Training	13/01/2023	27	Damaged caused by wild mammals in cereals, pulses and vegetable and their management at Harikishunpur
	24/05/2023	43	Challenges in adaptation of Climate-Resilient and Climate-Smart agriculture practices among farmers and their solutions' at Dalsagar.
	26/05/2023	42	Role of technology in enhancing climate smart agriculture at Ramobariya
	13/10/2023	32	Integrated insect pest management in rice crop at Balapur
	17/10/2023	33	Insect and disease management in Pigeonpea crop at Ramobariya
	19/10/2023	27	Integrated Insect pest management in Rice crop at Harikishunpur
	20/10/2023	32	Integrated Insect pest management in Rice crop at Dalsagar
	21/10/2023	33	Insect and disease management in Rice crop at Churamanpur
Total participants		**688**	-

Fig. 19.4 Glimpse of field day and training programs

Seed Hub Programme

Under the aegis of Pulse Seed Hub, KVK Buxar produced quality seeds of chickpea and other pulses. In addition, foundation, certified and TL seeds of paddy and wheat were also produced, details of which are given below (Table 19.6 & 19.7):

Table 19.6 Details of participatory seed production under pulse seed hub

Sl.No	Crop/Variety	Production (q)	Type of Seed	No of beneficiaries		
				Male	Female	Total
1.	Pigeon pea / IPA 203	40	FS	14	4	18
2.	Chickpea / GNG2207	90	CS	25	9	34
3.	Chickpea / 2299	62	FS	17	10	72
4.	Lentil / IPL220	50	CS	21	3	24
5.	Lentil / IPL220	40	FS	13	4	18
	Total	**282**	—	**90**	**30**	**166**

Table 19.7 Details of seed production of paddy and other crops at the Farm of KVK, Buxar

Crop	Variety	Quantity of seed (q)	Types of Seed	Area (ha)
Paddy	BPT 5204	55	FS	1.8
	MTU 7029	30	FS	1.3
	Rajendra Sweta	12.5	FS	0.4
	CO 51	5	TL	0.4
Wheat	DBW 187	6	CS	0.2
	DBW 222	8.4	FS	0.25
Pigeon pea	IPA 203	1.5	TL	0.2
Lentil	IPL 316	2.40	CS	0.3
	IPL 220	2.0	FS	0.3
Chickpea	RVG 202	4.40	TL	0.5
	Pusa 3043	15.0	FS	1.6
	Pusa shubhra	0.40	TL	0.1
Mustard	PM 31	0.5	TL	0.1
	Grand Total	**143.1**		

Fig. 19.5 Glimpses of Pulse Seed Hub Program undertaken at KVK, Buxar

NICRA-Technology Demonstration Component Project, KVK Buxar

Table 19.8 Summary of Interventions taken up during 2023

Villages	FST1 No. of farmers involved in demonstrations	FST2 No. of farmers involved in demonstrations	FST3 No. of farmers involved in demonstrations	FST4 No. of farmers involved in demonstrations
Village 1	10	20	12	10
Village 2	20	12	10	12
Village 3	10	12	15	10
Total	**40**	**44**	**37**	**32**

Table 19.9 Natural Resource Management Interventions taken up in farming system typology

Resilient practices	No. of Demo	Farmers covered	Area covered (ha)
Trench *cum* bunding (Convergence)	135	135	150
Conservation tillage: Zero tillage	30	30	13.1
Raising the bund height around the rice field (Training and awareness)	71	71	142
Rain water harvesting structure (Convergence)	04	04	04
Micro irrigation system: Application of sprinkler (Convergence)	03	03	03
Foliar application of 0.5% potassium nitrate in late sown wheat to escape terminal heat	80	80	50
Increasing organic carbon levels through green manuring by *Sesbania sp.*	12	12	5.5

Table 19.10 Crop production interventions taken up in farming system typology

Resilient practice	No. of Demo	Farmers covered	Area covered (ha)
Drought tolerant rice variety (Swarna Shreya)	30	30	14
Utilizing residual moisture for timely sowing of pulses with short-duration rice variety (CO 51)	16	16	4.7
Raising a staggered rice nursery at 7 and 10 days intervals	04	04	1.4
Production of timely sown wheat (HD-3249)	40	30	12
Demonstration of ZT sown Lentil (IPL 316) using paddy residual moisture	16	16	5.0
Production of Chickpea (Pusa 3043)	32	32	10
Demonstration of flood tolerant Rice (Swarna Sub-1)	30	30	7.5
Demo of rice (Sabour Heera) in low land area	06	06	3.0
Paira / Utera seeding of lentil (IPL 316) and chickpea (Pusa 3043) in rice fields using rice residual moisture in low land areas	08	08	2.5
Total	**182**	**172**	**60.1**

Table 19.11 Livestock and Fisheries Interventions taken up in farming system typology

Resilient practice	No. of Demo	Farmers covered	No. of animals covered	Area covered (ha)
Using paddy straw balers for baling straw and its supply as the feed	04	04	105	**2.5**
Supply of cutting of HN CO_3 & CO_4	10	10	32	0.96
The deworming of small ruminants, including sheep and goats	65	65	315	-
Suppling of area- specific mineral mixture, conducting Animal Health Camps and diagnostic camps	63	63	135	-
Back yard poultry breed Vanaraja	67	67	1340	67 unit (18 F + 2 M) birds per unit
Fish production: PC RCM, Grass carp, (Yearlings) and feed management	04	04	-	1.4
Total	**213**	**213**	-	-

Out scaling of Natural Farming program

Table 19.12 Overall achievement under Natural Farming program

Sl. No.	Name of Activity	No. of activities	No. of beneficiaries
1.	Awareness program	25	1423
2.	Training program(Natural Farming: Importance and possibilities)	01	40
3.	Demonstrations	7	9
	Total	33	1472

Fig. 19.6 Glimpse of activities under Natural Farming

Backyard poultry production for generation of farm income

65 units of a poultry breed Vanraja were demonstrated for backyard poultry production in 04 villages: Gurdas Mahtiya, Hukha, Nathpur and Pawani under SCSP program among the landless farmers and weaker community of society. Vanaraja chicks may be reared for both eggs and meat. Products from native fowls are widely preferred because of their pigmentation, taste, leanness, flavor and suitability in adverse temperatures. The average body weight 1.35 Kg at 14 weeks of age is viable in rural village condition and 164 eggs produced after 165 days.

Fig. 19.7 Distribution of backyard poultry chick

Visit of RAC members at KVK, Buxar

The 19th Research Advisory Committee visited KVK, Buxar on May 19, 2023 under the Chairmanship of Dr. K. D. Kokate (Former DDG, Agricultural Extension, ICAR, New Delhi) along with members of the committee, namely Dr. Masood Ali (Ex Director, IIPR, Kanpur), Dr. S. D. Singh (Ex ADG, Fisheries Sciences, ICAR, New Delhi) and Dr. S. Kumar (Ex Head, FSRCHPR, Plandu, Ranchi). The Chairman and members interacted with farmers at Harikishanpur village. The committee also interacted and discussed with SMSs and staff of the KVK, Buxar about their ongoing activities.

Fig. 19.8 RAC Chairman and members interacted with farmers

Certificate Training Program for Fertilizer Dealers

A 15 day Certificate-based Training Program was organized for 42 fertilizer input dealers of the Buxar district from June 02-20, 2023 at KVK, Buxar. The program was inaugurated by Dr. Anup Das, Director, ICAR RCER, Patna. Training program was focused on upgradation of knowledge and skill of fertilizer input dealers, and creating awareness on Integrated Nutrient Management, balanced use of fertilizer as well as use of fertilizer on the basis of soil health card.

Fig. 19.9 Director, ICAR-RCER, Patna interacted with input dealers during INM Training

Celebration of Technology week

Technology week was organized at KVK, Buxar during which various topics such as bio-fortified varieties, natural farming, organic farming, application of Nano Urea through Drone, Micro sprinkler system, and the like were discussed. Happy Seeder, Zero Till *cum* Ferti seed Drill, Multi-crop Planter & Seed Drill, Tractor Mountain Sprayer, Potato Planter, Potato Digger, Laser Land Leveler (for precision farming) and Mini Sprinkler (for the promotion of the ***Per Drop More Crop***) were demonstrated. The program was conducted during 16-18 July, 2023 for 137 participants.

Fig. 19.10 Different activities during technology week

Krishi Vigyan Kendra, Ramgarh

KVK, Ramgarh plays a pivotal role in disseminating agricultural technologies within Ramgarh district of Jharkhand. Like any other KVK, its primary functions relate to organizing various activities aiming at disseminating innovative agricultural practices and technologies directly to farmers through OFTs, FLDs, CFLDs, Trainings, Exposure visits, and the like.

On-farm Trials

1. Assessment of INM along with micro nutrients application on yield and quality of *Amrapali* variety of mango

Table 19.13 Details of technologies for assessment of INM in *Amrapali* variety of mango

Problem diagnosed	**Low yield and poor quality due to poor nutrient management**
Final recommendation for micro level situation	Basal application of 1 kg lime, NPK @ 0.5:0.5:0.3 kg, 100 g zinc sulphate, 50 g copper sulphate and 50 g boric acid per tree after harvest and two foliar spray of 0.1% boric acid, 0.2% zinc sulphate and 0.1% copper sulphate-first before flowering, and the second at marble stage to obtain good quality, high yield and better return from 5-6 years old *Amrapali* variety

Fig. 19.11 On Farm Trial for Assessment of INM in *Amrapali* variety of mango

2. Assessment on yield and quality of INM of sweet potato

Table 19.14 Assessment on yield and quality of INM of sweet potato

Problem diagnosed	Lack of awareness about nutrient management and imbalanced use of nutrients result in low yield and returns
Final recommendation for micro level situation	To improve soil health and to get maximum yield and better quality of tuber with good return, STCR based nutrient management is the best in sweet potato



Fig. 19.12 On Farm Trial for Assessment of INM in sweet potato

3. Assessment of Effectiveness Extension Methods for dissemination of Commercial Vegetable Production Technologies

Table 19.15 Details of technologies for Effectiveness of Extension Methods for dissemination of Commercial Vegetable Production Technologies

Problem diagnosed	Low effective approach of Extension Methods
Final recommendation for micro level situation	Use of personal contact method proves to be an effective approach for spread of commercial vegetable production technology

4. Assessment of Kisan Mobile Advisory for green cob grower

Table 19.16 Details of Kisan Mobile Advisory technologies for green cob grower

Problem diagnosed	Poor dissemination of technological Knowledge at appropriate time
Final recommendation for micro level situation	Farmers are getting satisfactory income with Kisan Mobile Advisory through Audio and Video message (Same text message) about varieties, Nutrient management, Insect Pest Management and market information

5. Assessment the effect of leaflet for refreshing knowledge in long time for Broccoli grower

Table 19.17 Details of technologies related to the effect of leaflet for refreshing knowledge in long time for Broccoli grower

Problem diagnosed	Farmers do not have access to updated knowledge due to unavailability of literature for home study
Final recommendation for micro level situation	Farmers are achieving satisfactory incomes after having access to leaflets which refresh their knowledge periodically.

Front Line Demonstrations

Table 19.18 Details of Front Line Demonstration conducted and their coverage

Sl. No.	Crop	Name of the technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase
					Demo	Check	
1	Rice	Drought tolerance Rice cv. Swarna Shakti Dhan	25	10	44.24	35.60	24.26
		Drought tolerance Rice cv. Swarna Shreya	25	10	42.89	34.77	23.35
		Drought tolerance Rice cv. CR Dhan 320	25	10	44.82	34.80	28.79
		Drought tolerance Rice cv. IR 64 drt-1	55	15	39.3	35.5	10.70
2	Finger millet	Popularization of high yielding Cv. A-404	60	20	17.52	14.80	18.37
3	Sunflower	cv. Modern	51	20	5.80	7.42	27.93
4	Bottle gourd	Popularization of powdery mildew and downey mildew tolerant bottle gourd var. Swarna Sneha	20	2	206.7	167.9	23.10
5	Brinjal	Popularization of bacterial wilt resistant brinjal var. Swarna Shyamali	50	5	435.8	344.6	26.46
6	Tomato	Popularization of bacterial wilt resistant tomato var. Swarna Sampada	30	3	643.0	533.4	20.54

Fig. 19.13 Field view of Finger Millet var.-A404 , Bottle Gourd var. Swarna Sneha, Brinjal var. Swarna Shyamali and Tomato var. Swarna Sampada at farmer field

Details of Cluster front line demonstration on Pulses and Oil seeds Crop under NFSM and NMOOP

Table 19.19 Details of Cluster frontline demonstration on pulses and oilseed crops

Sl. No.	Crop	Technology	Area (ha)	No of beneficiaries			Village covered
				Male	Female	Total	
01	Linseed	Priyem + Seed treatment, Foliar spray of NPK (19:19:19) and need based insecticide	20	51	37	88	Sondeeha, Jamsingh, Budhakhap, Vyang
02	Pigeon Pea	IPA 203+Seed treatment with Rhizobium, Foliar spray of NPK (19:19:19) and need based insecticide	50	112	196	308	Jobla, Budhakhap, Pannatand, Tillaiya, Badka chumba, Dundigachhi, Korambey
03	Lentil	HUL 57 + Seed treatment, Foliar spray of NPK (19:19:19) and need based insecticide	20	41	48	89	Chitarpur, Jamsingh, Gargali, Budhakhap

04	Mustard	PM 25 + Seed treatment, Foliar spray of NPK (19:19:19) and need based insecticide	20	46	54	100	Jamsingh, Ambatand, Madgi, Govindpur, Gargali, Karma, Hesagarha
		Total	**110**	**250**	**335**	**585**	

Fig. 19.14 Field view of lentil cv. HUL 57

Fig. 19.15 Field view of pigeonpea cv. IPA 203

Demonstration of Sunflower in rice fallow land

Sunflower cv. *Modern* was demonstrated in 20 ha rice fallow area, encompassing 52 farmers' fields under the SCSP program. As part of this initiative, comprehensive training sessions were provided to all the participating farmers while focusing on the scientific package and best practices for cultivating sunflowers. Additionally, continuous follow-up advisories were provided to ensure that the farmers received timely guidance and support throughout the cultivation process. The yield obtained from the Sunflower cv. *Modern* under this program was 1.12 t/ha. The integration of the sunflower cultivation not only holds the potential to diversify agricultural practices, but also contributes to the economic empowerment of the participating farmers.

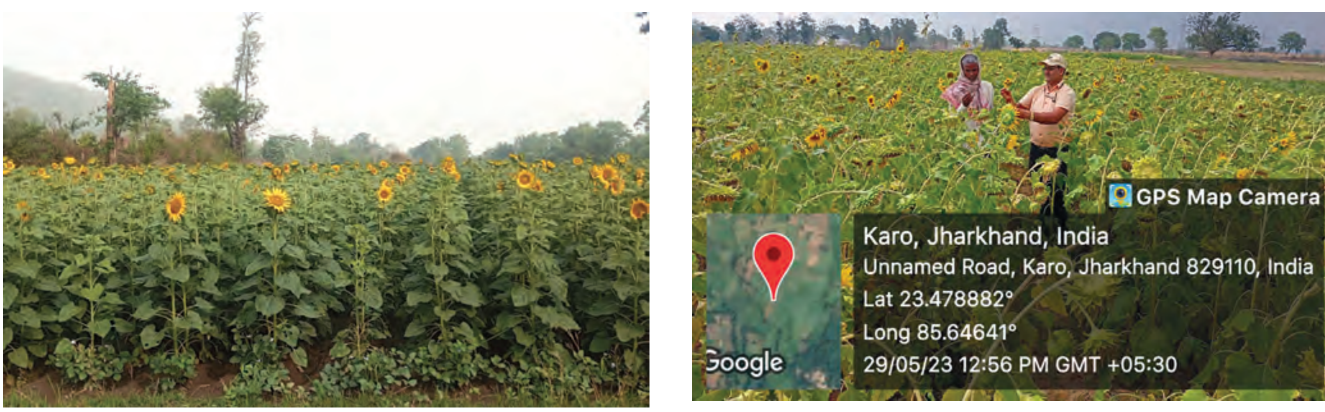


Fig. 19.16 Field view of Sunflower *var.* Modern

Training Program and Extension activities conducted

Table 19.20 Details of Training Program for Practicing Farmers

Sl. No.	Topic	No of training	No of beneficiaries		
			Male	Female	Total
1.	Total training program for Practicing Farmers	50	746	902	1648
2.	Training program for Rural Youth	8	113	108	221
3.	Training program for Extension Functionaries	6	60	70	130



Fig. 19.17 Training Programs for Practicing Farmers, Rural Youth and Extension functionaries

Table 19.21 Details of extension activities conducted by KVK, Ramgarh

Extension Activity	No. of activities	Male	Female	Total
Kisan Mela	03	539	741	1280
Field Day	02	45	71	116
Kisan Ghosthi	05	259	418	677
Exhibition organized	02	118	251	369
Participation in exhibition	03	482	681	1163
Film Show	02	37	52	89
Method Demonstrations	05	61	104	165
Workshop	03	44	68	112
Group discussion	05	38	116	154
Lectures delivered as resource persons	35	125	148	273
Advisory Services	62	321	405	726
Scientific visit to farmers field	56	311	382	693
Farmers visit to KVK	281	1580	2092	3672
Diagnostic visits	29	35	78	113
Exposure visits	03	63	118	181
Ex-trainees Sammelan	03	45	62	107
Soil health Camp	04	55	69	124
Animal Health Camp	03	53	65	118
Soil test campaigns	06	72	74	146
Self Help Group Conveners meetings	05	11	108	119
Newspaper coverage	59			

Celebration of Important Days

Table 19.22 Details of Extension activities conducted by KVK Ramgarh

Extension Activity	Date	Male	Female	Total
Republic day	26.01.2023	22	10	32
International Women's Day	08.03.2023	24	44	66
International Yoga Day	21.06.2023	18	29	47
Independence Day	15.08.2023	21	28	49
Parthenium Awareness Week	16.08.2023 - 22.08.2023	36	45	81
Gandhi Jayanti	02.10.2023	39	48	87
Mahila Kisan Diwas	15.10.2023	12	45	57
World Food Day	16.10.2023	12	25	37
Vigilance Awareness Week	30.10.2023 - 05.11.2023	10	16	26
World Soil Day	05.12.2023	36	68	104
Kisan Diwas	23.12.2023	26	18	44

Fig. 19.18 Activities during Parthenium Awareness week

World Soil Day

World Soil Day was celebrated on December 5, 2023, at the KVK. A total of 104 farmers from different villages attended this program. One of the key highlights of the program related to the emphasis on the balanced use of fertilizers, catering to the specific needs of individual soils as determined through soil testing. Farmers were enlightened on the importance of soil testing for optimizing crop productivity while simultaneously preserving soil health and biodiversity. In addition to informative sessions, hands-on training sessions were conducted to demonstrate proper soil sampling techniques. This practical training enabled farmers to collect soil samples effectively, ensuring accurate assessment of soil composition and nutrient levels. Impressively, a total of 50 soil samples were collected during the event, underscoring the proactive engagement and commitment of the farming community towards better soil management practices.

