भाकृअनुप
ICAR

25 YEARS

OF EXCELLENCE IN AGRICULTURAL RESEARCH AND INNOVATION

वार्षिक प्रतिवेदन 2025

ANNUAL REPORT 2025

भारतीय कृषि अनुसंधान परिषद् का पूर्वी अनुसंधान परिसर, पटना

ICAR RESEARCH COMPLEX FOR EASTERN REGION, PATNA

Annual Report 2025

Celebrating 25 years of service

Indian Council of Agricultural Research

ICAR Research Complex for Eastern Region

ICAR Parisar, P.O.: BVC, Patna-800 014, Bihar, India

www. https://icarrcer.org.in/

Annual Report 2025

ICAR Research Complex for Eastern Region, Patna

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Citation

Annual Report 2025. ICAR Research Complex for Eastern Region, Patna, 138p.

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Printed at

Virtue Enterprises
Patna-800 001
Call : 9304410331, 9386836044

PREFACE

The year 2025 marks a significant milestone for ICAR Research Complex for Eastern Region (ICAR RCER), Patna, as the institute completes its 25 years of dedicated service to the agricultural development of eastern India. Over the past quarter century, the institute has emerged as a leading centre for agricultural research, innovation, technology development, capacity building and dissemination, addressing the region's unique challenges while promoting sustainable agricultural growth. ICAR RCER, through its headquarters at Patna, the Farming System Research Centre for Hill and Plateau Region, Ranchi, and Krishi Vigyan Kendras at Buxar and Ramgarh, has continued to develop location-specific technologies for farming communities across eastern India.

A landmark contribution of the institute has been the large-scale greening of rice-fallow ecosystems through resource-conservation technologies involving short-duration rice followed by zero-till pulses and oilseeds cultivation. These interventions have contributed to the reduction of nearly 15 lakh ha of rice-fallow area in Eastern India compared to 2015-16. The institute has also developed integrated farming system models and sustainable rice-based production technologies, besides releasing 13 climate-resilient rice varieties, 67 vegetable varieties and 6 fruit varieties suited to diverse agro-ecologies.

During the year, significant progress was made in sustainable intensification of rice-wheat systems, resource conservation and natural farming. Several rice genotypes, including IR 102860-10:6-B-B, Swarna Purvi Dhan 2, Swarna Shreya, Swarna Shusk Dhan, Swarna Shakti Dhan and Swarna Unnat Dhan, performed well under natural farming conditions with grain yields ranging from 3.76 to 4.49 t ha^{-1}. Studies demonstrated improvements in soil organic carbon and biological activities under natural and conservation agriculture systems. Research on soil microbiomes, resource recycling, precision irrigation, agri-drone applications and climate-smart agriculture further strengthened sustainable farming strategies of the institute.