Exposure Visits of School Children to the KVK

The KVK has opened its gate for the rural youth and school children to foster agricultural awareness and practical learning. The exposure visit provides a unique opportunity to the students to get acquainted with various technological advancements and demonstration units at the Kendra. During the visit, the students were introduced to a diverse array of innovative techniques and models, including the Integrated Farming System (IFS) model, Goatery unit, Duckery unit, and Poultry unit. They also had the chance to witness firsthand the High-Density Plantation (HDP) techniques employed for mangoes, guavas, and lemons, as well as Multitier orchards of fruits, protected vegetable cultivation, and Hi-tech nursery setups. Moreover, the students were exposed to the concept of a nutri-garden, as well as the cultivation of medicinal and aromatic plants, highlighting the importance of biodiversity in agriculture. A pivotal aspect of the visit was the interactive session between the students and scientists, providing a platform for fruitful discussions and knowledge sharing. The exchange of knowledge facilitated a deeper understanding of agricultural concepts and encouraged the students to explore potential career paths in the field of science and agriculture.

Table 19.23 Details of Exposure Visit of School Children

Name of school	Date of Exposure visit	No. of children
Sarmik + 2 High School, Sirka, Argadda, Ramgarh	22.02.2023	50
Janta + 2 High School, Chainpur, Ramgarh	24.02.2023	50
Public School Kujju, Ramgarh	15.11.2023	50
Sarvodaya Niketan Senior secondary school	20.12.2023	50
S.N. High School, Barkakana	26.12.2023	50

Comprehensive Training on Feed and Fodder Management

The KVK and the National Seeds Corporation (NSC), Ranchi collaborated to organize a comprehensive training program on feed and fodder management on December 20, 2023. This initiative targeted Farmers Producer Organizations (FPOs), Farmers Producer Companies (FPCs) and input dealers/seed sellers across the state, aiming to enhance their expertise and capabilities in modern agricultural practices. The training program covered a diverse range of topics crucial for the sustainable growth of agricultural enterprises as well as green fodder production techniques and their significance in augmenting milk production in Jharkhand.

Fig. 19.19 Comprehensive Training on Feed and Fodder for FPOs

Rabi Workshop

On December 21, 2023, the KVK in collaboration with the District Agriculture Office, Ramgarh organized an impactful Rabi Workshop. This joint endeavor aimed to apprise the farmers about the knowledge and strategies necessary to realize the optimum potential of Rabi crops. Experts from the KVK as well as District Agriculture Office participated in the discussions and interactive sessions, providing farmers the practical guidance relevant to local agricultural contexts. In the workshop integrated pest and disease management strategies including cultural, biological, and chemical control measures were discussed. Early detection techniques and preventive measures were emphasized to minimize yield losses and ensure crop health.

Fig. 19.20 Rabi Workshop

RAWE Program

From August 1, 2023 to September 15, 2023, a Rural Agricultural Work Experience (RAWE) program for B.Sc. Agriculture students from Sai Nath University, Ranchi was organized at KVK, Ramgarh. This intensive program exposed all the nine students to practical agricultural experiences and equipped them with invaluable skills essential for their future careers in agriculture. Expert-led lectures on organic farming, natural farming, INM, IPM, IFS and protected vegetable cultivation provided the students a solid theoretical foundation. Moreover, the program emphasized hands-on learning experiences, ensuring that students would gain practical expertise in diverse agricultural domains. Feedback from the students revealed that the programme not only enriched their academic pursuits, but also equipped them with the skills, knowledge and confidence to become future leaders in the field of agriculture.

Fig. 19.21 Field visit under RAWE Program for B. Sc Agriculture

Certificate Course on Integrated Nutrient Management

The KVK organized a 15 days' Certificate Course on Integrated Nutrient Management from June 08-22, 2023. The program, inaugurated by Dr. Anup Das, Director, ICAR-RCER, Patna, underscored the importance of incorporating a technological approach in farming practices, highlighting the collective efforts required to enhance income generation through agriculture. The active participation of 40 input dealers and rural youth in the training program demonstrated the collective commitment to embrace innovative agricultural practices for fostering sustainable agricultural development. The comprehensive training program equipped the participants with essential knowledge on integrated nutrient management.

Awareness program in agriculture under Mission Life style for Environment

An awareness Program was organized under the *Mission Lifestyle for Environment* to create awareness among 35 farmers about critical aspects of environmental conservation, healthy dietary practices and the significance of establishing nutritional gardens on June 5, 2023. During the technical session, the critical role of trees in mitigating climate change, enhancing biodiversity and safeguarding ecosystems for future generations was emphasized. Additionally, the importance of establishing and maintaining nutritional gardens was also discussed by the experts. The session aimed to inspire participants for cultivating nutrient-rich crops in their own gardens in order to sustain food security.

Fig. 19.22 Mission Life style for Environment

Inauguration of Administrative building and Hi-tech Nursery

The KVK marked a significant milestone on October 31, 2023 with the virtual inauguration of its new administrative building. The ceremony was graced by the Chief Guest Dr. Himanshu Pathak (Secretary, DARE and Director General, Indian Council of Agricultural Research, New Delhi), along with special guests Dr. S.K. Chaudhari (Deputy Director General, NRM) and Dr. U. S. Gautam (Deputy Director General, Agricultural Extension). Dr. Anup Das (Director, ICAR-RCER) welcomed the guests, and highlighted the achievements of KVK, Ramgarh over the years. As part of the inauguration, a state-of-the-art Hi-tech nursery was also unveiled at KVK Ramgarh. The chief guest praised the work of KVK Ramgarh, acknowledging its efforts in disseminating the latest agricultural technology information to farmers. He encouraged farmers to adopt scientific farming practices to increase their income. Echoing similar sentiments, Dr. S.K. Chaudhari emphasized the importance of adopting new agricultural techniques and urged the farmers to share knowledge among themselves. Dr. U. S. Gautam highlighted the role of youth in agriculture and encouraged them to pursue agriculture as a profession. Dr. Anjani Kumar (Director, ICAR-ATARI, Patna) emphasized the significance of KVKs in promoting profitable farming and demand-based production. Dr. A.K. Singh (Head, FSRCHPR, Plandu Ranchi) suggested the farmers to increase their income through integrated farming systems. A seminar *cum* exhibition on “Crop Diversification for Nutritional Security” was also organized during which twenty progressive farmers were honored for their outstanding contributions to agriculture and animal husbandry.

Fig. 19.23 Inauguration of Hi-tech nursery

Fig.19.24 Inauguration of Administrative building

Exposure Visits of Tribal Farmers to Agrotech Farmers Fair at BAU, Ranchi

The KVK organized an exposure visit of 50 tribal farmers to BAU, Kanke (Ranchi) on February 3, 2023. The farmers also participated there in the Agrotech Farmers Fair, which proved to be a transformative experience for the tribal farmers.

Fig. 19.25 Exposure Visits of Tribal Farmers to Agrotech Farmers Fair at BAU, Ranchi

Field Days on Vegetables and Lentil

On February 17, 2023, a field day was organized at Village Lodhma (Block: Ramgarh; District: Ramgarh) with a focused agenda on promoting Rabi vegetables (onion, pea and faba bean) under the Tribal Sub Plan (TSP). This initiative aimed to encourage year-round vegetable farming, particularly during the winter season, and to showcase various innovative techniques for vegetable cultivation. In continuation, another Field Day on lentil (HUL 57) was organized at Vyang village of the Dulmi block on March 23, 2023 which served as a pivotal platform for farmers and agricultural experts to exchange invaluable insights into the cultivation and performance of the Lentil variety, *HUL57*.

Fig. 19.26 Field day on Lentil Cv. HUL 57

Fig.19.27 Field Day on Rabi Onion under TSP

Distribution of Small Farm Implements

Seven hand-operated farm tools were distributed to selected farmers under the Scheduled Caste Sub-Plan (SCSP) program. These farm implements were specifically designed to enhance farmers' efficiency in various agricultural operations, particularly in vegetable cultivation.

Tribal Sub Plan activities

The demonstration of specific varieties of vegetable crops, such as tomato (Swarna Sampada and Swarna Lalima), brinjal (Swarna Pratibha and Swarna Shyamali), chilli (Swarna Praphulya), bottle gourd (Swarna Sneha), ridge gourd (Swarna Manjari and Satputia), sponge gourd (Swarna Prabha), faba bean (Swarna Safal) and vegetable pea (Arkel), has been vital in promoting crop diversification and improving the net income to the tribal farmers. Furthermore, providing pure bucks of the local *Black Bengal* breed of goats on a community basis has significantly contributed to enhancing the breed's overall genetic potential. This approach has led to a noticeable increase of 15 to 20% in the average body weight of the kid, indicating improved livestock management and productivity within the community. Similarly, the demonstration of the improved backyard breed of poultry (Sonali) resulted in notable progress, with an average body weight of 2.5 kg in 6 months and an egg production of 230 eggs per annum. This intervention not only promoted sustainable poultry farming practices, but also contributed to the economic empowerment of the tribal farmers through enhanced poultry productivity.

Fig. 19.28 Black Bengal buck distribution under TSP Project

Fig. 19.29 Seed distribution under TSP Project

District Agromet Advisory Services

The issuance of 26 block-level Agromet Advisory bulletins in bilingual format by the *District Agromet Advisory Services* (DAMU) of the KVK (under the aegis of ICAR-RCER, Patna) has significantly contributed to the dissemination of crucial agricultural information to a wide array of stakeholders in the district. Through the utilization of Information and Communication Technology tools, the advisory service has effectively reached and benefited approximately 250 stakeholders and nearly 2980 progressive farmers.

Fig. 19.30 Meeting for Agromet Advisory with FPOs

Fig. 19.31 Awareness program under DAMU

20 Participatory Research Application for Year-round income and Agricultural Sustainability

Participatory Research Application for Year-round income and Agricultural Sustainability

PRAYAS is a flagship outreach program of ICAR-RCER Patna, dedicated to demonstrating advanced agricultural technologies across seven states in Eastern India: Bihar, West Bengal, Jharkhand, Odisha, Assam, Eastern Uttar Pradesh, and Chhattisgarh (Fig. 20.1) in collaboration with ICAR-National Institute of Biotic Stress Management (NIBSM) Raipur and ICAR – Indian Institute of Agricultural Biotechnology (IIAB). This initiative integrates the TSP, SCSP, and other institutional programs under one umbrella. The primary objective is to enhance agricultural productivity and sustainability through improved practices. PRAYAS also focuses on creating awareness and providing skill development opportunities for resource-poor farmers, enabling them to adopt profitable farming techniques. By establishing linkages with grassroots stakeholders, the project ensures the widespread adoption of these practices. Additionally, PRAYAS examines the impact of institutional interventions on sustainable livelihoods. Through participatory research and community engagement, PRAYAS empowers farmers, promotes agricultural sustainability, and contributes to improved livelihoods and economic resilience in the region. Fig. 20.1 Study Areas of PRAYAS in Eastern India

Fig. 20.1 Study Areas of PRAYAS in Eastern India

Table 20.1: Villages adopted under the PRAYAS in Eastern India

SC Villages (8)	ST Village (8)	District (12)	State
Dhipuji Janpam, Chandrapur Block	Rewa-Mahaswari Demoria block	Kamrup District	Assam
-	Naurangia, Ramnagar Block	Bettiah (West Champaran)	Bihar
Selhauri, Dulhin Bazar Block	-	Patna	
Guleriyachak, Tekari Block	-	Gaya	
Kumekela, Pathalgaon Block	Kandora Kunkuri block	Jashpur	Chhattisgarh
Basantpur, Sohaon Block	-	Ballia	Eastern UP
-	Palandu and Kharsidag, Namkum Block	Ranchi	Jharkhand
Udlu Mandu block	Lodma Ramgarh	Ramgarh	
Mangratoli village Nuagaon block	-	Sundargarh	Odisha
Begunbari Habibpur Block	Hatinada, Baghmundi Block, Ajodhya Hill,	Purulia	West Bengal
-	Chandandighi, Gazole block	Malda	
-	Chakkathalia, Bagda Block	24 Parganas	

The PRAYAS project has concentrated its efforts on villages classified as Scheduled Caste (SC) and Scheduled Tribe (ST) across 12 districts in 7 states within Eastern India. This initiative aims to implement targeted technological interventions to foster development and address the unique needs of these communities (Table 20.1). A comprehensive needs assessment survey was conducted, followed by a problem prioritization process employing multi-criteria decision-making techniques. This methodological approach allowed for a systematic evaluation of the identified needs and gaps, assessing them based on their significance and potential impact. Each identified issue was subsequently assigned a score to denote its priority in enhancing agricultural sustainability and promoting income generation within the targeted regions (Table 20.2).

Table: 20.2 State wise major issues and Interventions under PRAYAS

Major issues	Interventions	State
Lack of quality planting material, prevalence of rain-fed farming	Plantation crops and horticultural based IFS	Assam
Lack of livelihood opportunities, dearth of quality seed and agricultural technologies	Promotion of backyard poultry mushroom for income generation, Skilling women and promotions of Nutrigarden	Bihar
Majority of Rice fallow area, Water scarcity, Lack of livelihood opportunities	Goat Based IFS	Chhattisgarh
Wide knowledge gap regarding advance agricultural practices, lack of improved variety of vegetables	Trainings, Vegetable based interventions	Eastern UP
Water scarcity, hilly topography, wide skill and technology gap	Pig based and Horticulture based IFS	Jharkhand
Water scarcity, poor farmers, very low land holdings	Promotion of backyard poultry,	Odisha
Lack of marketing facilities, Lack of improve varieties of Crops and breeds	Mushroom for nutrition and income, Poultry, Goat and Fish based interventions	West Bengal
Lack of quality planting material, water scarcity	Plantation crops and horticultural based IFS	Assam
Lack of livelihood opportunities, quality seed and agricultural technologies Quality seed of crop and vegetable and Livelihood for farmers	Promotion of Backyard Poultry, Skilling Women and promotions of Nutrigarden	Bihar
Rice fallow, Water scarcity, technology gap	Goat Based IFS	Chhattisgarh
Irrigation facility, improved variety of vegetables	Vegetable based interventions	Eastern UP
Water scarcity, Unemployment, Wide skill and technology gap	Pig based and Horticulture based IFS	Jharkhand
Water scarcity	Promotion of backyard poultry	Odisha
lack of market, unemployment and marginalization, lack of improve varieties of Crops, chick and fisheries	Mushroom Poultry and Goat and Fish based interventions	West Bengal

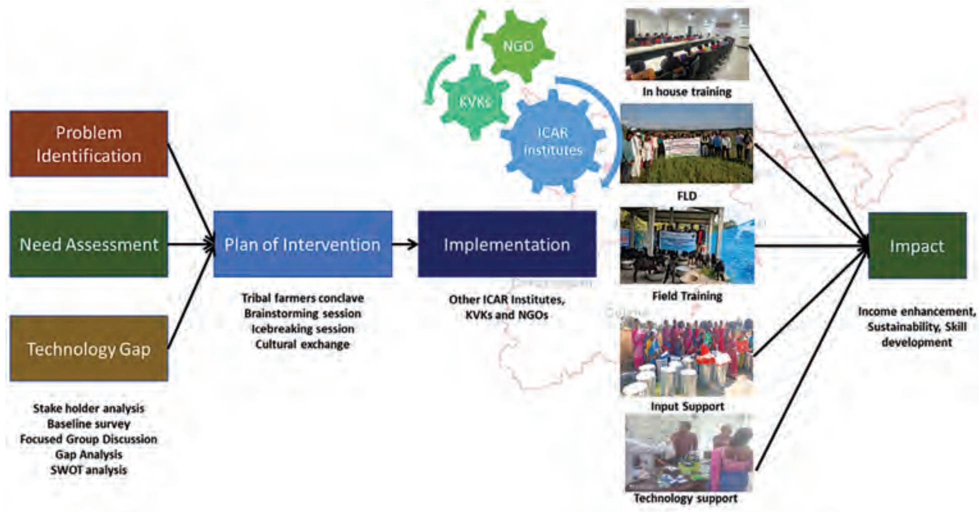


Fig. 20.2 Process model of PRAYAS

The PRAYAS process model delineates the systematic approach undertaken to address agricultural challenges in Eastern India, progressing from problem identification to achieving measurable impact. The model begins with the identification of issues, needs assessment, and the recognition of technological gaps. These insights inform the development of a strategic intervention plan (Fig. 20.2).

Implementation is conducted collaboratively by ICAR institutes, Krishi Vigyan Kendras (KVKs), and non-governmental organizations (NGOs), ensuring the necessary expertise and resources are in place. Training forms a core component of the process, encompassing in-house sessions, front-line demonstrations, and field training provided to farmers. This structured approach leads to significant outcomes, including increased income, sustainable farming practices, and skill development, thereby enhancing the livelihoods and economic resilience of farming communities in the region.

The implementation strategy focuses on three specific goals: income enhancement for farmers, sustainability of agricultural systems, and human resource development. Under the sustainability component, efforts such as drudgery reduction through the provision of small tools and implements, and knitting machines for women, were initiated. Farmers were exposed to improved technologies, including modern varieties, breeds, and comprehensive packages of practices (Table 20.3).

Location-specific programs were tailored to meet the unique needs of local populations. For example, in West Bengal, farmers received water pumps and pipes for irrigation, as well as seed storage bins to preserve local seeds. In Bihar, water pumps were provided to support vegetable cultivation during the *rabi* season.

Income enhancement activities were promoted through cost-minimizing technologies, secondary agriculture initiatives, and establishing linkages with stakeholders such as KVKs. These integrated efforts collectively aimed at achieving the overarching goals of the PRAYAS project: enhancing farmer incomes, ensuring the sustainability of agricultural systems, and fostering human resource development (Fig. 20.3).

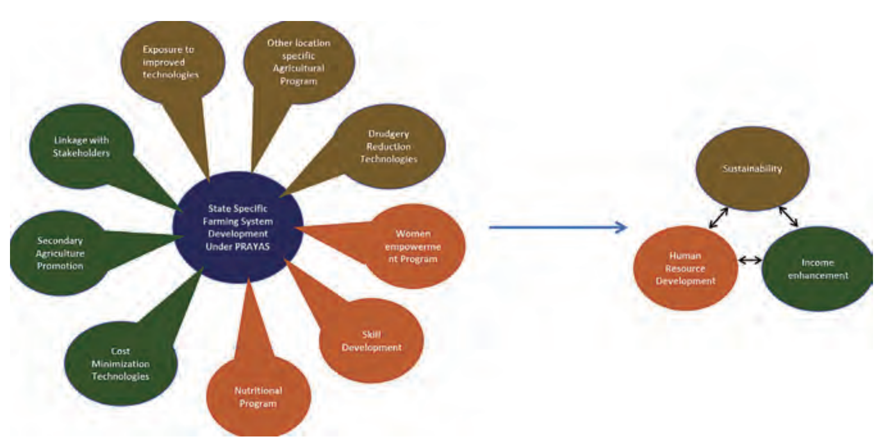


Fig. 20.3 Components of PRAYAS intervention for attaining Sustainability, income enhancement and human resource development

Table 20.3 State wise interventions under PRAYAS

Program	Assam	West Bengal	Bihar	Jharkhand	Chhattisgarh	Eastern UP	Odisha
Capacity Building							
Trainings (No.)	2	3	4	8	3	2	3
Awareness programs (No.)	4	7	5	14	5	4	4
Tribal farmers conclave							
Tribes attended	Rabha	Santhal	Tharu	Santhal	Gond	Gond	Munda
Farmers participated	7	14	600	30	7	15	7
Interventions for enhancing income and sustainability							
Farms tools for drudgery reduction and resource Use efficiency (No.)	12	247	579	1057	156	254	116
HYV seed for FLDs(ha)		4	5	15	2	5	2
Plants for agroforestry/home garden (Nos. household)	50	15	30	220		20	
FYM/Biofertilizer/ Vermi compost based interventions		10	20	25	10	15	15
Goat/Pig based IFS model developed		25	60	75	40		15
Backyard Poultry based intervention		30	70	30			30
Animal Health Camps conducted	1	2	3	1			
Beneficiaries							
SCSP	-	341	225	-	159	255	192
TSP	144	647	748	8550	-	-	-
Total beneficiary	144	988	973	8550	159	225	192
Female	35	547	587	2736	61	22	35
Male	109	441	386	5814	98	203	157

Baseline survey

Need identification

c. Farm Resource survey

d. Village resource survey

Fig. 20.4 a,b,c & d Data collection from different villages under PRAYAS

a. Goat based Intervention

b. Backyard Poultry based interventions

a. Knitting machine for year-round income of farm women

b. Promotion of Nutri-garden for women

Fig. 20.5 a,b,c & d Agricultural imput distributed under PRAYAS

a. Tribal Dance performance (Gond tribes of Bihar) during Tribal Farmers Conclave

b. Tribal Dance performance by Santhal Tribes of Jharkhand during Tribal Farmers Conclave

c. Products of tribal FPO for displayed during Tribal Farmers Conclave

d. Awards to tribal farmers for conservation practices

Fig. 20.6 a,b,c & d Different activities conducted under PRAYAS

21 Training and Capacity Building

The employees of the institute regularly undergo training and capacity building activities in order to keep themselves updated in concerned discipline. Following employees of the Institute have undergone training during year 2023.