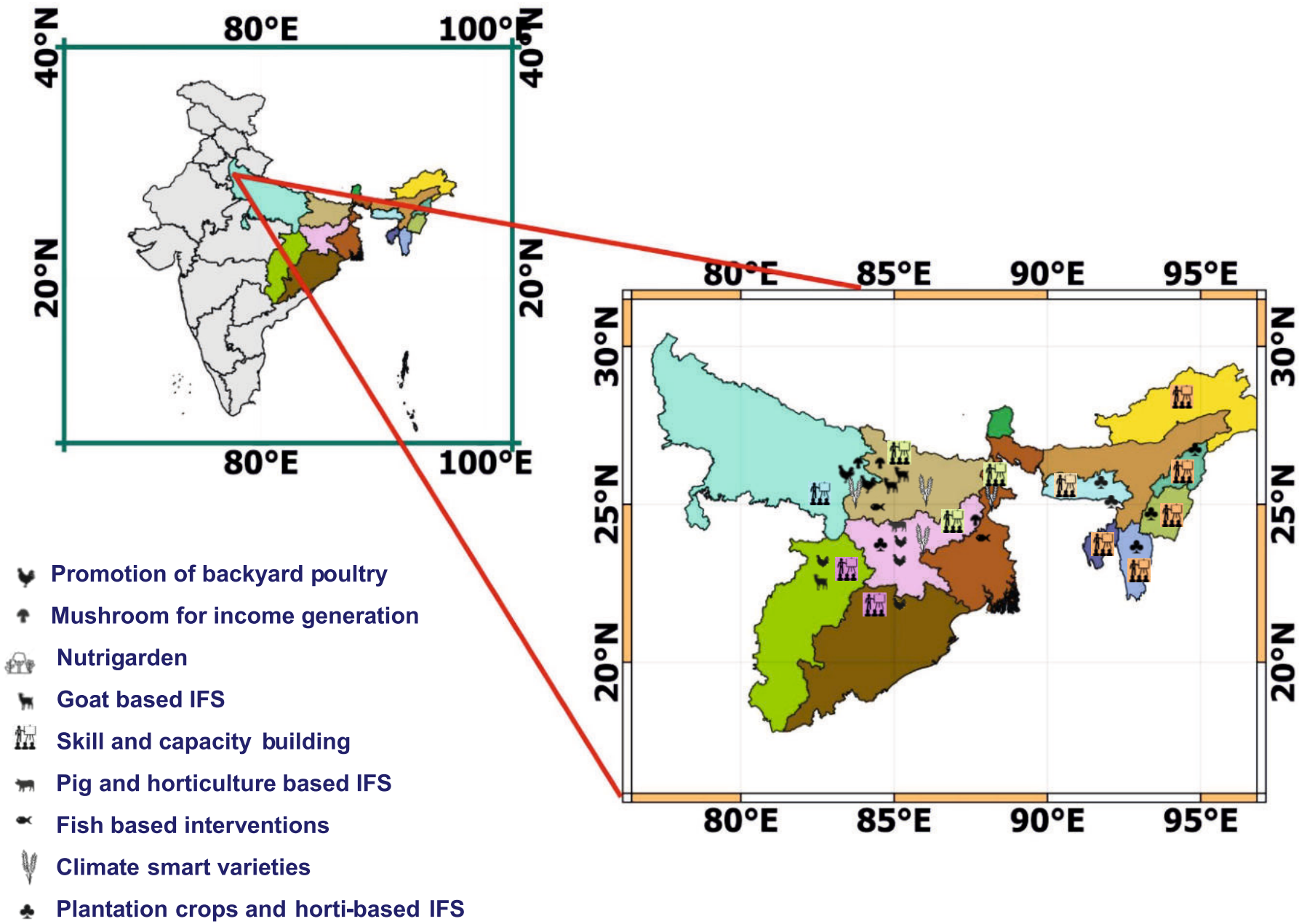
In crop improvement programmes, six promising rice genotypes were nominated to AICRIP for multi-location evaluation, while several lines were identified for drought, direct-seeded and multiple-stress environments, contributing to regional food and nutritional security. The institute also achieved a major milestone in animal genetic resource conservation through registration of four indigenous breeds - Medini cattle, Palamu goat, Mala chicken and Kodo duck-the first registered breeds from Jharkhand. Research on livestock and fish productivity and integrated crop–livestock-fish farming systems continued to support farm resilience and livelihood diversification.

A major highlight of the year was the implementation of *Kaushal se Kisan Samriddhi* initiatives under SCSP/TSP/NEH, helped reaching over 18,000 farmers in Eastern and Northeastern states and demonstrated income enhancement ranging from 14.7% to 38.5% through integrated farming approaches. The institute also actively coordinated as a nodal organization in the *Viksit Krishi Sankalp Abhiyan* (VKSA) 2025 for Bihar and Jharkhand, strengthening farmer-scientist interactions and technology dissemination. During the year, three innovative technologies were certified, five new Memoranda of Understanding were signed, and extensive training and demonstration programmes benefited more than 10,000 farmers and stakeholders.

New initiatives on microplastic contamination, sensor-based precision agriculture, agri-photovoltaics, and nano- and micro-homestead models further supported the institute's commitments towards sustainable agricultural intensification under changing climatic conditions. We acknowledge the invaluable support, guidance and constant encouragement of Dr. M. L. Jat, Secretary, DARE and Director General, ICAR, and Dr. A. K. Nayak, Deputy Director General (Natural Resource Management), ICAR. Their visionary leadership, unwavering support and continued inspiration have been instrumental in bringing out this valuable report. I gratefully acknowledge the Chairman and members of the Research Advisory Committee, the Quinquennial Review Team, collaborating institutions, state departments and all stakeholders for their continued cooperation. Above all, I place on record my deep appreciation for the dedication and commitment of the scientists, technical staff, administrative personnel and students of the institute including larger farming communities, whose collective efforts have made these milestone achievements possible.

(Anup Das)

Coverage of ICAR RCER technologies and outreach activities in Eastern states and NEH region of India



INSTITUTE AT A GLANCE 2025

HUMAN RESOURCES

62	29	41	14	8	38
Scientist	Administrative Staff	Technical Staff	Other Staff	PG Students	UG Students

INTELLECTUAL PROPERTY

03	08	01	62	04
ICAR Certified Technology	Varieties Registered	Copyright and Design	NCBI Accession	Breed Registered

PUBLICATIONS

119	09	29	16	37	12
Research Papers	Books Edited	Popular Articles	Extension Folders	Book Chapters	Bulletins

CAPACITY BUILDING

228	8805	09	~2 lakh	~2000
Training / Workshops Conducted	Total farmers benefited	Animal Health Camps Conducted	VKSA Beneficiary farmers	Beneficiary farmers under NEH activities

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SUCCESS STORY

From jobless graduate to crorepati nursery entrepreneur: A success story nurtured by ICAR RCER

Mr. Shravan Kumar, a progressive farmer-entrepreneur from Ranchi, Jharkhand, has emerged as a remarkable example of livelihood transformation through horticulture and scientific nursery management. Born on 28 January 1973, he completed his graduation but faced unemployment in his early years. Although his family supported him by establishing a grocery shop, his interest lay in horticulture and plant propagation. Fig. Shri Shravan Kumar at his nurseryA turning point in his life came when he participated in a fruit nursery training programme organized by ICAR RCER, Farming System Research Centre for Hill and Plateau Region (FSRCHPR), Plandu, Ranchi. The intensive hands-on training on grafting, budding and air-layering provided him with the technical knowledge, confidence and entrepreneurial vision required to establish his own nursery enterprise. Inspired by the training, he established Fal Udyog Nursery in 2004 at Jariyagarh village of Khunti district on 0.4 ha land. Starting with limited resources and facing several market and financial challenges, he gradually expanded the enterprise through adoption of scientific nursery practices and quality planting material production.

Today, the nursery has expanded to about 30 ha (10 ha owned and 20 ha leased) and produces nearly 6 lakh fruit plants and 40,000 timber plants annually. The nursery supplies quality planting materials of mango, guava, litchi, jamun, bel, papaya, mahogany and other species to farmers in Jharkhand, Bihar and West Bengal. The enterprise follows scientific production protocols, including use of sterilized growing media, standardized containers and quality mother blocks.

The venture presently generates an annual net income of approximately Rs. 2 crore and provides year-round employment to nearly 50 workers. Beyond his own success, Mr. Kumar has mentored and supported more than 40 entrepreneurs in establishing nursery enterprises. Shravan Kumar's journey demonstrates how timely technical guidance, skill development and continuous institutional support from ICAR RCER, combined with determination and entrepreneurship, can transform an unemployed youth into a successful agri-entrepreneur.

Photo: Shri Shravan Kumar at his nursery

At a Glance

Enterprise: Fal Udyog Nursery, Ranchi, Jharkhand

Expertise: Plant propagation and nursery management

Area under enterprise: 30 ha

Annual production: 6 lakh fruit plants and 40,000 timber plants

Employment generated: ~50 persons

Annual net income: ~Rs.2 crore

Future goal: Establishment of a training centre and conservation of rare plant species