Table 21.1 Proportion of employees undergone training

Category	Total No. of employees	No. of trainings planned for each category during 2023-24 as per ATP	Total No. of employees undergone training during January to December 2023	% Realization of trainings planned during 2023-24
Scientist	71	12	20	100
Technical	46	3	7	100
Administrative & Finance	17	16	3	18.75
SSS	36	10	0	0
Total	**170**	**41**	**19**	**73.17**

Feedback of trainees were collected, consolidated and sent to ICAR, New Delhi.

Table 21.2 HRD fund allocation and utilization (Rs. in Lakh)

S. No.	BE 2023-24 for HRD	Actual expenditure up to December, 2023	% Utilization
1	0.56	0.56	100.00

Sponsored Training Programmes Organised

The following farmers' training programmes have been conducted at ICAR–RCER, Patna and FSRCHPR, Ranchi during year 2023-24.

Table 21.3 List of Farmers training sponsored/organized by the institute

Name of training programme	Sponsoring authority	Duration	No of participants
Opportunities in the processing of vegetable soybean	ICAR-RCER Patna	10 Jan, 2023	79
Hybrid seed production in vegetables	ABI, ICAR RCER	10 - 12 Jan, 2023	26
Hybrid seed production in vegetables	ABI, ICAR RCER	13 - 15 March, 2023	29
Fruit crops management and maintenance	AICRP of fruits (TSP)	13 March, 2023	50
Fruit crops management and maintenance	AICRP of fruits (TSP)	27 March, 2023	50
Scientific cultivations of vegetables	GT Bharat LLP Hazaribagh	15 -17 May, 2023	54
Integrated farming system for climate change adaptations	Watershed management project, Bokaro	28 Aug to 01 Sept 2023	25
Integrated farming system for climate change adaptations	Watershed management project, Bokaro	04-08 Sep,2023	25

Name of training programme	Sponsoring authority	Duration	No of participants
Integrated farming system for climate change adaptations	Watershed management project, Bokaro	11-15 Sep, 2023	25
Application of drone in agriculture	Agri-drone project	11 Oct, 2023	50
Integrated Farming System practices	Extension training Centre, Hehal, Ranchi	24 Nov, 2023	45
Integrated Farming System practices	Extension training Centre, Hehal, Ranchi	30 Nov, 2023	45
Integrated Farming System practices	Extension training Centre, Hehal, Ranchi	05 Dec, 2023	47
Integrated Farming System practices	Extension training Centre, Hehal, Ranchi	14 Dec, 2023	26
Production technology of milky mushroom	AICRP on Mushroom	08 Feb, 2023	25
Production technology of oyster mushroom and their value addition	AICRP on Mushroom	15 Feb, 2023	25
Production technology of oyster mushroom and their value addition	AICRP on Mushroom	01 – 02 March, 2023	25
Production technology of oyster mushroom and their value addition	AICRP on Mushroom	03 March, 2023	25
Integrated Farming System for Rainfed Ecosystem	Scheduled Caste Sub Plan (SCSP)	20 – 22 March 2023	25
Integrated Farming System for Doubling Farmers Income”	Scheduled Caste Sub Plan (SCSP)	21 – 23 March, 2023	25
Techniques on Phenotypic characterization in livestock and poultry	ICAR-RCER, Patna	19-21 Dec., 2023	7
ABIGROW 2.0 for Incubates organised by ICAR NAARM, Hyderabad	ABI Project	22-24 Oct 2024	5

Table 21.4. Training programs organised for master trainers

Name of master training programme	Duration	No. of participants	Sponsoring authority
Propagation and nursery management in horticultural crops	26 Dec 2022 to 05 Jan 2023	21	BAU, Ranchi
Improved cultivation practices in horticultural crops	06 - to 17 Feb 2023	11	YBN, University, Ranchi
Recent advances in Entomology	22 May to 01 June 2023	25	BBMKU, Dhanbad

Table 21.5. Field Day/KisanGoshthi/Awareness programmes

S No	Name of Programme	Sponsoring Agency	Organised at	Date of Programme	No of participants
1.	Awareness programme on ABI Project	ABI Project	FSRCHPR, Ranchi	07.06.2023	100
2.	Field Day on “Paddy-Swarna Shreya”	Farmer First Programme	Malti village, Namkum, Ranchi	17.11.2023	65

S No	Name of Programme	Sponsoring Agency	Organised at	Date of Programme	No of participants
3.	Kishan-Vaigyanik Samvad	ICAR-RCER	FSRCHPR, Ranchi	16.12.2023	500
4	Animal Health Camp	Scheduled Caste Sub Plan (SCSP) of Govt. of India	Kumekela, Pathalgaon, Jashpur Chhattisgarh	22.03.2023	7310
5	Animal Health Camp	Farmer FIRST Programme	Malti, Namkum, Ranchi	07.11.2023	700

Table 21.6. Training attended by employees of FSRCHPR, Ranchi during 2023

Name of the person	Title of the training program	Organised by	Organised at	From date	To date
Dr Reena Kamal	Emerging Problems and Recent Advances in Applied Sciences: Basic to Molecular Approaches	ASTHA Foundation, Meerut, U.P.	Online Mode	26.02.2023	18.03.2023
Dr Ajit K. Jha	Training on Mushroom Taxonomy Research, Solan	ICAR-Directorate of Mushroom	ICAR-DMR, Solan	22.03.2023	23.03.2023
Dr Bhavana P.	Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management	Astha Foundation, Meerut, U.P.	Online Mode	10.082023	20.08.2023
Dr Bhavana P.	Next Generation Sequencing and Data Analysis	ICAR NAARM, Hyderabad	Online Mode	16.10.2023	20.10.2023
Dr Jaipal S Choudhary	Laboratory assessor’s	National Accreditation Board for Testing and Calibration Laboratories, Gurgaon	ICAR-CIFRI, Barrackpore, Kolkata	17.01.2023	17.01.2023
Dr Meenu Kumari	Training Programme on Next Generation Sequencing and Data Analysis	ICAR-NAARM, Hyderabad	Online Mode	16.10.2023	20.10.2023
Dr Santosh S Mali	Capacity building program on advance tools for sustainable water management	International Water Management Institute, New Delhi	IWMI, Colombo, Sri Lanka	15.11.2023	25.11.2023
Dr Santosh S Mali	“Remote Pilot Course” approved by the Directorate General of Civil Aviation (DGCA)	Indira Gandhi Rashtriya Udran Academy, New Delhi	Drone Destination, Bilaspur, Haryana	18.03.2023	22.03.2023

Training/exposure visit/workshop etc organized at ICAR RCER, Patna

- Training programme on “Management strategies for improving agricultural production” sponsored by ATMA, Madhepura at ICAR-RCER, Patna from 23-25th January, 2023.
- 10 weeks Industrial attachment/Internship (student READY) training to B. Tech. (Agri. Engg.) student on “Land and water management techniques in agriculture” sponsored by Dr RPCAU, Pusa, Samastipur at ICAR-RCER, Patna during 2nd January-10th March, 2023.
- Training programme on “Millet production under climate change scenarios” sponsored by ATMA, Lakhisarai at ICAR-RCER, Patna from 17-19th October, 2023.
- Five days farmer’s training programme on “Soil and Water conservation for Sustainable Agriculture Development” was organized at ICAR-RCER, Patna during 30th October -3rd November 2023 sponsored by BAMETI, Patna, Bihar.
- Training programme on “Land & Water Management Techniques in Agriculture” of six B.Tech (8th semester, Agril. Engg.) students from College of Agricultural Engineering & Technology, Dr. RPCAU, Pusa during 2nd January 2023 to10th March 2023.
- Two days training on “Recent agriculture technologies for livelihood improvement of farmers” (SCSP funded) was conducted during 18th to 19th August, 2023 at Begunbari village, Habibpur block, Malda district in West Bengal jointly by ICAR-Research Complex for Eastern Region Patna and ICAR-CISH Regional Research Station, Malda. Workshop on “Gender Dynamics of Seed Systems in Bihar” organized at ICAR RCER, Patna on November 07, 2023.
- Awareness Programme on “Farm waste management” organized on 22 December, 2023 at Buxar district.
- High-End Workshop (Karyashala) on “Advanced Instrumentation for Assessment of Greenhouse Gas Emission and Molecular Techniques in Microbial Diversity Analysis” organized from 21-27 June, 2023 at ICAR RCER, Patna sponsored by SERB, New Delhi..
- Consultancy Workshop on “Building a community based resilient and sustainable food security model through community participation in Bihar under national food security ACT 2013” organized by Centre, DIRECT, Abhiyan and Vikash Samvad on 29.03.2023 at ICAR RCER, Patna.
- Training Programme on Vermicomposting and mushroom cultivation” on 09-02-2023 at ICAR-RCER, Patna.
- Training programme on IFS at ICAR-RCER Research Farm w.e.f. 28-30 August 2023, funded by ATMA, Bhagalpur.
- Training programme on Crop Diversification for farmers of East Champaran district at KVK, Piprakothiw.e.f. 07-08 Nov. 2023.
- Training programme on Crop Diversification for Extension personnels of East Champaran district at KVK, Piprakothiw.e.f. 08-09 Nov. 2023.
- Training programme on Crop Diversification for farmers of West Champaran district at Samudayik Bhawan, Betiah w.e.f. 07-08 December 2023.
- Training programme on Crop Diversification for Extension personnels of West Champaran district at Samagra Sikchhan and Vikas Sansthan (NGO), Betiah w.e.f. 08-09 December 2023.
- Exposure visit on IFS for 50 farmers w.e.f. 17-18 August 2023 at IFS site of ICAR-RCER, Patna.
- “Farmers-Scientist interaction” meeting organized on February 22, 2023.at ICAR RCER, Patna.
- National Workshop as the capacity of organizing Secretary on ‘Agricultural Water Management in Changing Climate’ on March 27, 2023 at ICAR Research Complex for Eastern Region, Patna.
- Field day-cum-awareness programme on “Livelihood Improvement of Scheduled Caste Farmers through Agricultural Technology Inputs” held during 21-22nd January, 2023 at Balsagra village of Hazaribagh district (Jharkhand) under Schedules Caste Sub-Plan (SCSP).
- Farmer response programme on 25th January, 2023 under SCSP project at Saristabad village (Block: Nobatpur) Patna.
- Awareness programme on “Livelihood Improvement of Scheduled Caste Farmers through Agricultural Technology Inputs” held during 23-25th February, 2023 at Ballia, Uttar Pradesh under Schedules Caste Sub-Plan (SCSP).
- Farmers awareness programme on “Kisano ke bich kurshi mausam pramar shseva ka prasar” at Silhouri village, Patna on 2nd June, 2023.
- Farmers awareness programme on “Kisano ke bich kurshi mausam pramar shseva ka prasar avm kisano ke liye es ka mahatav” at Saristabad, Patna on 8thJume, 2023.

- Awareness-cum-input distribution programme on "Livelihood Improvement of Scheduled Caste Farmers through Agricultural Technology Inputs" held during 18-19th July, 2023 at Basantpur (Narsingh patti-1 & 2), Ballia, Uttar Pradesh under Schedules Caste Sub-Plan (SCSP).
- Awareness-cum-demonstration programme on "Spraying of Agro-chemical through drone at farmers' field" on 9th August, 2023 at Murgiyachak village, Rahui block, Nalanda under Agri-drone project.
- Awareness-cum-demonstration programme on "Application of drone technology in agriculture" on 11th October, 2023 at FSRCHPR, Ranchi Jharkhand under Agri-drone project.

Participation of employees in Training

- Manisha Tamta completed "German Language A1 Certificate Course" from 15th November 2021-28th February 2022 with "A" grade, under Institutional Development Plan of National Agricultural Higher Educational Project (IDP-NAHEP) at G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand.
- Manisha Tamta completed 6-week course on "Certificate Course in Machine Learning using Python" from 15th February - 12th April, 2022 with "S" grade, conducted by National Institute of Electronics & Information Technology, Gorakhpur.
- Manisha Tamta completed training workshop on "Crop Simulation Modelling for Managing Agriculture under Changing Climates" organized by The Alliance of Bioversity International & CIAT, New Delhi during 22-26 May 2023.
- Manisha Tamta completed 12th Advanced Course on Conservation Agriculture for Asia & North Africa: Gateway for Sustainable and Climate Resilient Agrifood Systems" organized by International Maize and Wheat Improvement Centre (CIMMYT), ICAR-Central Soil Salinity Research Institute (CSSRI) and Borlaug Institute for South Asia (BISA) during 09-24 December, 2023 in India.
- Santosh Kumar participated in training on "Users Training cum Workshop on AICRIP Intranet functionalities" organized by ICAR-IIRR, Hyderabad (in virtual mode) during 15-17th February 2023.
- Santosh Kumar Rakesh Kumar, TK Koley, AK Dubey, K. Shubha, and Saurabh K, participated in Pedagogical Development Programme on "Enhancing Pedagogical Competencies for Agricultural Education" during at National Academy of Agricultural Sciences (NAAS), New Delhi
- Ved Prakash attended training programme on "Impactful ICT Applications and Technologies in Agriculture" during 6-10th February, 2023 organized by ICAR-NAARM, Hyderabad.
- Ved Prakash attended training programme on "Big Data Analytics in Agriculture" during 09-10th March, 2023 organized by ICAR-NAARM, Hyderabad.
- Sonaka Ghosh attended Pedagogical Development Programme on "Enhancing Pedagogical Competencies for Agricultural Education" organized by NAAS, New Delhi held from 25-30th September, 2023.
- Sonaka Ghosh attended the training programme on "12th Advanced Course on Conservation Agriculture for Asia and North Africa" organized by CIMMYT and BISA from 09-24th December, 2023.
- Akram Ahmed attended online training programme on "Data Visualization using R" during 1-8th March, 2023 organized by ICAR-NAARM, Hyderabad.
- Akram Ahmed attended online training programme on "Impactful ICT Applications and Technologies in Agriculture" during 6-10th February, 2023 organized by ICAR-NAARM, Hyderabad.Ved Prakash attended training on "Management strategies for improving agriculture production" from 23-25th January 2023 at ICAR-RCER, Patna.

Participation in Conferences/Seminars/Workshops/ Symposia/Meetings/Brain storming sessions

1. A Upadhyaya attended 2ndBihar Food Processing & Agritech Startup conclave cum Expo and Industry Meet at Chandragupt Institute of Management Patna on 9th October, 2023.
2. A Upadhyaya attended Consultation meeting regarding training and resource persons organized by BAMETI, Patna on 30th June, 2023.
3. A Upadhyaya attended IWMI-CYMMIT meeting at Hotel Maurya, Patna on 12th October, 2023.
4. A Upadhyaya attended Online review meeting of ITMUs/ZTMCs/ABIs in the discipline on NRM on 25th May, 2023.
5. A Upadhyaya attended SLSC meeting for PMKSY at Patna on 23rd June, 2023.
6. A Upadhyaya presented a paper on World Food Day 2023: Water is Life, Water is Food: Leave No One Behind in a Seminar on World Food Day organized

by Bihar State Productivity Council, Patna on 16th October 2023.

7. A.K Chaudhary attended (Online) a National Seminar on "*Pulses Promotion*" organized by ICAR-IIPR, Kanpur on May 22, 2023.

8. A.K Chaudhary attended "Planning *cum* Launch" meeting of DAC funded Network Project on Lentil organized by ICAR-IIPR, Kanpur on October 31, 2023.

9. A.K Chaudhary attended "State Rabi Group Meet" (Online) on October 06, 2023 organized by BAU, Sabour.

10. A.K Chaudhary attended meetings organized for finalization of Bihar Krishi Road Map-IV on January 06, 11 and 19, 2023.at Bihar Animal Science University, Patna.

11. A.K Chaudhary participated and conducted Breeder Seed Monitoring of pulses at ICAR RCER, Patna on March 14, 2023.

12. AK Singh, Pawan Jeet, A Upadhyaya, S Ghosh and A Das presented paper on "Scope of Natural Farming in Bihar" in the International Conference on 'Natural Farming for Revitalizing Environment and Resilient Agriculture (NF-RERA – 2023)' held during 17-19th March, 2023 organized at College of Agriculture, Iroisemba, Central Agricultural University, Imphal, Manipur.

13. AUpadhyaya attended national workshop on agricultural water management in changing climate at ICAR Research Complex for Eastern Region, Patna on 27th March, 2023.

14. AUpadhyaya. attended Agriculture Advisory Committee meeting organized by Doordarshan Kendra Patna on 2nd June, 2023.

15. Bikash Sarkar and PK Sundaram attended QRT meeting and presented 5-year achievements of CRP on FM & PF project (2017-2022) at CCS HAU Hisar during 26-27th July 2023.

16. Bikash Sarkar and PK Sundaram participated and presented annual report of Consortia Research Platform (CRP) on Farm Mechanization and Precision Farming (FMPF) and Micro-irrigation System (MIS) at Virtual Platform on 12th January, 2023 during 8th Annual Review Workshop.

17. Kirti Saurabh attended a workshop on Dissemination of project learnings and white paper on Nitrogen Use Efficiency (NUE) jointly organized by Environmental Defence Fund, Digital Green, CIMMYT and JEEViKA on 8th August 2023 at Hotel Chanakya, Patna.

18. Kirti Saurabh attended Hindi workshop (online) on Introduction to Statistical and Machine Learning Techniques in Agriculture conducted during June 06-12, 2023 at ICAR-Indian Agricultural Statistics Research Institute, New Delhi.

19. Meenu Kumari attended All India Co-ordinated Research Project (Vegetable Crops) Annual meeting at Sher-e-Kashmir University of Agriculture Science & Technology, Jammu & Kashmir from 3-5 June, 2023

20. Meenu Kumari attended International conference on Environment, Aquaculture and sustainable agriculture held at Department of Botany, St. Xavier's College, Ranchi on 22-24 September, 2023.

21. Meenu Kumari participated in on-line mode "National conference on ethnic vegetables at DR. YSRHU-College of Horticulture, Anantharajupeta during 27-28th May, 2023".

22. Meenu Kumari presented (online mode) a paper on "*Eryngiumfoetidum* L.: A potential aromatic herb for tropical regions of India" in National conference on ethnic vegetables at DR. YSRHU-College of Horticulture, Anantharajupeta during 27th to 28th May, 2023.

23. Mridusmita Debnath presented paper in a National conference on "Machine learning taknik ka upoyog karte huwe rainshadow ksetra mein jalwayu paribartan pravawit stream flow projections" on "Jalwayu paribartan ebang jal prabandhan" organized by 7thRashtriya Jal Sanghosthi. NIH Roorkee, Uttarakhand during 17-18 August, 2023.