कार्यकारी सारांश

भारतीय कृषि अनुसंधान परिषद का पूर्वी अनुसंधान परिसर, पटना, पूर्वी भारत की कृषि से संबंधित विविध चुनौतियों के समाधान एवं संभावनाओं के सदुपयोग हेतु रणनीतिक, अनुप्रयुक्त तथा अनुकूलनात्मक अनुसंधान करता है। संस्थान अपनी अनुसंधान एवं विकास गतिविधियों का संचालन पाँच प्रमुख विषयगत क्षेत्रों के अंतर्गत करता है, जिनमें शामिल हैं: जलवायु-सहिष्णु कृषि के लिए पुनर्योजी एवं समेकित कृषि प्रणाली; आनुवंशिक संसाधन प्रबंधन एवं उन्नत उत्पादन प्रौद्योगिकियाँ; भूमि एवं जल उत्पादकता वृद्धि हेतु प्राकृतिक संसाधन प्रबंधन; सतत् पशुधन एवं मत्स्य उत्पादन प्रणाली तथा सामाजिक-आर्थिक, प्रसार एवं नीतिगत अनुसंधान। वर्ष 2025 के दौरान संस्थान ने अनेक प्रमुख अनुसंधान एवं विकास कार्यक्रमों पर विशेष ध्यान केंद्रित किया, जिनमें धान-परती पारितंत्रों का हरितीकरण, उत्पादकता वृद्धि हेतु जल-स्मार्ट कृषि, फसल विविधीकरण, समेकित कृषि प्रणाली तथा देसी पशुधन एवं कुक्कुट आनुवंशिक संसाधनों का अभिलक्षण एवं पंजीकरण शामिल हैं। इन प्रयासों से क्षेत्र में कृषि उत्पादकता, संसाधनों के उपयोग की दक्षता, जलवायु सहनशीलता तथा आजीविका सुरक्षा में उल्लेखनीय वृद्धि हुई। संस्थान की प्रसार गतिविधियाँ पूर्वी भारत के सात राज्यों में इसके प्रमुख आउटरीच कार्यक्रमों—"निरंतर आय एवं कृषि स्थिरता हेतु सहभागी अनुसंधान अनुप्रयोग" (PRAYAS) तथा "कौशल से किसान समृद्धि" के माध्यम से संचालित की गईं। ये दोनों कार्यक्रम अनुसूचित जाति उप-योजना एवं जनजातीय उप-योजना के अंतर्गत संचालित समर्पित पहल हैं, जिनका उद्देश्य कौशल विकास एवं उद्यमिता संवर्धन के माध्यम से ग्रामीण युवाओं तथा महिलाओं को सशक्त बनाना है। संस्थान ने अपने उत्तर-पूर्वी पर्वतीय कार्यक्रम का क्रियान्वयन चार प्रमुख रणनीतियों—संस्थागत सहयोग, ज्ञान साझेदारी, क्षमता निर्माण तथा प्रक्षेत्र-आधारित सहभागी प्रदर्शनों के माध्यम से किया, जिससे लगभग दो हजार किसान लाभान्वित हुए । वर्ष 2025 के दौरान अनुसंधान, प्रौद्योगिकी विकास तथा प्रसार के क्षेत्र में संस्थान की प्रमुख उपलब्धियों का संक्षिप्त विवरण निम्नलिखित है।

- जलवायु-अनुकूल कृषि के अंतर्गत गया जी जिले में धान-परती क्षेत्रों के प्रबंधन हेतु खरीफ मौसम में अल्पावधि धान की किस्म स्वर्ण श्रेया तथा अरहर की किस्म आईपीए-203 (IPA-203) का समावेश किया गया। इसके उपरांत रबी मौसम में उन्नत फसल प्रबंधन एवं संसाधन संरक्षण प्रौद्योगिकियों के माध्यम से अल्पावधि दलहनी एवं तिलहनी फसलों की खेती 733 एकड़ क्षेत्र में की गई , जिससे 832 किसान लाभान्वित हुए। धान-परती क्षेत्रों को हरा-भरा बनाने के परिणामस्वरूप धान में 4.5–5.0 टन/हेक्टेयर, अरहर में 1.9–2.0 टन/हेक्टेयर, मसूर में 1.24–1.37 टन/हेक्टेयर, चना में 1.40–1.58 टन/हेक्टेयर, सरसों में 1.18–1.24 टन/हेक्टेयर तथा कुसुम में 1.13–1.32 टन/हेक्टेयर की उत्साहवर्धक उपज प्राप्त हुई।