24. Pawan Jeet participated in the "drone pilot training programme" during 29th March to 2nd April, 2023 held at Drone Destination, Bilaspur, Haryana.

25. Pawan Jeet presented a paper in an International conference on 'Natural Farming for Revitalizing Environment and Resilient Agriculture (NF-RERA – 2023)' held during 17-19th March, 2023 at College of Agriculture, Iroisemba, Central Agricultural University, Imphal, Manipur.

26. PK Sundaram attended state level technical committee Meeting on 27.04.2023 at Krishi Bhawan, Mithapur, Patna

27. PK Sundaram attended workshop on Agricultural Water management in Changing Climate on 27th March, 2023.

28. Rachana Dubey attended "Webinar on Carbon Credit for Ecosystem services in Agriculture" on 7th November 2023, organized by National Institute of Agricultural Extension Management, Hyderabad.

29. Rakesh Kumar Attended Innovation in Agri-food Systems through the Hub Models organized by CIMMYT, Texacco, Mexico on October 22-29, 2023.

30. Reena Kumari Kamal attended "International conference on environment, Aquaculture and sustainable agriculture" held at department of Botany, St. Xavier's college, Ranchi on 22nd-24th September, 2023.

31. Reena Kumari Kamal attended National Conference on "Futuristic Approach to Viable Animal Production vis-à-vis Climate and Calamity Challenges" on the occasion of 29th Annual Convention of Indian Society of Animal Production & Management (ISAPM) – 2023 held at C.V.S. & A.H., OUAT, Bhubaneswar-3 during 18-20 January, 2023.

32. Reena Kumari Kamal participated in the meeting of Institute Animal Ethics Committee (IAEC) for control and supervision of experiments on animals (CCSEA), Department of Animal Husbandry and Dairy, Govt. of India on 29.03.2023 as Scientist from outside the institute at Sidho-Kanho-Birsha-University, Ranchi Road, Sainik School, Purulia, W. Bengal on 29.03.2023.

33. RS Pan attended 2nd Regional Advisory Group Meeting of NABARD at Ranchi on 14.02.2023

34. RS Pan attended International Conference on "New Generation Horticulture for Prosperity" held at OUAT, Bhubaneswar on 20-21 January, 2023 on virtual mode and made oral presentation on "Evaluation of edamame/vegetable soybean for horticultural and nutritional characters" on 20.01.2023.

35. RS Pan attended International Conference on "Sustainable Natural Resource Research-2023" held at Bhubaneswar on 18-19 November, 2023 on virtual mode and made oral presentation on "Evaluation of aromatic/*Basmatic* vegetable soybean for yield and nutritional quality" on 18.11.2023

36. RS Pan attended Meeting of DG, ICAR on Review of ICAR Institutes of Jharkhand on virtual mode on 14.12.2023

37. Sanjeev Kumar Participated in the Bihar Millet Conference & Expo, organized by FSSAI, Kolkata and PHD Chamber of Commerce & Industry at Urja Auditorium, Patna on 29th April 2023.

38. Sanjeev Kumar Participated in the National Symposium on "Climate Smart Agronomy for Resilient Production System and Livelihood Security" organized by Indian Society of Agronomy, New Delhi at CARI, Goa from 22 to 24 November 2023.

39. Sanjeev Kumar Participated in the VII Biennial Workshop on IFS, organized by IIFSR, Modipuram and MPKV, Rahuri at MPKV, Rahuri from 18 to 21 Jan, 2023.

40. Santosh Kumar participated and given presentation in the launch meeting of ICAR-IRRI collaborative project "Plant Direct (Dry Direct Seeded Rice for the Indo-Gangetic Plains of India) project" aligned to the proposed Thematic IRRI-ICAR work plan 2023-2027 held on March 3, 2023 at PAU, Ludhiana.

41. Santosh Kumar participated in an international webinar on "Intellectual Property Rights (IPR): Patents, Designs, Trademarks, GI & Copyrights" organized by Bioingene.com on 26th October, 2023.

42. Santosh Kumar participated in One IRRI-NARES India Advancement Meeting-2023, conducted during April 6-8, 2023 at IRRI South Asia Hub, Hyderabad, Telangana State, India

43. Santosh Kumar participated in Regional Stakeholder Consultation Meeting cum workshop organized by Agrinnovate India Ltd. In collaboration with RPCAU at KVK, Madhopur (West Champaran), Bihar on 06.11.2023.

44. Santosh Kumar participated in State level approval committee meeting under Rashtriya Krishi Vikash Yojana (RAFTAAR) on 10.01.2023 organized under chairmanship of Developmental Commissioner, Bihar by Directorate of Agriculture, Bihar.

45. Santosh Kumar participated in the Unit Cost Committee Meeting for demonstration programmes of different crops during 2023-2024, organized by Directorate of Agriculture, Bihar on 28.04.2023at Krishi Bhawan, Mithapur, Patna, Bihar, India.

46. Sonaka Ghosh presented research work in XXII Biennial National Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security" held at ICAR-CCARI, Goa from 22-24 November, 2023.

47. SS Mali participated in IPSR Innovation Scaling Workshop on Solar Irrigation Pump (SIP) Sizing Tool for Nepal oraganised by International Water Management Institute at Kathmandu, Nepal during June 26-27, 2023.

48. Ved Prakash attended international conference on "Climate Resilient Agriculture for Food Security and Sustainability" organized by CCS Haryana Agricultural University, Hisar from February 17-19, 2023.

49. Ved Prakash, MM Lunagaria, AP Trivedi and A Upadhyaya presented in an International conference on Agrivoltaic system impacts on solar radiation distribution in a middle Gujarat region. Paper "Climate Resilient Agriculture for Food Security and Sustainability" organized by CCS Haryana Agricultural University, Hisar from February 17-19, 2023.

50. Y Kumar, V Prakash, N Naushik and ML Khichar presented paper in an international conference on Enhancing microclimatic conditions through agrivoltaic system for betterment of food security on "Strategies for global food and national security, sustainability and wellness-NUTRI-2023" organized by CCS Haryana Agricultural University, Hisar from December 4-6, 2023.

Field Day/KisanGoshthi/Mass awareness programme attended by employees of KVK, Buxar

Training/Workshop/Seminar	Venue	Date	Name of personnel
Participated Awareness programme on state level farmer programme on Sri Ann Mota Anaj Mahotsav organized by NCDEXIPF & PACS, AatharBuxar in the chairmanship of Honorable Sri Ashwani Kumar Chauve, MoSGoI,	Athar Buxar	Feb 12, 2023	Dr Deo Karan
Participated in review meeting on financial progress of KVK and projects at, ATARI, Zone IV Patna. at ICARRCER, Patna on ATARI, Zone IV Patna	ATARI, Zone IV Patna	Feb 13, 2023	Dr Deo Karan
Participated ICARRCER,Patna foundation and farmer-scientist interaction.	ICARRCER, Patna	Feb 22, 2023	Dr Deo Karan
Attended as a member recruitment recommendation committee meeting for fill up SRF,NICRA Project KVK Buxar at ICARRCER, Patna.	ICARRCER, Patna.	Mar 22, 2023	Dr Deo Karan
Participated NICRA Project review workshop of NICRA KVKs and other official other work at ICARRCER&ATARI , Patna	ATARI, Patna	Mar 25, 2023	Dr Deo Karan
6th Annual Zonal workshop of KVKs Zone IV ATARI Patna. RKMVER, Institute from 8-10 July 2023Morabadi Ranchi	RKMVER, Morabadi Ranchi	8-10 Jul 2023	Dr Deo Karan
25thEextension Education Council meeting of DEE , Bihar Agricultural University, Sabour	BAU Sabour	Sep 22, 2023	Dr Deo Karan
Meeting on Seed Hub and expansion of horticulture crop area in district with Dr Mangla Rai, Former DG, ICAR and Agril. Advisor of Hon'ble CM of Bihar and Secretary Agril. Govt. of Bihar,	BAMETI, Patna	Sep 20, 2023	Dr Deo Karan
State Level Workshop on Natural Farming	KVK piprakothi Motihari	Sep17-18, 2023	Dr Deo Karan
Inaugural function of office Building cum Farmers fair of KVKRamgarh , Jharkhand.	KVK Ramgarh	Oct 31,2023	Dr Deo Karan
Exposure visit at Ethiopia (South Africa) by CIMMYT-BISA	ILRI, Ethiopia (South Africa)	Nov 2-7, 2023	Mr Ramkewal

22 IARI, Patna Hub

Indian Council of Agricultural Research has taken initiatives to upgrade the Indian Agricultural Research Institute, New Delhi as the IARI Mega University by creating multiple Hubs at different locations pan India involving ICAR institutes of the given locations based on Sun, planet and satellite model (Fig. 22.6). To this direction, IARI, New Delhi has initiated formal academic collaborations with 16 clusters of ICAR institutes in different regions across the country as per directive of the Secretary, DARE and DG ICAR, New Delhi. These clusters have been referred to as the IARI hubs. Since academic session 2023-24, ICAR-RCER, Patna has started to operate as one of the IARI hubs for eastern part of the country. This institute is a nodal institute as the planet, and ICAR-ATARI (Patna), Central Potato Research Station (Patna) and NRC on Litchi (Muzaffarpur) are satellite institutes of IARI Patna hub. Being a Research complex, it has an advantage of having faculties from different disciplines as well as research and seed production farms for the practical exposure to the student. There are few labs also, viz., soil laboratory, plant pathology laboratory and animal science laboratory, which are being utilized for practical classes. At present, there are 21 UG students (BSc Agriculture (Hons), 2 PG students and 01 Ph D student (Soil Water Conservation Engineering) in IARI Patna hub. The students are from Assam, Bihar, Chhattisgarh, Jharkhand, Haryana, Himachal Pradesh, Maharashtra, Kerala, Rajasthan, West Bengal and other parts of the country.

Fig. 22.1 UG - Students alongwith hub Director, Dr Anup Das at IARI-Patna hub, ICAR RCER, Patna

Fig. 22.2 Orientation Programme of newly admitted students at IARI-Patna hub, ICAR RCER, Patna

For the Academic Calendar Year 2023-24, a total of 45 courses were offered to students of Ph.D., M. Tech and B.Sc. (Hons) Agriculture. For the first semester of M. Tech. programme in Soil and Water Conservation Engineering, 7 courses were offered with 16 credit hour and in second semester there were 8 courses with 18 credit hour. Similarly, for Ph.D. in Soil and Water Conservation Engineering in first and second semester a total of 4 courses (15 credit hour) and 6 courses (16 credit hour) were offered respectively. For B.Sc. (Hons) Agriculture Course, there were 11 and 9 courses in first & second semester respectely of 24 credit each were offered.

Fig. 22.3 Field and practical experience of the Students, ICAR RCER, Patna

Fig. 22.4 Field and practical experience of the Students, ICAR RCER, Patna

Apart from the regular course work, many interactive sessions with eminent personalities of Agriculture sector were also organized for the benefit of students. In this series, Dr RS Paroda, Former Secretary (DARE) & DG, ICAR interacted with students in a virtual session and inspired and motivated them to do well in their chosen career during the Agricultural Education Day on December 3, 2023. During the visit of Dr. P. L. Gautam, Chancellor, Dr. RPCAU, Pusa & former VC, GBPUA&T, Pantnagar, an interaction with students took place. In his address to hub students, Dr. Gautam encouraged them to actively engage in collaborative efforts with scientists for contributing to societal well-being and tackling challenges in agriculture. Students also actively took part in different institute activities like celebration of foundation day, world

Fig. 22.5 Interactive session Dr PL Gautam with students of IARI Hub, ICAR RCER, Patna

Table 22.1 Important Events of IARI Patna hub

Sl No.	Date	Events	Remark
1.	03.02.2023	Identification of IARI hubs and nodal academic centre	
2.	16.11.2023	Start of the Admission Process at the IARI hubs	Physical verification of documents of the selection candidates
3.	03.12.2023	Virtual Interaction with students during Agricultural Education Day	Dr R S Paroda, Former Secretary (DARE) & DG, ICAR was Chief guest
4.	05.12.2023	Orientation Programme of Newly admitted Students at IARI Patna Hub	Students and scientists
5.	06.12.2023	Start of classes	
6.	14.12.2023	Interaction meeting with the students	Dr P L Gautam, Chancellor, DR RPCAU, Pusa & former Vice chancellor , GB Pant University of Agriculture & Technology
7.	23.12.2023	Interaction on Climate Resilient Agriculture	Farmer-Scientists-Students participated

Sun	:	**ICAR-IARI, New Delhi**
Planet	:	**Nodal institute in Hub/ off campus centre**
Satellite	:	**Neighbouring institutes of Nodal Institute**

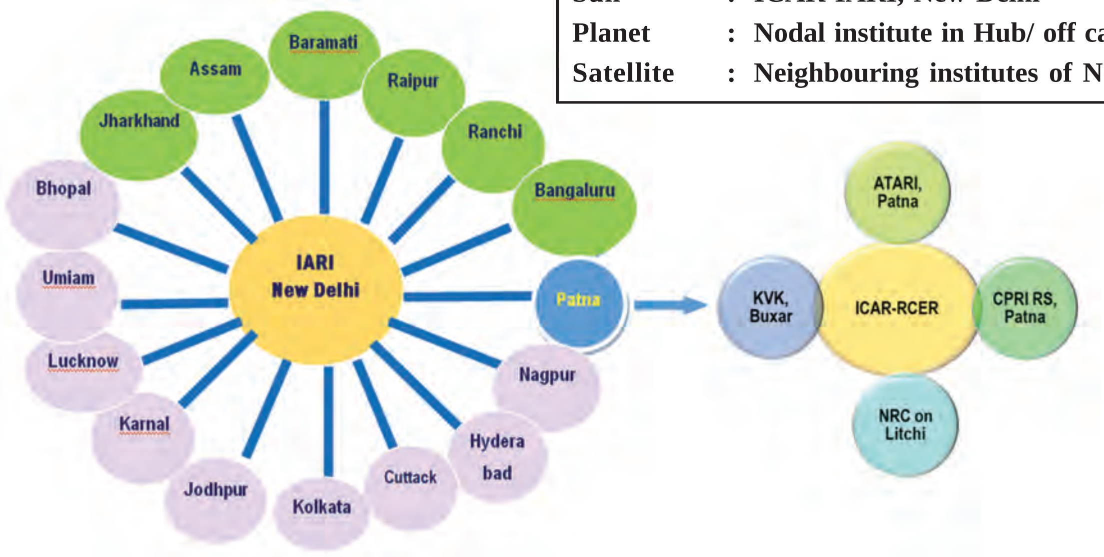


Fig 22.6 Sun-Planet-Satellite Model of IARI Patna Hub

23 Events Organized

Mango Festival cum Farmers Fair

On June 7, 2023, a grand Mango Festival-cum-Farmers Fair was organized at Farming System Research Center for Hill and Plateau Region, Ranchi. The chief guest of the function, The Hon'ble Governor of Jharkhand Shri C.P. Radhakrishnan inaugurated the program. Hon'ble governor inaugurated the Mango exhibition wherein the mangoes brought by farmers from eastern states were exhibited (Fig.23.1). More than 175 mango cultivars were displayed. On this occasion, Dr. Suresh Kumar Chaudhari, Deputy Director General (NRM), ICAR, New Delhi, Shri Abubakkar Siddikh, Secretary, Department of Agriculture, Animal Husbandry and Cooperation, Government of Jharkhand, Ranchi and and many distinguished guests were present. More than 350 farmers from the eastern states of the country participated in this event. Hon'ble Governor also felicitated the progressive farmers from different eastern states for their excellent work. On this occasion, the processed product "Mango Masala Roll" developed from mango pulp was also released.

Fig. 23.1 Glimpses of Mango Festival organised at FSRCHPR, Ranchi

Inauguration of Administrative building and Hi-tech Nursery

Krishi Vigyan Kendra (KVK), Ramgarh marked a significant milestone on October 31st with the inauguration of its new administrative building. The ceremony graced virtually by Chief Guest Dr. Himanshu Pathak, Secretary, DARE and Director General, Indian Council of Agricultural Research, New Delhi, along with guests of Honour Dr. S.K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi, and Dr. U.S. Gautam, Deputy Director General (Agricultural Extension), ICAR, New Delhi (Fig.23.2). The inauguration commenced with the ceremonial lighting of the lamp by the distinguished guests, followed by the release of the half-yearly Newsletter published by KVK and a success story book highlighting the achievements of district farmers. Dr. Anup Das, Director, ICAR Eastern Research Complex, Patna, welcomed the guests and highlighted the achievements of KVK, Ramgarh over the years. As part of the inauguration, a state-of-the-art Hi-tech nursery was also unveiled at KVK Ramgarh, aiming to provide quality improved fruit and vegetable materials to local farmers (Fig.23.3). The guests planted saplings on the KVK premises, emphasizing the importance of environmental conservation and sustainable agricultural practices. Additionally, a farmer seminar and exhibition on "Crop Diversification for Nutritional Security" was organized, showcasing innovative agricultural practices and technologies. Chief Guest Dr. Himanshu Pathak praised the work of KVK Ramgarh, acknowledging its efforts in disseminating the latest agricultural technology information to farmers. He encouraged farmers to adopt scientific farming practices to increase their income. Echoing similar sentiments, Dr. S.K. Choudhary emphasized the importance of adopting new agricultural techniques and urged farmers to share knowledge among themselves. Dr. U. S. Gautam highlighted the role of youth in agriculture and encouraged them to pursue agriculture as a profession. Dr. Anjani Kumar, Director, ICAR-ATARI, Patna, emphasized the significance of KVKs in promoting profitable farming and demand-based production. The programme also included the distribution of small agricultural equipment to tribal farmers under the tribal sub-plan. Various departments displyed exhibits to inform farmers about various schemes and imporved technologies.

Fig. 23.2 Inauguration of Administrative building

Fig. 23.3 Inauguration of Hi-tech nursery

Visit of Shree Arjun Munda, Hon'ble Union Minister to Ranchi centre

The Minister of Tribal Affairs and Minister of Agriculture and Farmers' Welfare, Shree Arjun Munda visited the FSRCHPR, Ranchi on 16th December, 2023. The hon'ble minister chaired an interaction meeting with the farmers wherein the progressive farmers shared their success stories (Fig. 23.4). Dr. Anup Das, Director of the institute, briefed about the recent achievements and activities of the institute. Appreciating the role of the research center in agricultural development of the region, Hon'ble minister expressed the need for unleashing the potential of processed products, streamlining of market linkages and promotion of Agri-Drones on wider scale. He also urged the farming community to take advantages of several important schemes launched by the Government like, PM Fasal Bima and PM Kisan Samridhi. He also planted a sapling of Rudraksh in the office premises.

Fig. 23.4 Glimpses of the Visit of Shree Arjn Munda Ji to the FSRCHPR, Ranchi

Farmer-Scientist Interaction and Agri-Exhibition

A 'Farmer Scientist Interaction and Agri-Exhibition' meet was organized on 16th December 2023 at Ranchi center of the institute (Fig. 23.5). Shree Arjun Munda, Hon'ble Minister of Tribal Affairs and Minister of Agriculture and Farmers' Welfare was the chief guest of the function. More than 250 farmers from the eastern states of the country participated in this event. Dr. Anup Das, Director, ICAR-RCER welcomed the Agriculture Minister and made a presentation on the activities, achievements and future plans of the center. In his address, Honourable Agriculture Minister said that our mere existence is because of farmers and we should have utmost respect towards farmers. Behind every tasty cuisine, there is a hard work of a famers. Appreciating the work of the center, he said that farmers can save their time and resources through adoption of technologies like Kisan Drones. He encouraged the farmers of Jharkhand to do farming in natural and scientific ways. On this occasion, many progressive farmers shared their success stories in front of the Honourable Minister. During the Interactive session, the experts/scientists working in various fields of agriculture research also interacted with the farmers and addressed the questions raised by the participating farmers.


Fig. 23.5. Glimpses of the Farmer-Scientist Interaction and Agri-Exhibition

Visit of Secretary, DARE and DG, ICAR to ICAR-RCER, Patna

Hon'ble Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR), Dr. Himanshu Pathak visited ICAR-Research Complex for Eastern Region, Patna on 27th Feb, 2023 (Fig.23.6). He was warmly welcomed by Director of the institute Dr. Anup Das. Dr. Pathak interacted with all the Scientists, Administrative and Technical staffs of the institute. Director of the institute briefed about the progress made by the institute. He also presented future course of action to be taken by the institute in the field of research, capacity building and extension during the interaction. Honorable DG, ICAR appreciated the effort made by the institute and congratulated Scientists and other staff for the achievements. He emphasized on technology commercialization, developing entrepreneurship, use of modern technologies (AI, Drone etc.), effective technology dissemination, need for strengthening consortia approach engaging other ICAR Institutes, Agricultural Universities, Line departments etc. for overall agricultural development of eastern region of India and innovation and focused research with the aim of generating desired products, concepts, package etc. to meet present day demand by stakeholders, industries and market. He also said that each Scientist should have a focused area of research so that resources are efficiently utilized and results can be delivered in a time frame. Further, he stressed upon the need for brainstorming to come out with areas in which Institute would focus its research activities and accordingly frame projects. Dr. Pathak released two books namely "Matasya paalan ki unnat taknikiyan" and "Profitable goat farming", one technical bulletin on "Vegetable varieties suitable for cultivation in eastern India" and one extension folder on "Production technology for nutri-cereals". On this occasion, a progressive farmer "Sri Kamakhya Narayan Sharma" from Naubatpur block, Patna shared his experience on pond based IFS Model and informed that he is getting significant monetary return from the model. Honorable DG, ICAR felicitated the farmer for his work.

Fig. 23.6. Dr Himanshu Pathak, Secretary DARE and DG ICAR at ICAR RCER, Patna

Visit of Secretary, DARE and DG, ICAR to ICAR-RCER FSRCHPR, Ranchi

Dr. Himanshu Pathak, Secretary DARE and Director General ICAR, visited the Ranchi center on 6th September. He was accompanied by Dr Anup Das, Director, ICAR-RCER and Dr Sujay Rakshit, Director ICAR-IIAB, Ranchi. Dr. Hamanshu Pathak also visited the Ranchi center of the institute for the second time on 20th September, 2023 (Fig.23.7). During this visit to the experimental fields, Dr. Anup Das, Director of Eastern Research Complex, Patna and Dr. Arun Kumar Singh, Head of the centre briefed about the various technologies developed by the center. An interaction meeting with the scientists of the center was also organized wherein different ongoing activities of the center were discussed. Dr Pathak planted a sapling of litchi variety "Swarna Madhu" to mark the inauguration of plantation program for establishment of Mother Block of the variety developed by the center. On this occasion, 100 saplings of 'Swarna Madhu' were planted by the scientists of the centre. Its pertinent to mention that the litchi mother block is established after the name of Hon'ble DG, ICAR. Dr. Pathak praised the litchi variety 'Swarna Madhu' and other technology development works carried out by the scientists of the center.

Fig. 23.7 Dr Himanshu Pathak, Secretary DARE and DG ICAR at FSRCHPR farms

Visit of Dr. S K Chaudhari, Deputy Director General, NRM, ICAR to FSRCHPR, Ranchi

Dr. S.K. Chaudhari, Hon'ble Deputy Director General, Natural Resources Management (NRM), Indian Council of Agricultural Research (ICAR), New Delhi visited Ranchi center on 7thJune 2023 (Fig. 23.8). Dr. Chaudhari reviewed the research and development activities of the FSRCHPR, Ranchi. He visited the research farms and laboratories and interacted with the scientists of the center. During the interactions he urged all the scientists to get more focused and committed for excellence in scientific work. He also urged scientists to work in a system mode. He also told that through innovative research, technological interventions and collaborative efforts we can effectively address the challenges faced by agriculture. On his visit, Dr. Chaudhari also planted a sapling of Rudraksh in the office premises. Hon'ble DDG, NRM also planted a mango (variety Himsagar) sapling along with other scientists in mango mother block established after his name.

Fig. 23.8 Dr S K Chaudhari, DDG, NRM with Scientists and staff at FSRCHPR, Ranchi

Dr. Mangala Rai interacted with Scientists on World Food Day

On the occasion of World Food Day, Dr. Mangala Rai, former Secretary, DARE and Director General, ICAR, engaged in an eloquent interaction with the scientists of ICAR Research Complex for Eastern Region, Patna on 16 October, 2023 (Fig.23.9). He highlighted on the pertinent issues of water use efficiency in India as our country has 17% of world population and holding only 4.2% fresh water resources. He highlighted the world produces enough food to feed all of its 8 billion people, yet 828 million people go hungry every day, and of those hungry populace over 40% are facing acute levels of hunger. There is an urgent need of enhancing funding in Agricultural Research in level up India's Research Intensity Ratio at par with the other developed nations. Dr. Rai urged the scientists to unite in a collaborative effort, focusing on enhancing factor productivity at the grassroots level in agriculture and emphasized on agricultural intensification and to work in system mode. Dr. Rai also highlighted the pressing need for extensive research in the realm of oilseed crops. A considerable amount of Indian capital, about Rupees 1.57 lakh crore is spent in import to fulfill 60% of the domestic demand. The scientist of India need to take effort in Oilseed, Pulses and Millets research to bridge the demand gap & contribute to climate resilient agriculture. Dr. Rameswar Singh, Vice Chancellor of Bihar Animal Science University, commended the institute's progress in this pivotal direction. He also shed light on the achievements of BASU in veterinary and fishery research in Bihar.

Fig. 23.9. Interaction with Dr. Mangala Rai, former Secretary, DARE and Director General of ICAR

Dr. U.S. Gautam, DDG (Extension) visited ICAR-RCER, Patna

Dr. U.S. Gautam, DDG (Extension) visited ICAR-RCER, Patna on 15 September, 2023 (Fig.23.10). He was accompanied by Dr. Anjani Kumar, Director, ICAR-ATARI, Patna. Dr. Anup Das, Director, ICAR-RCER, Patna, welcomed him and appraised about the research & extension activities of the institute. Dr. Gautam interacted with the scientists of the institute and expressed his admiration for the research complex, as he started his career from this institute. Next day, Dr. Gautam also visited the research farm of the main campus and Sabajpura, planted the sapling in the office premises to mark the occasion and appreciated the efforts of the scientists and all staff of the institute for well-maintained farm. During the interaction, Dr. Gautam focused on the aspects like belongingness to the institute, commitment and dedication for betterment of the individual staff and institute. He also highlighted the new research areas like water footprint, ecosystem services, zero hunger etc. in which scientists should focus their research activities. On this occasion, Director, ATARI Patna also expressed his views on how extension activities can be taken further under the guidance of DDG (Extension). Considering the financial needs of the institute for both the KVKs (Buxar and Ramgarh), Dr. Gautam assured all the support for their development.

Fig. 23.10 Dr. U.S. Gautam, DDG (Extension), ICAR New Delhi

Brainstorming session cum seminar on "Positive aspects of Natural and Organic farming" organized at ICAR RCER, Patna

A Brainstorming session cum seminar on "Positive aspects of Natural and Organic farming" was organized at ICAR RCER, Patna on July 14, 2023 (Fig.23.11). Chief Guest of the function Dr Anjani Kumar, Director, ATARI, Patna in his address informed the gathering about the research work being conducted at 39 KVKs across Bihar and Jharkhand. He emphasized on data generation regarding components, procedures, and varieties suitable for Natural farming. He also suggested relative yield comparison among Natural Farming, Organic farming and conventional fertilizer based farming through long term trials. Dr Anup Das, Director, ICAR RCER, Patna in his remarks emphasized on need for developing and standardizing package of practices for natural farming in different agro-ecosystem. He also suggested to develop integrated natural/organic farming system model with different components like perennial crops, animal, fodder etc. He said that except yield decrease, there are many positive aspects of natural farming like good quality produce, better soil structure, no pollution, safe environment etc. Earlier, the programme started by a brief presentation on "Natural & Organic farming Vs. Chemical farming" by Dr Shivani, Principal Scientist (Agronomy). She advocated the need for natural farming in low input small land holding areas. She also suggested that institutional arrangement through KVKs & FPOs are required for its promotion and market linkage for premium price for the products.

Fig. 23.11 Dr Anjani Kumar, Director, ATARI, Patna

Organized National Workshop on "Agricultural Water Management in Changing Climate"

A National workshop on "Agricultural Water Management in Changing Climate" was organized on March 27, 2023 at ICAR RCER Patna (Fig. 23.12). This was attended by renowned NRM scientists, *viz*., Dr AK Sikka (Country Representative-India, IWMI), Dr A Sarangi (Director, IIWM, Bhubaneswar), Dr KG Mandal (Director, MGIFRI, Motihari), Dr. Man Singh, representatives of IIT, Patna, Department of agriculture also attended and deliberated on the topic. Dr Anup Das (Director, ICAR-RCER, Patna & Chairman, Organizing Committee) and welcomed the chief guest (Dr AK Sikka) and other dignitaries. He emphasized on increasing the water productivity in agriculture by promoting the use of alternate source of water and employing scientific water management approaches and enhancing the capacity of farmers to cope with climate variability and change. In his presidential address, Dr S K Chaudhari (DDG, NRM) highlighted the importance of agricultural water management, and called for the adoption of precision agriculture, artificial intelligence, sensor-based monitoring, irrigation and canal automation. In his keynote address, Dr A K Sikka emphasized on innovative water management solutions for sustainable agriculture. Dr A K Upadhayaya (Head, DLWM) highlighted the importance of flood and drought management, irrigation and drainage management and on-farm water management under changing climate scenario. Four progressive farmers of Bihar also participated in the workshop.

Fig. 23.12 National workshop on Agricultural Water Management in Changing Climate

Rice Transplantation Day celebrated at Sabajpura farm

ICAR Research Complex for Eastern Region, Patna celebrated Paddy Transplantation Day with great zeal at Sabjpura Farm on 3rd July 2023 (Fig. 23.13). Transplantation of paddy is an important activity in the *Kharif* season. Farmers celebrate this day as a festival in different states. On this occasion, the Director of the Institute, Dr. Anup Das, thanking the farming community said that farmers are our food providers and life cannot be imagined without food. Our laborer family also support and works hard like transplanting paddy, due to which the whole country gets food. The main objective of celebrating this day is to get recognition for their hard work. For centuries, farmers have been working very hard and the entire institute is with them. The chief guest of the program, Dr. Anjani Kumar, Director of ATARI, Patna said that we scientists are with the farmers and together we have to end the food problem of the whole world. On this occasion, CSISA scientist Dr. S.P. Punia praised the institute and said that various research works are being done on paddy, which will prove to be useful to the people in future. Dr. Lora Carey of Cornell University also participated in this function. Hon'ble guests also planted paddy in the program, due to which the farmers and laborers present felt very happy and excited. More than 100 participants including scientists, employees of the institute and farmers from nearby areas participated in the program. The program concluded with a vote of thanks by Dr. Rakesh Kumar, Senior Scientist (Agronomy).

Fig. 23.13 Rice Transplantation Day celebrated at Sabajpura farm

Celebration of 23rd Foundation Day

The ICAR-Research Complex for Eastern Region, Patna, Bihar celebrated its 23rd Foundation Day on 22nd February, 2023 under the theme "Millets for Nutritional Security in Eastern India" (Fig. 23.14). Dr. Vilas A Tonapi, Former Director, ICAR-IIMR, Hyderabad delivered the Foundation Day Lecture on "India's Millet Makeover: Current Status & Opportunities". He highlighted the importance and nutritional composition of millets and emphasized on the diversification of food plates with millets. He stressed on the need of mainstreaming millets for nutritional security and improved livelihoods. In his inaugural address, the Chief Guest, Dr. N. Saravana Kumar, Secretary, Department of Agriculture and Department of Animal & Fish Resources, Government of Bihar congratulated the Director and employees of the institute for its foundation day. He focused on strengthening collaborative research among ICAR, State Government and Agricultural Universities for better research and technology promotion. He stressed on the impact of climate change on agriculture and needs for promotion of climate-resilient crop production technology for supporting farmers. Earlier, welcoming the dignitaries, Dr.Anup Das, Director, ICAR-RCER, Patna congratulated the employee on the occasion of 23rd Foundation Day and highlighted the major achievements of ICAR-RCER during the last one year. Dr. Rameshwar Singh, Hon'ble Vice Chancellor, BASU, Patna highlighted on integrated nutrient and farming management, balance fertilization, precision agriculture and technologies for improvements in livestock production. Dr. B.S. Mahapatra, Hon'ble Vice Chancellor, BCKV, Coochbehar, W.B. emphasized on the importance of millets production and processing as well as its nutritional benefits. Dr. Anjani Kumar, Director, ICAR-Agricultural Technology Application Research Institute, Patna, Bihar emphasized on the nutritional importance of millets and insisted on adopting millets in the Mid-day meal programs. Dr. Bikas Das, Director, ICAR-NRC Litchi, Muzaffarpur urge to work in farming system mode for more sustainable and climate ready agriculture. Total 14 employees of the institute were awarded for their outstanding contributions during the year 2022. Exhibition, farmers-scientists interaction and field visits were also organized on the occasion. Around 56 Progressive Farmers from Eastern states viz. Assam, Bihar, Chhattisgarh, Eastern UP, Jharkhand Odisha and West Bengal were also felicitated for their contributions in agriculture during the occasion.

Fig. 23.14 23rd Foundation Day on 22nd February, 2023

Celebration of World Soil Day

World Soil Day was commemorated on 5th December, 2023 at ICAR-RCER, Patna on the theme "Soil and Water: A Source of Life" (Fig. 23.15). The main goal of the programme was to make the farmers and students aware of the importance of healthy soil and to advocate for eco-friendly soil management. The event was attended by around 30 farmers, 15 students joining IARI Patna hub along with scientific staff of ICAR-RCER, Patna. The Chief Guest, Dr. Anjani Kumar, Director, ICAR-ATARI, Patna stressed about better nutrient management practices. He also highlighted about soil test-based fertilizer recommendation. Dr. Anup Das, Director, ICAR-RCER, Patna shared his thoughts on significance of maintaining the quality of soil and how important it is in our life and food system in the face of climate change scenario. He also delivered his thoughts on survival of the planet Earth by symbiotic linking of soil and water, which is the foundation of our agricultural systems through various sustainable management practices.

Fig. 23.15 Celebrating World soil day at Patna

The program was also organized at Ranchi center of the institute (Fig. 23.16) wherein 60 farmers from different districts of Jharkhand participated. During the interaction session, deliberations were made on conservation of soil and improvement of soil health. The process of soil sample collection was discussed with the farmers and the information on labs available for soil testing in Jharkhand was provided.

Fig. 23.16 Celebrating World soil day at Ranchi

Swachhata Pakhwada and Special Swachhata Campaign 3.0

Swachhata Pakhwada was observed from 15th September to 2nd October 2023 for highlighting the importance of cleanliness, health and well-being in daily life, working place and place of habitat. Various activities like cleaning of premises of cow shed, canteen and workshop areas, tree plantation, cleaning of old office records, agro-waste management, recycling of waste water in households were undertaken in the institute. A special session on efficient utilization of agri waste for vermicomposting was held in different villages of Namkum block of Ranchi. Awareness on cleanliness and sanitation drive was carried out at Plandu village to create awareness on safe ways of disposing biodegradable and non-biodegradable wastes.

Special Swachhata Campaign 3.0 was organized on 2nd

October, 2023 to 31st December, 2023. Under this campaign, a drawing competition was organized for the teachers and students from Immaculate Heart of Merry High school, Namkum, Ranchi (Fig. 23.17). Prizes were distributed to the winners of the various competitions held. A student's rally was carried out in the Plandu village with banners and placards portraying slogans about self and village cleanliness. Cleanliness and scrap clearance drives were conducted at Engineering Workshop, Cattle Shed at the IFS Unit of ICAR RCER FSRCHPR Ranchi. A Cleanliness Awareness session was also held for students of St. Xavier Ranchi College, Ranchi.

Fig. 23.17 Activities carried out during Swachhata Abhiyan at Ranchi

World Intellectual Property Day celebrated

The Ranchi center celebrated World Intellectual Property Day on April 26, 2023, with the theme "Women and IP: Accelerating Innovation and Creativity" under the ITMU, National Agricultural Innovation Fund (Fig. 23.18). The programme was celebrated as a part World Intellectual Property Right day with the objectives of educating and creating awareness about IPR issues, particularly copyright and trademarks, among the scientific community. Dr Abhijit Kar, Director, ICAR-NISA was the chief guest on the event. The Guest Speaker, Dr K Syamala, Associate Professor and Dean, National University of Study and Research in Law, Ranchi, delivered a thought-provoking and interesting lecture on "Women and IP: Accelerating Innovation and Creativity". About 70 scientific and technical personnel from ICAR-NISA, KVK Ramgarh, KVK Buxar and ICAR-RCER participated in the event virtually. Awareness lecture on "Intellectual Property" by Dr Praveen Malik (CEO Agrinnovate India Limited (Hybrid Mode) was also organized on 12th October 2023.

Fig. 23.18 Felicitation of Guest speaker Dr K Syamala on the occasion of world Intellectual Property Day celebrations

World Environment Day 2023 Celebrated

ICAR Research Complex for Eastern Region, Patna celebrated World Environment Day 2023 to create awareness and encourage people to take actions for protecting the environment (Fig. 23.19). Under the dynamic leadership of Dr. Anup Das, Director of the Institute, a team of scientists took active participation in the tree plantation drive on June 05, 2023 with a thrust on the Mission Life i.e., Lifestyle for Environment. The Director explained the participants about the duty and responsibility of individual for safeguarding our environment by planting trees and to adopt right lifestyle towards making our environment clean and healthier. He also drew our attention towards the ecosystem restoration, judicious use of water and avoiding use of plastics. He also encouraged the youth and children, who are the future generation of our country, to safeguard our environment by planting and taking care of trees. The team of scientist also visited Simra village of Naubtpur block, Patna, in which more than 50 farmers, youth and children participated in the tree plantation cum awareness programme. Saplings of various fruits and timber trees viz., mango, guava, lemon, teak mahogany and jackfruit were planted and also distributed among the farmers. Scientists of the Institute interacted with the farmers on various environmental issues like conservation of natural resources, climate change, deforestation, air pollution, water pollution, loss of biodiversity, ill effects of using plastic etc. and inspire them to join hands towards growing trees in and around their farm boundaries and village common lands to safeguard our environment. Mr. Kamakhya Prasad, a progressive farmer of the village also shared his view about importance of tree plantation towards environment protection.

Fig. 23.19 Celebrating World Environment Day 2023

Exposure visit of NABARD Managers

A team of 35 officials from National Bank for Agriculture and Rural Development (NABARD) visited FSRCHPR, Ranchi on 22nd Aug, 2023 to gain experience and understand the new technologies and practices in the field of horticulture (Fig. 23.20). The managers were briefed about the achievements of the center over past few decades. The centre's technologies that can be potential candidates for NABARD's developmental schemes were also marked. The technologies like water harvesting using Doba, Multi-tier cropping systems and resource conservation technologies (drip + mulch + fertigation) were greatly appreciated. Discussions were held on bringing stronger collaboration and association with FSRCHPR for strengthening training, exposure visit and technical guidance.