- धान-परती प्रणाली में फसल लगाने एवं अवशेष प्रबंधन तकनीकों के अंतर्गत धान की पारंपरिक रोपाई विधि द्वारा अधिकतम धान की उपज (5.17 टन/हेक्टेयर) प्राप्त हुई, जो शून्य जुताई विधि द्वारा धान की सीधी बुआई (ZTDSR) एवं संरक्षण जुताई विधि द्वारा धान की सीधी बुआई (CTDSR) की तुलना में क्रमशः 24.9% तथा 14.5% अधिक थी।

- एक एकड़ वर्षा-आधारित समेकित कृषि प्रणाली में 4,480.31 किग्रा CO_2-समतुल्य ग्रीनहाउस गैसों का उत्सर्जन दर्ज किया गया, जबकि 6,710.63 किग्रा CO_2-समतुल्य कार्बन का अवशोषण हुआ। इस प्रकार, प्रणाली का शुद्ध कार्बन संतुलन -2,230.31 किग्रा CO_2-समतुल्य रहा। कुल उत्सर्जन का 78.57% भाग पशुधन से प्राप्त हुआ, जबकि जैविक आदानों एवं कृषिवानिकी के समावेशन ने कार्बन अवशोषण क्षमता में वृद्धि कर इस प्रणाली को शुद्ध कार्बन सिंक बनाया ।

- सब्जी-आधारित समेकित कृषि प्रणाली से ₹1.56 लाख प्रतिवर्ष का शुद्ध प्रतिफल प्राप्त हुआ तथा 15 वर्षों में मृदा जैविक कार्बन में 13–27% की वृद्धि दर्ज की गई। इस प्रणाली में आउटपुट-इनपुट ऊर्जा अनुपात 3.2 प्राप्त हुआ तथा ग्रीनहाउस गैसों का शुद्ध ऋणात्मक उत्सर्जन (किग्रा CO_2-समतुल्य) दर्ज किया गया। फलस्वरूप यह प्रणाली जलवायु-सहिष्णु एवं कार्बन-पॉजिटिव कृषि प्रणाली के रूप में परिलक्षित होती है।

- महिला सशक्तिकरण एवं आजीविका उन्नयन हेतु 250 वर्गमीटर (सूक्ष्म) तथा 125 वर्गमीटर (नैनो) क्षेत्रफल वाले गृहवाटिका-आधारित समेकित कृषि मॉडल विकसित किए गए। इन मॉडलों में सब्जियों, फलों, पशुधन, मशरूम आदि का एकीकृत समावेश किया गया, जिससे क्रमशः ₹45,466 तथा ₹19,150 की वार्षिक शुद्ध आय अर्जित हुई।

- संरक्षण कृषि आधारित शून्य जुताई द्वारा धान की सीधी बुआई–शून्य जुताई गेहूँ–शून्य जुताई मूंग (ZTDSR–ZTW–ZTG) फसल प्रणाली में मृदा सूक्ष्मजीव समुदाय का 92–96% भाग जीवाणु-प्रधान पाया गया, जिससे मृदा की जैविक गुणवत्ता में सुधार हुआ। साथ ही, इस प्रणाली में पारंपरिक जुताई की तुलना में सूक्ष्मजीवी विविधता एवं स्थिरता भी अधिक दर्ज की गई।

- पटना में प्राकृतिक खेती की परिस्थितियों में किए गए मूल्यांकन में IR 102860-10:6-B-B, स्वर्ण पूर्वी धान-2, स्वर्ण श्रेया, IR 14L362, IR 97069-1-1-1-1, IR 14L157, IR17L1060, IR98976-20-1-2-2, IR18R1123, स्वर्ण शुष्क धान, IR16L1499, स्वर्ण शक्ति धान, IR 95781-15-1-1-4 तथा स्वर्ण उन्नत धान ने श्रेष्ठ प्रदर्शन किया। इन जीनोटाइपों की उत्पादकता 3.76 से 4.49 टन/हेक्टेयर के मध्य दर्ज की गई।

- चौथे वर्ष के दौरान धान–गेहूँ–मूंग फसल प्रणाली की सकल उत्पादकता जैविक खेती, प्राकृतिक खेती, पारंपरिक खेती तथा एकीकृत पोषक तत्त्व प्रबंधन के अंतर्गत