Fig. 23.20 Team of NABARD officials at FSRCHPR, Ranchi

Mass Awareness programs on Kisan Drone

The 'Drone' is one of the most recent and advanced agricultural technology used to accomplish the tasks of spraying of agrochemicals in crops. In order to spread the awareness about Kisan drones among the farming community, three Mass Awareness Programs were carried out under the 'Agri-Drone Project' of the institute (Table 23.1). Live demonstrations on drone were conducted to spread the awareness on applicability of drones in spraying of agro-chemicals. Farmers were informed about the potential applications of drone technology in the agriculture, particularly in spraying of agro-chemicals (Fig. 23.21,22,23 & 24). These awareness programs included session highlighting the potential kisan drones in improving the productivity, production and income to the farmers. Technical sessions on also covered the aspects of type of chemicals used, effectiveness of spraying of agro-chemicals and the economic gains the drone technology. Farmers were also briefed about the procedures to buy a Kisan Drone and to how they can obtain a drone pilot training.The mass awareness programs were effective in communicating the information about Kisan Drones and various schemes of Government of India.

Table 23.1 Mass Awareness Programs (MAP) organised under Agri-Drone project

Name of the program	Location	Date	No of farmers
“जन जागरूकता कार्यक्रम”	FSRCHPR, Ranchi	16 December 2023	300
Use of Agri-Drones in Spraying of Agro-Chemicals	FSRCHPR, Ranchi	11 October 2023	50
Demonstration cum Awareness Program on Kisan Drone in Shahid KisanMela	Gondpur village, District Saraikela Kharsawan	01 January 2024	500

Fig. 23.21 MAP during Mango Festival, Ranchi

Fig. 23.22 Mass Awareness Program, Ranchi

Fig. 23.23 Regional Agricultural Fair, Khunti

Fig. 23.24 Shahid Kisan Mela, Saraikela Kharsawan

Parthenium Awareness Week

ICAR Research Complex for Eastern Region, Patna has organized “18th *Parthenium* Awareness Week” from 16-22 August, 2023 by involving Regional Centre and its KVKs to make farmers and general public aware about the menace of *Parthenium* and its management strategies (Fig. 23.25). A wide range of activities were conducted to spread maximum awareness among staff members, farm and campus workers. On the eve of “18th *Parthenium* Awareness Week”, a brainstorming session was arranged, in which the scientific and technical staffs of the Institute actively participated and suggested ways to manage it. The Director of the Institute, Dr. Anup Das stressed on the public awareness and community approach to manage this problematic weed. In this programme, Dr. Sonaka Ghosh, Scientist, Division of Land and Water Management, ICAR-RCER, Patna delivered a lecture on “Strategies for *Parthenium hysterophorus* L. Management”.

Fig. 23.25. Parthenium awareness programme at ICAR RCER, Patna

Celebration of World Water Day 2023

World Water Day 2023 was celebrated at ICAR RCER Patna on 22nd March, 2023 in association with ATARI Patna (Fig. 23.26). About 40 farmers from nearby villages participated in this programme. Farmers were sensitized about the importance of water in our life and measures to adopt for sustainable use of water.

Fig. 23.26 Celebrating World Water Day 2023

Research Advisory Committee Meeting

The 19th Research Advisory Committee Meeting of ICAR-RCER, Patna was held during May 18-19, 2023 under the Chairmanship of Dr. K. D. Kokate, Ex- DDG (Agricultural extension), ICAR, New Delhi. Other RAC members present in the meeting were Dr. Masood Ali, Ex Director, Indian Institute of Pulse Research, Kanpur, Dr S.D. Singh, Ex ADG, Fisheries Sciences, ICAR, New Delhi, Professor K.N. Tiwari, IIT, Kharagpur and S. Kumar, Ex- Head, ICAR RCER Research Centre, Ranchi (Fig. 23.27 & 23.28). All the Heads of Departments and Heads of Research Centre, Ranchi, KVKs (Buxar and Ramgarh) and Research centre on Makhana, Darbhanga participated in the meeting and presented the research achievements of their divisions/ centers. Chairman of the committee Dr. K.D. Kokate, stressed on the importance of aligning the institutes' research efforts with both national and global priorities. He emphasized the need to concentrate on four key areas discussed at the G-20 Meeting: food and nutritional security, promoting resilience and sustainability while ensuring profitability, digital agriculture, and fostering partnerships. Dr. Kokate proposed a collaborative approach, suggesting the institute to work in consortia with various institutions and universities. This collective effort would enable the institute to tackle pressing challenges and contribute significantly to the advancement of these crucial focus areas. Other members of the committee have also given constructive inputs, useful suggestions and guidance for the ongoing and future research and developmental programs of the institute in their respective field of expertise. Earlier, Director of the institute, Dr Anup Das welcomed Chairman and members of RAC and gave a brief presentation on research achievements of the institute, management issues as well as constraints faced by the institute. The Chairman and members of RAC also visited the research fields, experimental farms and laboratories of the institute.

Fig. 23.27 Research Advisory Committee Meeting

Fig. 23.28 Presentations during Research Advisory Committee Meeting

The Institute Research Council Meeting

The Institute Research Council Meeting was convened from July 4-7, 2023 under the Chairmanship of Dr. Anup Das, Director ICAR RCER, Patna which was attended by all the scientists from the Headquarters, Regional station and KVK including technical officers of the institute who are associated with the institutional projects (Fig. 23.29). Dr

Anjani Kumar Director ATARI, Patna was the Guest of Honour in this meeting. At the outset, PME In-Charge, Dr. Abhay Kumar welcomed the Chairman, Guest of Honour and all the members to four-day deliberations of various institutional projects. Dr. Anjani Kumar, Director, ATARI Patna, in his introductory remarks mentioned that the new research work should be based on the problems and feedback of the farmers and project's target should always be explicit. All scientists need to focus on externally funded projects for generating resources and explore new ideas. Furthermore, he recommended a meeting/workshop with the innovative farmers for a productive discussion.

The Chairman in his inaugural remarks urged the scientists to do the critical analysis and meaningfulness of the research work being carried out and stressed on sharing responsibility of rendering services by each division/centre, which needs to be carried out efficiently and timely. He further emphasized the need for technological interventions, particularly on food-energy-climate change approach, natural and organic farming system development, integrated pest management practices, nutrient / water use efficiency, study on medicinal crops, nutritional aspects in fruits, use of geo-spatial tools like GIS, AI and robotics. He also urged on development of tools for weed management, product-based marketing, climate impact studies in livestock and fisheries, development of livestock-based fodder systems, and participatory research. He recapitulated the achievements of each Division and Regional Station of the Institute and emphasized that all divisions and regional stations including KVK's should strive to bring more visibility at national and international levels in terms of the importance of the work they undertake. He motivated all the scientists to develop team and take initiative for dissemination of institute technologies to the farmers' fields. Moreover, he advised to publish research papers in high rated journals for researchers and academician and technical bulletins, extension bulletins, folders etc. in Hindi for farming community. He also emphasized on technology commercialization, entrepreneurship development, patent etc. to bring institute in forefront at national level.

Fig. 23.29 Institute Research Council Meeting

Celebration of Hindi Pakhwada 2023 at Patna

Hindi Pakhwada-2023 celebrations started at ICAR-RCER, Patna with the celebration of Hindi Diwas on 14.09.2023 (Fig. 23.30). Dr. Anup Das, Director, ICAR-RCER, Patna inaugurated the program by lighting the lamp. Congratulating all the officers and employees of the institute on the occasion of Hindi Diwas, Dr. Das mentioned that Hindi is the simplest medium of communication and it binds us together. Our institute comes under 'A' region, due to which there is a constitutional requirement that all official work i.e. 100% have to done in Hindi, so that we may meet the target given by the Department of Official Language, Ministry of Home Affairs, Government of India. Dr. Das emphasized that the publications of the Institute should also be in Hindi language, so that it may benefit the farmers and other stakeholders.

Dr. Ashutosh Upadhyaya, Co- Chairman, Official Language Implementation Committee discussed the importance of Hindi in the field of agricultural research. He informed about various competitions to be organized in the institute during Hindi Fortnight. During the program, Heads of all divisions/ sections/cells/units also expressed their views on the Official language. Saraswati Vandana and Hindi songs were the centre of attraction in the program.

The closing ceremony was presided over by Dr. Anup Das, Director, ICAR-RCER, Patna. Dr. Bikash Das, Director, ICAR- NRC on Litchi was present as the chief guest of the event. Dr. Anup Das said that Hindi is not only a language but also the identity of our country. It is connected to our hearts and soul. He urged all officers and employees to promote and propagate Hindi as much as possible. According to Dr. Bikash Das, Director, ICAR- NRC on Litchi, Muzaffarpur, Hindi is a language that can integrate all the languages. Working in the official language Hindi is simple and understandable. If official work is done in Hindi, it will be a commendable step in the interest of the nation.

All the winners of various competitions organized during the fortnight were awarded certificates and cash prizes.

Fig. 23.30 Celebration of Hindi Pakhwada 2023 at Patna

Hindi Pakhwada observed at Ranchi

Hindi Pakhwada is one of the important events of the institute which provides an opportunity for promotion of Hindi language, literature and culture. The Hindi Pakhwada was inaugurated on 14 Sept, 2023 at FSRCHPR, Ranchi (Fig. 23.31). By participating in collectively organized programs, the employees of the center are encouraged to live a better life together. In this 14-day long program, various competitions such as, debate, essay writing, poem recitation, vocabulary, annual work evaluation and Hindi quiz were organized. The valedictory function of the Hindi Pakhwada was organised on 29thSeptember 2023. Chief Guest of the function, Dr Kamal Kumar Bose, Ex-Head, Department of Hindi, St Xavier's College, Ranchi, appreciated the activities of center in use and promotion of Hindi in the official works. Dr Anjesh Kumar, Ex-Chief Technical Officer, ICAR-NISA was the special guest on the occasion. The chief guest and special guest distributed the prizes to the winners of different competitions organized during the pakhwada. The valedictory function and Hindi workshop concluded with great enthusiasm.

Fig.23.31 Hindi Pakhwada celebration at Ranchi Centre

Shri Narendra Singh Tomar, *Hon'ble Minister for Agriculture and Farmers' Welfare of India* and *President, ICAR Society*, visited *Research Centre for Makhana*, Darbhanga on February 28, 2023 (Fig. 23.32). Hon'ble Minister appreciated the work done by the scientists of the Centre, and assured to upgrade the status of the Centre as the National Research for Makhana. During the occasion Fig. 23.32 Visit of Shri Narendra Singh Tomar, Hon'ble Minister for Agriculture and Farmers' Welfare of India and President, ICAR Society Hon'ble minister interacted with the makhana farmers.

Shri Kailash Choudhary, *Hon'ble Minister of State for Agriculture and Farmers' Welfare of India*, visited ICAR-RCER, Patna on February 18, 2023 (Fig. 23.33). Hon'ble Minister visited the experimental site of Natural Farming along with the Director and scientists of the Complex. He appreciated the research work being performed to make "Natural Farming" a ground reality. Hon'ble minister urged scientist to work closely with farmers & promote natural farming for sustainable agriculture.

Fig. 23.32 Visit of Shri Narendra Singh Tomar, Hon'ble Minister for Agriculture and Farmers' Welfare of India and President, ICAR Society

Fig. 23.33 Visit of Shri Kailash Choudhary, Hon'ble Minister of State for Agriculture and Farmers' Welfare of India

24 Awards and Recognitions

Awards and Recognitions

- **Rajbhasha Second Prize 2021-22** for the efficient implementation of the official language policy of the Union in 'A' region by Ministry of Home Affairs, Govt. of India, New Delhi.
- Anup Das, '**Fellow, NABS 2022**' by National Academy of Biological Sciences, Chennai.
- Anup Das, '**ISA Gold Medal Award-2021**' by Indian Society of Agronomy, New Delhi.
- Govind Makarana, '**M.S. Swaminathan Research Fellow Award-2023'** by Plantica Foundation, Dehradun.
- Jaipal Singh Choudhary, '**Fellow, Society for Biocontrol Advancement-2023**' by Society for Biocontrol Advancement, Bengaluru, India.
- Manibhushan, '**Distinguished Scientist Award-2023**' by Astha Foundation, Meerut and University of Agricultural Sciences Raichur.
- Rachana Dubey, '**Scientist of the Year Award**' by National Environmental Science Academy (NESA) New Delhi and CSIR National Botanical Research Institute Lucknow.
- Rakesh Kumar, '**Dr. P.S. Deshmukh Young Agronomist Award-2021**' by Indian Society of Agronomy, New Delhi.
- Sonaka Ghosh, '**Best Ph.D. Thesis Award-2022**' by Indian Society of Agronomy, New Delhi.
- Ved Prakash, '**Best Ph.D. Thesis Award-2023**', by Association of Plant Science Researchers (APSR), Dehradun, Uttarakhand.
- VK Yadav, '**Best Team Award 2022-23'** for the excellent work on uplifting tribal farmers in Jharkhand under Farmers' FIRST project.

Best Paper/Poster/Presentation Awards

- P. Bhavana, '**Best Oral Presentation**' in the International Conference on Environment, Aquaculture and Sustainable Agriculture at St. Xaviers' College, Ranchi during 22-24 September, 2023.
- Kumari Shubha, '**Best Oral Presentation award**' in International Extension Education Congress held at Rajasthan Agricultural Research Institute, Durgapura, Jaipur during 18-20 December, 2023.
- Kumari Shubha, **'Best Oral Presentation Award'** in ICAR-Agripreneurs Meet cum National Symposium on Strategies for Promotion of Incubatee in Agriculture and Allied Sectors in the Northeastern Region of India held at ICAR Research Complex for NEH Region in Umiam, Meghalaya during 4-5 October, 2023.
- Rachana Dubey, '**Second Best Oral Presentation award'** in National Conference on Recent Trends & Challenges In Green Chemistry, Pollution Control and Climate Change during 14-16 December, 2023.
- Santosh Kumar, **'Second Best Oral Presentation award,** in National seminar on Challenges, Opportunities and Plant Science for Crop Improvement" held at Birsa Agricultural University, Kanke, Ranchi, Jharkhand during 8-9 November, 2023.
- Ashruti Upadhyaya, Ashutosh Upadhyaya, Akram Ahmed and Pawan Jeet, '**Best Research Paper Award-** 2022' by Indian Association of Soil and Water Conservationists, Dehradun.

25 Publications

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26 Personnel

Director	**Dr. Anup Das**
Division of Crop Research	**Division of Land and Water Management**
Scientists	**Scientists**
Dr. Sanjeev Kumar, Pr. Scientist & Head	Dr. A. Upadhyaya, Pr. Scientist & Head
Dr. A.K. Choudhary, Pr. Scientist (Plant Breeding)	Dr. A. Rahman, Pr. Scientist (Physics) upto 22.03.23
Dr. Md. Monobrullah, Pr. Scientist (Entomology)	Dr. Shivani, Pr. Scientist (Agronomy)
Dr. Narayan Bhakta, Pr. Scientist (Plant Breeding)	Dr. Anil Kumar Singh, Pr Scientist (Agronomy)
Dr. Santosh Kumar, Sr. Scientist (Plant Breeding)	Dr. Bikash Sarkar, Pr. Scientist (FMPE)
Dr. Rakesh Kumar, Sr. Scientist (Agronomy)	Dr. Ajay Kumar, Pr. Scientist (LWME)
Dr. Surajit Mondal, Scientist (Soil Science) upto 24.03.23	Dr. Manibhushan, Sr. Scientist (Comp. App.)
Dr. Abhisekh Kumar, Scientist (Agroforestry)	Dr. P.K. Sundaram, Sr. Scientist (FMPE)
Mr. K. Koteswara Rao, Scientist (Soil Science)	Dr. Pawan Jeet, Scientist (LWME)
Dr. Abhishek Kumar Dubey, Scientist (Plant Pathology)	Dr. Ved Prakash, Scientist (Agril. Meteorology)
Dr. Manisha Tamta, Scientist (Agricultural Meteorology)	Dr. Akram Ahmed, Scientist (LWME)
Dr. Kumari Shubha, Scientist (Vegetable Science)	Dr. Kirti Saurabh, Scientist (Soil Science)
Dr. Rachana Dubey, Scientist (Environmental Science)	Mrs. Mridusmita Debnath, Scientist (LWME)
Dr. Govind Makarana, Scientist (Agronomy)	Mrs. Arti Kumari, Scientist (LWME)
Dr. Saurabh Kumar, Scientist (Microbiology)	Dr. Sonaka Ghosh, Scientist (Agronomy)
Division of Livestock and Fisheries Management	**Technical Officer**
Scientists	Mr. Prem Pal Kumar, Technical Officer
Dr. Kamal Sarma, Pr. Scientist & Head	**Division of Socio-Economics and Extension**
Dr. A. Dey, Pr. Scientist (Animal Nutrition)	**Scientists**
Dr. S. Dayal, Pr. Scientist (Animal Genetics & Breeding)	Dr. Ujjwal Kumar, Pr. Scientist & Head
Dr. Pankaj Kumar, Pr. Scientist (Veterinary Medicine)	Dr. Abhay Kumar, Pr. Scientist (Agril. Statatics)
Dr. P.C. Chandran, Sr. Scientist (Animal Genetics and Breeding)	Dr. N. Chandra, Pr. Scientist (Agril. Economics)
Dr. Rajni Kumari, Sr. Scientist (Animal Biotechnology)	Dr. Dhiraj Kumar Singh, Sr. Scientist (Ag. Extension)
Dr. Jyoti Kumar, Sr, Scientist (Vet. Microbilogy)	Dr. Tanmay Kumar Koley, Sr. Scientist (Horticulture)
Dr. P. K. Ray, Sr. Scientist (Veterinary Pathology)	Dr. Rohan Kumar Raman, Sr. Scientist (Agil. Statistics)
Dr. Rakesh Kumar, Scientist (Animal Genetics & Breeding)	Dr. Anirban Mukherjee, Scientist (Agril. Extension)
Dr. Manoj Kumar Tripathi, Scientist (Animal Physiology)	Mr. Banda Sainath, Scientist (Agricultural Economics)
Dr. Tarkeshwar Kumar, Scientist (Aquaculture)	**Technical Officer**
Mr. Surendra Kumar Ahirwal, Scientist (FRM)	Mr. Sanjay Rajput, Technical Officer

	ICAR RCER Farming System Research Centre for Hill & Plateau Region, Ranchi
Dr Vivekanand Bharti, Scientist (FRM)	**Scientists**
Sh. Jaspreet Singh, Scientist (FRM)	Dr. A.K. Singh, Pr. Scientist & Head
Technical Officer	Dr. R.S. Pan, Pr. Scientist (Horticulture)
Sh. Amrendra Kumar, Technical Officer	Dr. B.K. Jha, Pr. Scientist (Horticulture)
Prioritization Monitoring & Evaluation Cell	Dr. Bikash Das, Pr. Scientist (Horticulture) upto 03.02.2023
Dr. Abhay Kumar, Pr. Scientist & I/c PME Cell	Dr. S. K. Naik, Pr. Scientist (Soil Science)
Technical Officer	Dr. V.K. Yadav, Pr. Scientist (Ag. Extension)
Mr. Sarfaraj Ahmad, STO (Computer)	Dr. S.S. Mali, Sr. Scientist (SWCE)
ARIS Cell	Dr. P. Bhavana, Sr. Scientist (Plant Breeding)
Dr. Manibhushan, Sr. Scientist	Dr. Ajit Kumar Jha, Sr. Scientist (Plant Pathology)
Technical Officer	Dr. J.S. Choudhary, Scientist (Entomology)
Sh. Anil Kumar, ACTO	Dr. Reshma Shinde, Scientist (Soil Science)
ICAR RCER, Krishi Vigyan Kendra, Buxar	Dr. Reena Kumari Kamal, Scientist (LPM)
Dr. Deokaran, (Sr. Scientist & Head) (Soil Science)	Dr. M.K. Dhakar, Scientist (Fruits Science)
Subject Matter Specialists	Dr. Meenu Kumari, Scientist (Veg. Science)
Mr. Ramkewal, SMS ACTO (T-7-8) (Plant Protection)	Dr. Prerna Nath, Scientist (Food Technology)
Dr. Mandhata Singh, SMS ACTO (T-7-8) (Agronomy)	Mr. Victor Thingujam, Scientist (Agroforestry)
upto 26.09.23	**Technical Officers**
Dr. Hari Govind Jaiswal, SMS CTO (T-9) (Plant Breeding)	Dr. G. P. Singh, CTO
Technical	Mr. Paul Sanjay Sircar, SETO (Computer)
Mr. Arif Parwez, Farm Manager (T-6)	Mr. Suresh Kumar, STO (Farm)
Administrative	Mr. Dhananjay Kumar, T-6 (Farm)
Mr. Rakesh Mani, Assistant	Mr. Arun Kumar, Technical Officer (Electrical)
ICAR RCER, Krishi Vigyan Kendra, Ramgarh	Mrs. Anima Prabha, Technical Officer (Press & Editorial)
Dr. Sudhansu Shekhar (Sr. Scientist & Head)	Mr. Vijay Kumar Singh, Technical Officer (Lab.)
Subject Matter Specialists	Sh. Shashi Kumar Azad, Technical Officer (Field/Farm)
Dr. Dushyant Kumar Raghav, SMS ACTO (T-7-8) (Plant Protection) upto 25.09.23	Sh. Ganga Ram, ACTO (T-7-8)
Dr. Indrajeet, SMS CTO (T-9) (Ag. Extension)	Sh. Chandrakant, ACTO (T-7-8)
Dr. Dharmjeet Kherwar, SMS (Agroforestry/ Horticulture) ACTO	**Farm Section, Patna**
Technical	Mr. Abhishek Kumar, ACTO
Shri Sunny Kumar, Farm Manager	Mr. P.K. Singh, ACTO
	Mr. A.S. Mahapatra, Sr. Technical Officer

Administration & Finance Section	
Mr. Pushpanayak, CAO (Study Leave w.e.f. 16.01.2023)	Mr. Ravi Shankar, AAO
Mr. Vipul Raj, AO (w.e.f. 21.02.2023)	Mr. Md. Sajid Mustaque, AAO
Sh. Rajat Kumar Das, FAO	Mr. Madan Paswan, Assistant
Mr. Prem Chandra, PPS	Ms. Divyadarshini, Assistant
Mr. K.K. Lal, AF&AO	Mr. Nagendra Kumar, Assistant
Mrs. Prabha Kumari, AAO (P)	Mr. Rashmikant, Assistant
Mr. Dayanand Prasad, AAO	Mr. Markanday Mishra, Assistant
	Mr. Lakshmi Prasad, Assistant

New Joining of staff during 2023

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Joined as	Discipline	Division/ Section of posting	Date of joining
1.	ICAR-RCER, Patna(HQ)	Dr. Anup Das, Principal Scientist, ICAR-RC for NEH Region Tripura Centre	Director	Agronomy	Director Cell	06.02.2023
2.	ICAR-RCER, Patna(HQ)	Sh. Vipul Raj, Administrative Officer, MGIFRI, Motihari	Administrative Officer	Administrative Officer	Administration	21.02.2023
3.	RC, Darbhanga	Sh. Rahul Kumar Rout	Scientist	Agricultural Structures and Process Engineering	RC, Darbhanga	03.02.2023
4.	ICAR-RCER, Patna(HQ)	Sh. Abhishek Kumar, Scientist	Scientist	Agroforestry	DCR	20.03.2023
5.	FSRCHPR, Ranchi	Dr. A.K. Singh, Pr. Scientist	Head, FSRCHPR, Ranchi	Vegetable Science	FSRCHPR, Ranchi	04.05.2023
6.	ICAR-RCER, Patna(HQ)	Dr. A. Upadhyaya	Head, DLWM	Land and Water Management Engineering	DLWM	14.06.2023
7.	ICAR-RCER, Patna(HQ)	Dr. Kamal Sarma, Pr. Scientist	Head, DLFM	Fish & Fisheries Science	DLFM	15.06.2023
8.	ICAR-RCER, Patna(HQ)	Dr. Sanjeev Kumar, Pr. Scientist	Head, DCR	Agronomy	DCR	17.07.2023
9.	ICAR-RCER, PATNA (HQ)	Sh. Banda Sainath	Scientist	Agricultural Economics	DSEE	21.07.2023
10.	KVK, Buxar	Dr. Deokaran, CTO, KVK, Buxar	Sr. Scientist cum Head	Agronomy	KVK, Buxar	21.08.2023
11.	FSRCHPR, Ranchi	Dr. Victor Thingujam	Scientist	Agroforestry	FSRCHPR, Ranchi	21.09.2023
12.	KVK, Ramgarh	Dr. Sudhansu Shekhar	Sr. Scientist cum Head,	Veterinary Medicine	KVK, Ramgarh	06.10.2023

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Joined as	Discipline	Division/ Section of posting	Date of joining
13.	ICAR-RCER, Patna (HQ)	Dr. Ujjwal Kumar, Pr. Scientist	Head, DSEE	Agricultural Extension	DSEE	06.12.2023

Promotions during 2023

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Category	From	Prom-oted to	Date of Promotion
1.	ICAR-RCER, Patna (HQ)/ DLWM	Dr. Manibhushan, Sr. Scientist (Computer Application)	Scientific	Sr. Scientist	Pr.Scientist	16.09.2019
2.	ICAR-RCER, Patna (HQ)/ DLFM	Dr. Pankaj Kumar, Sr. Scientist (Veterinary Medicine)	Scientific	Sr. Scientist	Pr. Scientist	08.01.2022
3.	ICAR-RCER, Patna (HQ)/ Administration	Sh. Rashmi Kant, UDC	Administrative	UDC	Assistant	01.02.2023
4.	ICAR-RCER, Patna (HQ)/ Administration	Sh. Anil Kumar, UDC	Administrative	UDC	Assistant	01.02.2023
5.	ICAR-RCER, Patna (HQ)/ Administration	Sh. Lakshmi Prasad, UDC	Administrative	UDC	Assistant	01.02.2023
6.	ICAR-RCER, Patna (HQ)/ Administration	Sh. Markanday Mishra, UDC	Administrative	UDC	Assistant	01.02.2023

Transfer during 2023

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Category	From	Transfer to	Relieving date
1.	ICAR-RCER, Patna (HQ)	Dr. A.Rahman, Pr. Scientist (Physics)	Scientific	ICAR-RCER, Patna	CSSRI Regional Research Station, Lucknow	22.03.2023
2.	ICAR-RCER, Patna (HQ.)	Dr. Surajit Mondal, Scientist (Soil Science)	Scientific	ICAR-RCER, Patna	Central Citrus Research Institute, Nagpur	24.03.2023
3.	ICAR-RCER, Patna (HQ.)	Sh. Prem Chandra, PPS	Administrative	ICAR-RCER, Patna	IISR, Lucknow	08.11.2023

Relieving for joining New Assignment during 2023

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Category	Post (new assignment) and place of joining	Relieving date
1.	FSRCHPR, Ranchi	Dr. Bikas Das Pr. Scientist	Scientific	Director at NRC for Litchi, Muzaffarpur	03.02.2023
2.	KVK, Ramgarh	Dr. Dushyant Kumar Raghav, ACTO	Technical	Sr. Scientist cum Head at KVK, Maldah, West Bengal under ICAR-CISH	25.09.2023
3.	KVK, Buxar	Dr. Mandhata Singh, ACTO	Technical	Sr. Scientist cum Head at KVK Deoria under ICAR-IIVR, Varanasi	26.09.2023

Retirements

Sl. No.	Head Quarter/ FSRCHPR, Ranchi/KVKs	Name & Designation	Category	Date of Retirement
1.	FSRCHPR, Ranchi	Sh. Chandrashekhar Prasad, ACTO	Technical	31.01.2023
2.	FSRCHPR, Ranchi	Sh. Firoz Akhter, Assistant	Administrative	31.01.2023
3.	ICAR-RCER, Patna	Dr. R.C. Bharati, Pr. Scientist	Scientific	31.01.2023
4.	FSRCHPR, Ranchi	Sh. Jagpati Singh Bariak, MTS (SSS)	Administrative	31.03.2023
5.	FSRCHPR, Ranchi	Dr. G.P. Singh, CTO	Technical	30.06.2023
6.	FSRCHPR, Ranchi	Sh. Arun Kumar, STO	Technical	31.08.2023
7.	FSRCHPR, Ranchi	Sh. Birsa Ekka, MTS (SSS)	Administrative	08.11.2023 (Death date)

27

ON-GOING RESEARCH PROJECTS

Theme wise Ongoing Institute Research Projects 2023

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
Theme 1. Farming System Research including Climate Resilient Agriculture					
1.0 Integrated Farming System and Cropping System for Eastern Region					
1.1	ICAR-RCER/ AICRP/ IFS/ EF/2010/25(i)	Development of location specific Integrated Farming System models for small and marginal farmers of Bihar	Sanjeev Kumar, A. Dey, Ujjwal Kumar, N. Chandra, Kamal Sarma, Shivani, Ajay Kumar, R.K.Raman, Rachana Dubey, Kirti Saurabh, Kumari Shubha, Saurabh Kumar, M. Monobrullah, AK Dubey	June 2010/ Sep. 2025	AICRP on IFS
1.2	ICAR-RCER/ RC Ranchi/ 2019/225	Evaluation of Natural Farming for Eastern Plateau and Hill Region (Modified title: Evaluation of Organic and Natural Farming for Eastern Plateau and Hill Region)	B.K. Jha, S.K. Naik, A. K. Jha, S.S. Mali, J.S. Choudhary	2019/2024	ICAR-RCER
1.3	ICAR-RCER/ RC Ranchi/ 2020/237	Development of multipurpose trees and medicinal plants based agroforestry models for Eastern Plateau and Hill Region	Reshma Shinde, M.K. Dhakar, Abhishek Kumar	2020/2025	ICAR-RCER
1.4	—	Studies on efficacy of natural farming and comparison with existing farming	Shivani, Kirti Saurabh, A. Upadhyaya, Sonaka Ghosh, Pawan Jeet, Rachana Dubey, Ved Prakash, Md. Monobrullah, Rakesh Kumar, Rohan Kr Raman, A.K. Dubey, Santosh Kumar, Mr. Prem Pal Kumar (Technical), associate	2022/2028	ICAR-RCER
2.0 Resource Conservation Technology					
2.1	ICAR-RCER/ DCR/EF/ 2015/40	Evaluation of Conservation Agricultural (CA) practices under Rice-fallow system of Eastern Region	Rakesh Kumar, B. K. Jha, S. K. Naik, S.S. Mali, Rachana Dubey	2015/2026	Consortium Research Platform on CA (ICAR)
2.2	ICAR-RCER/ DCR/EF/2016/	Cereal Systems Initiative for South Asia (CSISA) Phase III	Rakesh Kumar, Rachana Dubey, G. Makarana, Saurabh Kumar, J.S. Chaudhary , K. Saurabh	2016/Dec. 2021 Extd. March 2025	CIMMYT

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
2.3	—	Network project on Conservation of lac insect genetic resources (NPCLIGR)	Md. Monobrullah	Jan. 2019/ Dec., 2024	AINP on CLIGR
3.0 Climate Resilient Agriculture					
3.1	ICAR-RCER/ DSEE/ EF/ 2019/	Climate Resilient Agriculture Programme	**Project Leader:** Anup Das **PI:** Abhay Kumar **Co-PI:** Ujjwal Kumar Md. Monobrullah, P.K. Sundaram, Rakesh Kumar, Dhiraj Kr Singh, R.K. Raman, Santosh Kumar, Rachana Dubey, Manisha Tamta, Kirti Saurabh, Saurabh Kumar, Anirban Mukherjee, Ramkewal, Banda Sainath, Sarfaraj Ahmad	Nov. 2019/ Mar. 2025	Govt. of Bihar
3.2	—	Climate change impact studies at selected location in Bihar	Ved Prakash, Kirti Saurabh, Sonaka Ghosh, A. Upadhyaya, Akram Ahmed	2021/2024	ICAR-RCER
Theme- 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic crops					
4.0 Varietal Development					
4.1	ICAR-RCER/ HARP/2001/03	Plant genetic resource and improvement of fruit crops	M.K. Dhakar, J. S. Choudhary, D. Kherwar	2001/ Long term	ICAR RCER
4.2	ICAR-RCER/ RC Ranchi/ 2017/215	Genetic resource management in vegetable crops	A.K. Singh, P. Bhavana, R. S. Pan, V.K. Yadav, J.S. Chaudhary	Sept 2017/ Long term project	ICAR RCER
4.3	ICAR-RCER/ RC Ranchi/ 2019/ 226	Development of multiple disease resistant hybrids in solanaceous vegetables	P. Bhavana, A.K. Singh, A.K.Jha, J.S. Choudhary	2019/2024	ICAR-RCER
4.4	ICAR-RCER/ RC Ranchi/ 2020/ 244	Genetic enhancement of pigeon pea for yield and biotic stress resistance	P. Bhavana, J S Choudhary, A.K. Jha, Kishor Tribhuvan (ICAR-IIAB)	June 2020/ Dec 2025	ICAR-RCER
4.5	—	Improvement of French bean for disease resistance	Meenu Kumari, R.S. Pan A. K. Jha, J.S. Chaudhary	July2021/ June2025	ICAR-RCER
4.6	—	Genetic enhancement of selected vegetable legumes for Eastern India	Kumari Shubha, A.K.Choudhary, A.K. Dubey, R.S. Pan, V.K. Padala	2021/2024	ICAR-RCER
4.7	—	Development of high moisture tolerant pigeon pea and its agronomic practices for eastern India	A.K.Choudhary, A. Upadhyaya, Kirti Saurabh, Md. Monobrullah, Pawan Jeet, Rakesh Kumar	2021/2026	ICAR-RCER
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops					
5.0 Production Technologies					
5.1	ICAR-RCER/ RC Ranchi/ 2020/238	Standardization of basin enrichment in bearing orchards of Bael, Mango and Guava under eastern plateau and hill region	M. K. Dhakar, Reshma, Shinde	2020/2025	ICAR-RCER

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
5.2	ICAR-RCER/ DCR/2020/236	Standardization of agro-techniques in nutri-cereals for enhancing the productivity in eastern Indo-Gangetic plains	Rakesh Kuma, N. Bhakta	July 2020/ Dec. 2025	ICAR-RCER
5.3	—	Phosphorous mobilization through organic amendments in acidic soils of Hill and Plateau region	Reshma Shinde, S.K. Naik, A.K. Jha	2021/2026	ICAR-RCER
5.4	—	Evaluation of vegetable soybean for horticultural and nutritional traits	R S Pan, Meenu Kumari, Reshma Shinde, Sujit Bishi (ICAR-IIAB, Ranchi)	July 2021/ June 2026	ICAR-RCER
5.5	—	Sustainable fodder production system under different nitrogen and zinc management practices in eastern India	G. Makarana, Sanjeev Kumar, A. Dey, Saurabh Kumar	2021/2024	ICAR-RCER
5.6	—	Standardization of hydroponic technology for horticultural crops	T.K. Koley, Kumari Shubha, P.K. Sundram, A. Rahman	2021/2024	ICAR-RCER
5.7	—	Effect of nano-DAP fertilizer on the performance and yield of rice-wheat crop	Kirti Saurabh, Santosh Kumar, Ved Prakash, Sonaka Ghosh, A.K. Dubey, Govind Makarana	2021/2024	IFFCO
5.8	—	Understanding temporal variation in fruit maturity behaviour of litchi growing in Jharkhand and Bihar	Bikash Das, M K Dhakar, Santosh S. Mali, S.K. Naik, S.D. Pandey (ICAR- NRC for Litchi, Muzaffarpur), Dr S.K. Mehta (ICAR- NRC for Litchi, Muzaffarpur)	July 2022/ June, 2025	ICAR RCER
5.9	—	Promotion of Commercial Custard Apple Cultivation in Jharkhand	M K Dhakar, Meenu Kumari	April 2022/ March 2025	MIDH
5.10	—	Development of technology for post-harvest management and value addition of jackfruit in Eastern region	Prerna Nath, M.K. Dhakar, Ajit K Jha, S. J. Kale (IINRG), Abhishek Kumar (AF)	Jan,2022/ Dec,2024	ICAR-RCER
6.0	**Protection Technologies**				
6.1	—	Insect pest dynamics in litchi and their linking with digital tools for better management	J.S. Choudhary, S.S. Mali, M.K. Dhakar, S.K. Mehta	July2021/ June2026	ICAR-RCER
6.2	—	Morphological and molecular characterization of bottle gourd wilt complex	Ajit Kumar Jha, J.S. Chaudhary, P. Bhavana, Meenu Kumari, A.K. Singh	July2021/ June2025	ICAR-RCER
6.3	—	Weed seed bank dynamics, resource-use efficiency and greenhouse gas foot print under diverse tillage production systems in Eastern Indo-Gangetic Plains	Sonaka Ghosh, Rakesh Kumar, R. K. Raman Saurabh Kumar, Rachana Dubey, Kirti Saurabh, Ved Prakash	July 2021/ June 2024	ICAR-RCER

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
6.4	—	Bio-intensive management of fall armyworm (*Spodoptera frugiperda*) on maize	Md. Monobrullah, A K Dubey	2022/2026	ICAR-RCER
6.5	—	Management of false smut through modification in sowing dates and establishing disease relation with weather parameters	A.K. Dubey, Santosh Kumar, Manisha Tamta, Govind Makrana	2022/2026	ICAR-RCER
Theme- 4. Integrated Land & Water Management					
7.0 Land & Water Management					
7.1	ICAR-RCER/ DLWM/ 2020/ 234	Land feasibility analysis for rainwater harvesting planning at watershed level in Nalanda, Bihar.	Pawan Jeet, A. Upadhyaya	2020/2023 Extd2024	ICAR-RCER
7.2	ICAR-RCER/ DLWM/ 2020/ 239	Refinement of indigenous plough and weeding rake in Eastern Hill and Plateau region	Bikash Sarkar, P.K. Sundaram	2020/ Nov. 2023	ICAR-RCER
7.3	—	Umbrella project on floodplains of eastern India		July 2020/ June 2024	ICAR-RCER
7.3 (i)	—	Collection, evaluation and characterization of popular rice landraces in floodplains of eastern India.	N. Bhakta, Md. Monobrullah, A. K. Dubey		
7.3 (ii)	ICAR-RCER/ DSEE/ 2020/ 242	Resource inventorization of floodplain wetlands in eastern India	R. K. Raman, Jyoti Kumar, Dhiraj Kr Singh, *Associates:* Jaspreet Singh		
7.3 (iii)	—	Mapping of flood in eastern strategies	Akram Ahmed, Shivani Praveen, (NIH, Patna)		
7.3 (iv)	—	Resource assessment and management framework for sustainable fisheries in selected wetland	Vivekanand Bharti, T. Kumar, Jaspreet Singh, R.K. Raman, S.K. Ahirwal		
7.4	—	Assessment of bacterial diversity and characterization of PGPR in arsenic contaminated soil	Saurabh Kumar, Kirti Saurabh, Rachana Dubey, S K Naik (Associate)	Jan. 2021/ Dec. 2024	ICAR-RCER
7.5	ICAR-RCER/ DLWM/ 2021	Irrigation and nitrogen management of diversified rice based cropping system in middle Indo-Gangetic Plains	Shivani, Kirti Saurabh, Akram Ahmed	2021/2026	ICAR-RCER
7.6	—	Design and development of motorized cole crop harvester	P.K. Sundaram, Bikash Sarkar, A. Rahman	2021/2024	ICAR-RCER
7.7	—	Integrated Modeling approach for developing drought management strategies in the Sakri river basin, Bihar and Jharkhand	Pawan Jeet, Ajay Kumar, Arti Kumari	2021/2024	ICAR-RCER