क्रमशः 10.35, 10.43, 12.57 एवं 13.40 टन/हेक्टेयर रही। प्राकृतिक खेती में मूंग की सर्वाधिक 0.95 टन/हेक्टेयर उपज प्राप्त हुई, जो पारंपरिक खेती में प्राप्त 0.83 टन/हेक्टेयर की तुलना में 14.5% अधिक थी। इसके विपरीत, धान एवं गेहूँ की अधिक उपज एकीकृत पोषक तत्त्व प्रबंधन तथा पारंपरिक खेती प्रणाली के अंतर्गत प्राप्त हुई।

- पूर्वी पठारी एवं पहाड़ी क्षेत्र की प्रमुख फसल प्रणालियों में प्राकृतिक खेती अपनाने से मृदा जैविक कार्बन की मात्रा 0.80% दर्ज की गई, जो पारंपरिक खेती (0.73%) की अपेक्षा अधिक थी। अध्ययन की गई फसल प्रणालियों में लोबिया–चना प्रणाली ने 77.73 क्विंटल/हेक्टेयर की सर्वाधिक प्रणाली उत्पादकता प्राप्त की। ये परिणाम विशेषकर दलहन-आधारित फसल प्रणालियों में मृदा स्वास्थ्य में सुधार तथा सतत् उत्पादकता बनाए रखने में प्राकृतिक खेती की क्षमता को दर्शाते हैं।

- वर्षा-आधारित शुष्क धान की सीधी बुआई की परिस्थितियों के लिए IR18R 1179, RCPR 84, IR18R 1068, IR 132084-B-26-1-2-B-8, IR22EL1466, IR 132084-B-26-1-2-B-12, RCP 10-1, IR 97197-93-3-1-1, RCPR 100 तथा RCP 12-1 को संभाव्य जीनोटाइप के रूप में चिह्नित किया गया। इन जीनोटाइपों की उत्पादकता 1.64–2.95 टन/हेक्टेयर के बीच दर्ज की गई, जो सहभागी धान (1.26 टन/हेक्टेयर) तथा IR 64 (0.278 टन/हेक्टेयर) जैसी चेक किस्मों की तुलना में अधिक रही।

- धान के IR 95781-15-1-1-4, IR18R1068, IR22EL1466, IR22EL1242, IR14L613, IR 84899-B-185-8-1-1-1, IR 98925-11-1-2-1, RCP 10-1, IR83929-B-B-291-3-1-1, IR 97046-39-2-1-2 तथा IR18R1179 जीनोटाइपों की पहचान बहु-विकासीय अवस्थाओं पर सूखा-सहनशील सफल प्रविष्टियों के रूप में की गई। इनकी उत्पादकता 2.60–3.17 टन/हेक्टेयर दर्ज की गई, जो सहभागी धान (1.88 टन/हेक्टेयर) तथा IR 64 (0.854 टन/हेक्टेयर) जैसी चेक किस्मों की तुलना में अधिक रही।

- धान के छह आशाजनक जीनोटाइप (RCPR 102, RCPR 109, RCPR 110, RCPR 111, RCPR 112 तथा RCPR 113) को खरीफ 2025 के दौरान अखिल भारतीय समन्वित धान अनुसंधान परियोजना (AICRIP) के अंतर्गत बहु-स्थलीय परीक्षण एवं मूल्यांकन के लिए नामांकित किया गया।

- मक्का की 29 देशी किस्मों के आनुवंशिक विविधता विश्लेषण से कृषि-आकृतिक एवं पोषण संबंधी लक्षणों में उल्लेखनीय विविधता पाई गई। इनमें IC 625163, IC 625143 तथा IC 625139 को उच्च उपज के लिए, IC 625181 को अधिक लौह की मात्रा के लिए तथा IC 625168 को अधिक बीज भार के लिए श्रेष्ठ जीनोटाइप के रूप में चिह्नित किया गया।