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
7.8	—	Determining optimum decision variables in furrow irrigated system	Ajay Kumar, A. Upadhyaya, Sanjeev Kumar, Pawan Jeet, Kirti Saurabh	2022/2025	ICAR-RCER
7.9	—	Simulation of soil water dynamics in rice-wheat-moong bean cropping system	A Upadhyaya, Pawan Jeet, Kirti Saurabh	2022/2026	ICAR-RCER
7.10	—	Assessment of Evapotrans-piration and Crop Coefficients of fruit crops using Remotely Sensed Data and METRIC approach	S S Mali, S K Naik, M K Dhakar, Akram Ahmed	July 2022/ June 2025	ICAR RCER
Theme- 5. Livestock & Fisheries Management					
8.0 Livestock and Avian Management					
8.1	ICAR-RCER /DLFM/EF/ 2011/ 31	Network project on Buffalo improvement	P.C. Chandran, Pankaj Kumar, Rajni kumari, P.K. Ray, Rakesh Kumar, A. Dey (Associate)	June2012/ March 2024	ICAR RCER
8.2	ICAR-RCER/ DLFM/ 2018/ 202	Assessing genetic variability in ducks of eastern states	Rajni Kumari, P.K. Ray, S. Dayal, R. K. Kamal (Associate)	2018/2023 Extd.2024	ICAR RCER
8.3	ICAR-RCER/ DLFM/ 2019/ 231	Development of meat and egg strains of duck suitable for backyard farming	P.C. Chandran, R.K. Kamal, A. Dey, Rajni Kumari	2019/2024	ICAR-RCER
8.4	—	AICRP on Goat Improvement	A. Dey, R.K. Kamal, P.C. Chandran, S Dayal, Pankaj Kumar, Rajni Kumari, P.K. Ray, M.K. Tripathi, Rakesh Kumar	July 2019/ Mar 2025	ICAR
8.5	—	Evaluation of traditionally used growth promoters on production performances in pig and poultry	Reena K Kamal, A. Dey, Sushil Prasad, (BAU, Ranchi), Singrav S. Kullu, (BAU, Ranchi)	July 2020/ June 2023 Extd 2024	ICAR-RCER
8.6	—	Model project and Demon-stration unit for backyard poultry, livestock, vermifarming, and Moringa Integration (RKVY)	Reena K Kamal, Rakesh Kumar, A Dey, PC Chandran, Jyoti Kumar, P K Ray, Vivekanand Bharti	2021/2023	RKVY, Jharkhand
8.7	ICAR-RCER/ DLFM/ 2020/ 243	Assessment of antimicrobial drug resistance in bacteria of animal origin	Jyoti Kumar, S. Dayal,P.K. Ray	July 2020/ June 2025	ICAR-RCER
8.8	—	Reproductive abnormalities and associated common pathogens in special reference to Leptospirosis	Pankaj Kumar, Abhay Kumar, M.K. Tripathi, A. Mukherjee, Manish Kumar (IITG), S.K. Sheetal (BASU)	2021/2026	ICAR-RCER
8.9	—	Exploring genetic basis of Mastitis resistance in livestock	Shanker Dayal, Rajni Kumari, Jyoti Kumar, P.C. Chandran, M.K. Tripathi, Rakesh Kumar	2021/2025	ICAR-RCER

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
8.10	—	Effect of environmental exposure of arsenic in animals and fisheries in Bihar	M.K. Tripathi, Pankaj Kumar, A. Dey, Kamal Sarma, Arun Kumar (Mahavir Cancer Institute & Research Centre)	Jan,2022/ Dec,2026	ICAR-RCER
8.11	—	Characterization & evaluation of chicken germplasm in eastern region	Reena K Kamal, A. Dey P.C. Chandran	2022/2026	ICAR-RCER
8.12	—	Identification and characterization of common Zoonotic pathogens in domestic animals	Pradeep Kr Ray, Jyoti Kumar, P.C. Chandran, Rakesh Kumar	2022/2026	ICAR-RCER
8.13	—	Study of Genetic polymorphisms of candidate genes associated with production traits in Goats in Eastern Region.	Rakesh Kumar, Shanker Dayal, P C Chandran, P.K. Ray, MK Tripathi, Rajni Kumari	2022/2026	ICAR-RCER
9.0 Fisheries Management					
9.1	ICAR-RCER/ DLFM/ 2020/ 241	Effect of different manures on fish productivity	Kamal Sarma, Tarkeshwar Kumar, Jaspreet Singh, Jyoti Kumar, A. Dey, S.K. Ahirwal	July 2020/ June 2023 Extd.2024	ICAR-RCER
Theme- 6. Socio-Economics, Extension and Policy Research					
10.0 Socio-economic Research					
10.1	—	Enhancing food, nutritional and livelihood security of marginal and tenant farmers in Jharkhand through need based agricultural technologies	V.K. Yadav, R.S. Pan, A.K. Jha, Reena K. Kamal	June 2018/ Mar 2025	Farmer FIRST Project (Externally funded)
10.2	—	Value addition of principal food grains by farmers of Bihar	N. Chandra, Ujjwal Kumar, Dhiraj K. Singh, P.K. Sundaram	2018/2021 Extd 2023	ICAR RCER
10.3	ICAR-RCER/ DSEE/ 2019/ 230	Status of utilization of digital tools in agriculture sector in Eastern India	Ujjwal Kumar, N. Chandra, R.K. Raman, Ramkewal (KVK Buxar), Indrajeet (KVK Ramgarh), Dhiraj K. Singh	Oct. 2019/ Sep. 2024	ICAR-RCER
10.4	—	Agri-Business Incubation Project	A.K. Singh, Ujjwal Kumar, S.S. Mali, V.K. Yadav, P. Bhavana, M.K. Dhakar, Dhiraj K.Singh, T.K. Koley	2020/2025	NAIF
10.5	—	ITMU Project (NAIF Component I)	P. Bhavana, A.K. Singh,A Dey	2011/ Long term	NAIF
10.6	—	Model based inference on agricultural crops for food security in eastern India	R. K. Raman, Abhay Kumar, Ujjwal Kumar, Akram Ahmed	2021/2024	ICAR-RCER
10.7	—	Impact of e-NAM on improving marketing of agricultural produce in eastern India	D.K. Singh, Abhay Kumar, V.K. Yadav, Naresh Chandra, A. Mukherjee	2021/2024	ICAR-RCER

Theme wise Approved New Research Projects 2023-24

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
Theme 1. Farming System Research including Climate Resilient Agriculture					
1.0 Integrated Farming System and Cropping System for Eastern Region					
1.1	New	Optimization of integrated farming system model design	Manibhusan, A Upadhyaya, Sanjeev Kumar, Akram Ahmed	2023/2026 RCER	ICAR-
1.2	New	Development of sustainable Agroforestry models for Bihar's seasonally water-stressed agro- ecosystem	Abhishek Kumar, Rakesh Kumar (Agronomy), Md. Monobrullah, Kirti Saurabh, Mahesh Dhakar	2023/2027	ICAR-RCER
1.3	New	Standardization of organic farming practices for middle Indo-Gangetic Plains	Kirti Saurabh, Kumari Shubha, Abhishek Kr Dubey, Manisha Tamta, Govind Makarana, Abhishek Kumar (Farm section)	2023/2026	ICAR-RCER
3.0 Climate Resilient Agriculture					
3.1	New	Development of Weather based Agriculture Advisory System	Manisha Tamta, Ved Prakash, Manibhushan, Ajay Kumar, Sanjeev Kumar, Kumari Shubha, A K Dubey, Rakesh Kumar (Animal Science), R K Raman, S K Ahirwal T K Koley, Anirban Mukherjee	2023/2026	ICAR-RCER
3.2	New	Rice- Fallow Management (Umbrella Project)	**Project leader:**Dr. Anup Das, **Nodal officer:** Sanjeev Kumar **PI:** Rakesh Kumar, Ajay Kumar, Akram Ahmed, Manibhushan, K. Banerjee (ICAR MGIFRI), D K Singh, P. K. Sundaram, Santosh Kumar, Pawan Jeet, Kirti Saurabh, Kumari Shubha, Rakesh Kumar, (Animal Science), S K Ahirwal, Ved Prakash **FSRCHPR Team** B K Jha, S K Naik, SS Mali, J S Choudhary	2023/2027	ICAR-RCER
Theme 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic Crops					
4.0 Varietal Development					
4.1	New	One IRRI NARES Breeding Network (Plant Direct) Project (Erstwhile Accelerated Breeding: Meeting Farmers Needs with Nutritious, Climate-Resilient Crops)	Santosh Kumar, Rakesh Kumar, A K Dubey, Sonaka Ghosh	July 2022/ June 2027	ICAR–IRRI
4.2	New	Evaluation and characterization of rice genotypes for tolerance to drought and submergence	Santosh Kumar, Abhay Kumar, Rakesh Kumar,Rachana Dubey	July 2023/ June 2026	Institute

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
4.3	New	Studies on genetic variability and molecular marker associated with Maydis leaf blight in maize	P Bhavana, A K Jha, Santosh Kumar, A Dey, A K Dubey Ganpati Mukri (IARI, New Delhi), Jayant S Bhat (IARI, RRC, Dharwad)	2023/ 2027	ICAR-RCER
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops					
5.0 Production Technologies					
5.1	New	Utilization of major fruit seeds and underutilized fruits for development of functional food products	T K Koley, M K Dhakar, R K Raman, Ujjwal Kumar, Prerna Nath	2026	ICAR-RCER
Theme- 4. Integrated Land & Water Management					
7.0 Land & Water Management					
7.1	New	Multiple use of water for enhanced agricultural productivity in eastern India	**Project leader:** Anup Das **PI:** A. Upadhyaya **Co-PIs:** Akram Ahmed, Ajay Kumar, Shivani, Rachana Dubey, Pawan Jeet,T K Koley, Ved Prakash, S K Ahirwal, M K Tripathi, Abhishek Kumar, Arti Kumari **Associate,** AS Mahapatra, MK Sinha	2023/2028	ICAR-RCER
7.2	New	Evaluation of the diara ecosystem for sustainable food production	**Project leader:** Anup Das **PI:** A Dey, **Co-PIs**:Abhay Kumar, Sanjeev Kumar, Md. Monobrullah, N Bhakta, Akram Ahmed, T K Koley, Kamal Sarma, R K Raman, P K Sundaram, Saurabh Kumar, Kirti Saurabh, Mridusmita Debnath	2023/2026	ICAR-RCER
7.3	New	Energy flow, C balance, and water footprint of dominant cropping system under different agro ecological region of eastern India.	Bikash Sarkar, PK Sundaram, Rakesh Kumar, SS Mali, Pawan Jeet, Kirti Saurabh, A. Upadhyaya	2023/2026	ICAR-RCER
7.4	New	Performance Evaluation of Solar-Powered Pumping for Low Energy Pressurized Irrigation	Akram Ahmed, A Upadhyaya, Ved Prakash, Shivani, Mridusmita Debnath, Mukesh Kumar, CIAE, Bhopal	2023/2026	ICAR-RCER
7.5	New	Evaluation of tillage and crop establishment methods on productivity, resource use efficiency and soil health in rice mustard greengram cropping system of eastern plateau and hill region.	S K Naik, S S Mali, JS Chaudhary, Rakesh Kumar (Agronomy), BK Jha	2023/2028	ICAR-RCER

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
7.6	New	Water budgeting in various rice establishment techniques	M Debnath, Sonaka Ghosh, Arti Kumari, Rakesh Kumar (Associate)	2023/2026	ICAR-RCER
7.7	New	Development of solar photo-voltaic powered agricultural machineries	P.K. Sundaram, Bikash Sarkar, Pawan jeet, S.S.Mali, Kamal Sarma, A Dey, Rakesh Kumar (DLFM)	2023/2026	ICAR-RCER
Theme- 5. Livestock & Fisheries Management					
8.0 Livestock and Avian Management					
8.1	New	Assessment of ecosystem services rendered by indigenous livestock, poultry species, andbreed.	A Dey, PC Chandran, RK Raman, Reena K Kamal, Rachana Dubey	2023/2026	ICAR-RCER
8.2	New	Status of fluorosis in livestock of Bihar and evaluating the ameliorative effect of nutraceuticals on affected cattle population	Pankaj Kumar, Manoj K Tripathi, Jaspreet Singh, Saurabh Kumar, Vidya Shankar Sinha (KVK Sheikhpura)	2023/2026	ICAR-RCER
8.3	New	Transcriptome and metagenome approach to characterize the genetic basis of prolificacy in goat	Rajni Kumari, A Dey, Shanker Dayal, PC Chandran, PK Ray, Jyoti Kumar, Manoj Tripathi, Rakesh Kumar	2023/2026	ICAR-RCER
9.0 Fisheries Management					
9.1	New	Standardization of culture techniques of Pabda fish in eastern region of India	Tarkeshwar Kumar, Kamal Sarma, SK Ahirwal, Jaspreet Singh,Vivekanand Bharti	2023/2026	ICAR-RCER
9.2	New	Geospatial distribution and characteristics of microplastics in the riverine ecosystems of the Eastern Region India	Jaspreet Singh, Kamal Sarma, Tarakeshwar Kumar, Vivekanand Bharti, S. K Ahirwal	2023/2026	ICAR-RCER
Theme- 6. Socio-Economics, Extension and Policy Research					
10.1	New	Sustainability of FPO in eastern India	VK Yadav, A Mukherjee, RK Raman, Subhadeep Roy (ICAR-IIVR), Kaushik Pradhan (UBKV), Neetu Kumari (BAU, Ranchi)	2023/2026	ICAR-RCER
10.2	New	Assessing the impact of climate resilient agricultural interventions in enhancing farmers adaptive capacity in Bihar	Anirban Mukherjee, Dhiraj Kumar Singh, RK Raman, Manisha Tamta, Rakesh Kumar Agronomy), Ujjwal Kumar, Abhay Kumar, Ram Kewal (KVK Buxar), Ashok Kumar (KVK, Gaya)	2023/2026	Institute
10.3	New	Development of zero hunger and zero technology gap village through innovative interventions	***Project leader(s):*** Anup Das & Anjani Kumar(ATARI), Patna ***PI:*** Dhiraj Kumar Singh,Ujjwal Kumar, Abhay Kumar, Md. Monobrullah, Rakesh Kumar (Agronomy), Aniraban Mukherjee,	Oct 2023/ Sep 2026	Collaborative project: ATARI, Patna and ICAR RCER,

Sl. No.	Project code	Project Title	Name of PI & Co-PI	Start year/ Comp Year	Funding agency
			RK Raman, Arti Kumari, Jyoti Kumar, Kumari Shubha, Amarendra Kumar (ATARI, Patna), Pragya Bhaduria (ATARI, Patna), Deokaran (KVK,Buxar) Ramkeval (KVK, Buxar)		Patna
10.4	New	Participatory Research Application for Year round income and Agricultural Sustainability **(PRAYAS)**	***Project leader:*** Anup Das **Nodal Officer**: Bikash Sarkar ***PI:*** Anirban Mukherjee ***CCPI /Coordinators/ Associates as below***	2023/2026	Institute

PRAYAS TEAMS

Team of Assam
Dr Kamal Sarma, Pr. Scientist, State Coordinator
Prof. (Dr.) Jyogi Raj Bora, AAU
Dr N Bhakta, Pr. Scientist
Dr PC Chandran, Pr. Scientist
Dr Ajay Kumar, Pr. Scientist
Dr AK Choudhary , Pr. Scientist
Dr Manibhushan, Pr. Scientist
Dr TK Koley, Sr. Scientist
Dr R K Raman, Sr. Scientist
Dr Mridusmita Debnath, Scientist
Dr Govind Makarana, Scientist
Team of Bihar
Dr P K Sundaram, Sr. Scientist, State Coordinator
Dr Ujjwal Kumar, Head, DSEE
Dr Abhay Kumar, Pr. Scientist
Dr Shivani, Pr. Scientist
Dr Shankar Dayal, Pr. Scientist
Dr Rakesh Kumar, Sr. Scientist
Dr Santosh Kumar, Sr. Scientist
Dr Rajani Kumari, Sr. Scientist
Dr R K Raman, Sr. Scientist
Dr PK Ray, Sr. Scientist
Dr Rachana Dubey, Scientist
Dr Kirti Saurabh, Scientist
Dr Tarkeswar Kumar, Scientist
Dr Manisha Tamta, Scientist
Mr Sarfaraj Ahmad, STO
Mr Manoj Kumar Sinha, STA
Team of Chhattisgarh
Dr BK Jha, Pr. Scientist, State Coordinator
Dr RS Pan, Pr. Scientist
Dr Ajit Kumar Jha, Sr. Scientist

Dr SK Naik, Pr. Scientist, Ranchi
Dr SS Mali, Sr. Scientist, Ranchi
Dr JS Choudhary, Sr. Scientist, Ranchi
Dr Reena K. Kamal, Sr. Scientist, Ranchi
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Dr N. Chandra, Pr. Scientist
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Dr Jaspreet Singh , Scientist
Dr Saurabh Kumar, Scientist
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Dr DK Raghav, SS-cum Head, KVK, Malda-II
Dr Shailesh Kumar, SMS

Status of new and on-going activities 2023

S. No.	Title of Activities	PI
New Activities		
1.	Enhancing nutritional security of rural households through fruit based system.	T.K. Koley, K Shubha
2.	Optimizing soil organic carbon stock in rice-based cropping system in irrigated ecosystem	Rachana Dubey
3.	Development of biodegradable pots for residue management in agriculture	Kirti Saurabh
4.	To study the effects of feeding micro plastics to fish	Jaspreet Singh
5.	Enhancing nutritional security of rural households through vegetable based nutri-garden in Bihar	Kumari Shubha
6.	Development of location specific Integrated Farming System models for rainfed eco-system of Eastern Plateau Hill region	Reshma Shinde
7.	To develop DSS tool for prioritization of rice fallow areas	Manibhusan
8.	Integrated crop and nutrient management for sustainable intensification in eastern India	Shivani, K Shubha, K Saurabh, A Kumar (ACTO), PP Kumar
Ongoing Activities		
1.	Maintenance of advance breeding lines of cool season pulses	A.K. Choudhary
2.	Development of nutrient rich lines of pulse legumes for eastern India	A.K. Choudhary
3.	Evaluation of toria genotypes	N. Bhakta
4.	Breeding for submergence tolerance in rice	N. Bhakta
5.	Evaluation and development of drought tolerant rice for Eastern region	Santosh Kumar
6.	Evaluation and identification of rice genotypes for tolerance to drought stress at different growth stages.	Santosh Kumar
7.	Multi-objective optimization of integrated farming system	Akram Ahmed

Notes

आज़ादी का अमृत महोत्सव

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