- मैक्सएंट मॉडलिंग आधारित जलवायु परिवर्तन प्रभाव आकलन से ज्ञात हुआ कि कोनोपोमोर्फा साइनेंसिस के लिए वर्तमान में पूर्वी भारत के लीची उत्पादक क्षेत्रों में स्थान उपयुक्तता अधिक है। किंतु भविष्य की जलवायु परिस्थितियों, विशेषकर ग्रीनहाउस गैसों के उच्च उत्सर्जन परिदृश्यों में, इसके प्रसार पर प्रतिकूल प्रभाव पड़ने तथा भारत के अनेक क्षेत्रों में इसकी स्थानीय उपयुक्तता में कमी आने की संभावना है।

- आर्सेनिक-प्रतिरोधी पादप वृद्धि प्रोत्साहक राइजोबैक्टीरिया S10P2 *(Pseudomonas anuradhapurensis)* ने व्यापक उपापचयी क्षमता तथा बहु-धातु प्रतिरोध प्रदर्शित किया, जिससे यह जैव-उपचार के लिए अधिक उपयुक्त पाया गया। वहीं, B14P1 में लौह अवशोषण तथा फॉस्फेट उपापचय से संबंधित गुण अधिक प्रभावी पाए गए। दोनों जीनोम NCBI डेटाबेस में जमा किए गए हैं, जिससे इस क्षेत्र में भावी अनुसंधान एवं अनुप्रयोगों को प्रोत्साहन मिलेगा।

- शहतूत के 31 जीनोटाइपों के अनुसंधान प्रक्षेत्र पर मूल्यांकन में स्वर्ण रसरानी एवं HMS-1 सहित कई श्रेष्ठ जीनोटाइपों की पहचान की गई, जिनमें फल की गुणवत्ता तथा एंटीऑक्सीडेंट क्षमता बेहतर पाई गई। ये जीनोटाइप व्यावसायिक खेती एवं प्रजनन कार्यक्रमों के लिए उपयुक्त पाए गए।

- सोयाबीन के 34 जीनोटाइपों के मूल्यांकन में कैरोटेनॉयड की मात्रा 4214.88–4849.91 माइक्रोग्राम/100 ग्राम तथा एंटीऑक्सीडेंट गतिविधि 258.25–331.98 मि.ग्रा. AEAC/100 ग्राम के बीच दर्ज की गई। इनमें स्वर्ण सुगंधा (331.25 मि.ग्रा. AEAC/100 ग्राम; 13.32 टन/हेक्टेयर) तथा स्वर्ण वसुंधरा (327.23 मि.ग्रा. AEAC/100 ग्राम; 10.34 टन/हेक्टेयर) को एंटीऑक्सीडेंट क्षमता एवं उत्पादकता की दृष्टि से श्रेष्ठ जीनोटाइप के रूप में चिह्नित किया गया।

- कलमबद्ध टमाटर में कलम-संधान के दौरान किए गए तुलनात्मक मेटाबोलोमिक विश्लेषण से 60–67 उपापचयों के स्तर में वृद्धि तथा 55–62 उपापचयों के स्तर में कमी दर्ज की गई। यह रक्षा तंत्र एवं एंटीऑक्सीडेंट से संबंधित उपापचयों में गतिशील परिवर्तनों का संकेत देता है, जिससे जीवाणुजनित म्लानि के प्रति प्रतिरोध क्षमता में वृद्धि हुई।

- मटर में किए गए मेटाबोलोमिक एवं पोषणीय विश्लेषण के आधार पर ABL-39 में सर्वाधिक एन्थोसाइनिन (115.24 मि.ग्रा./100 ग्राम) तथा एंटीऑक्सीडेंट क्षमता (273.50 मि.ग्रा. AAE/100 ग्राम) दर्ज की गई, जबकि ABL-112 में सर्वाधिक प्रोटीन (80.77 मि.ग्रा./100 ग्राम) पाया गया।

- संस्थान में सेम के 521 तथा बरबटी के 215 जीनोटाइपों के मूल्यांकन के आधार पर बेलदार की सात तथा झाड़ीदार की दो आशाजनक प्रविष्टियों की पहचान की गई। इन प्रविष्टियों में प्रति पौधा 130–145 फलियाँ, 40–45 दिनों में पुष्पन, तथा कॉलर रॉट एवं पीत मोज़ेक रोग के प्रति सहनशीलता पाई गई। साथ ही, इनका प्रदर्शन

बिहार के चार कृषि-जलवायु क्षेत्रों में स्थिर रहा।

- खरीफ 2025 के दौरान संस्थान द्वारा धान की स्वर्ण श्रेया, स्वर्ण शक्ति धान, स्वर्ण समृद्धि धान, स्वर्ण उन्नत धान, स्वर्ण सूखा धान, स्वर्ण शुष्क धान, स्वर्ण पूर्वी धान-1, स्वर्ण पूर्वी धान-2, स्वर्ण पूर्वी धान-3, स्वर्ण पूर्वी धान-4 तथा स्वर्ण पूर्वी धान-5 किस्मों का 107.3 क्विंटल प्रजनक बीज, 3.30 क्विंटल नाभिकीय बीज तथा 54.5 क्विंटल सत्यांकित बीज का उत्पादन किया गया।

- सबजपुरा प्रक्षेत्र में विकसित जल-स्मार्ट कृषि प्रणाली मॉडल में मत्स्यपालन, उद्यानिकी, कुक्कुट पालन तथा रेज्ड एवं संकेन बेड पर आधारित फसल प्रणाली के एकीकरण से भूमि एवं जल उत्पादकता में उल्लेखनीय वृद्धि दर्ज की गई। इस प्रणाली के अंतर्गत 195–233 क्विंटल/हेक्टेयर भूमि उत्पादकता तथा 11.0–14.4 किग्रा./घन मीटर जल उत्पादकता प्राप्त हुई, जो एकल धान फसल प्रणाली की तुलना में क्रमशः 3.5–4.5 गुना तथा 20–25 गुना अधिक थी।

- मशीन लर्निंग आधारित रूपरेखा द्वारा समर्थित पद्धति के माध्यम से मध्य इंडो-गंगा मैदानी क्षेत्र में सीमित मौसम संबंधी आँकड़ों का उपयोग करते हुए प्रतिदिन वाष्पोत्सर्जन (ET_0) का उच्च सटीकता के साथ आकलन किया गया। एडा-बूस्ट (AdaBoost) मॉडल ने सर्वोच्च पूर्वानुमान सटीकता प्रदर्शित की (प्रशिक्षण हेतु R^2 = 0.86 तथा परीक्षण हेतु R^2 = 0.80–0.81)। वहीं, अधिकतम तापमान, न्यूनतम तापमान तथा उज्ज्वल धूप अवधि को सम्मिलित करने से स्टोकेस्टिक ग्रेडिएंट डिसेंट (SGD) मॉडल की पूर्वानुमान क्षमता में वृद्धि हुई, जिसमें R^2 का मान 0.82–0.83 दर्ज किया गया।

- भारतीय कृषि अनुसंधान परिषद का पूर्वी अनुसंधान परिसर, पटना के अंतर्गत कृषि प्रणाली का पहाड़ी एवं पठारी अनुसंधान केंद्र, राँची में स्थापित कृषि-फोटोवोल्टाइक प्रणाली ने ब्रोकली एवं फ्रेंच बीन की खेती के लिए सूक्ष्म जलवायु में उल्लेखनीय सुधार किया। इस प्रणाली के अंतर्गत मृदा नमी में 2–4% की वृद्धि, तापमान में लगभग 2°C की कमी तथा सौर विकिरण में 600–700 बनाम 800–860 वाट/वर्ग मीटर कमी दर्ज की गई। परिणामस्वरूप, जल उपयोग दक्षता में वृद्धि हुई तथा जलवायु तनाव की परिस्थितियों में फसलों के प्रदर्शन में उल्लेखनीय सुधार हुआ।

- गंगा एवं गंडक दियारा क्षेत्रों में मृदा की बनावट एवं पोषक तत्त्वों की परिवर्तनशीलता फसल उपयुक्तता के प्रमुख निर्धारक कारक पाए गए। अधिक रेतीली मृदाएँ लौकीवर्गीय फसलों के लिए उपयुक्त रहीं, जबकि अपेक्षाकृत कम रेतीली मृदाओं में मैदानी फसलों की खेती अधिक उपयुक्त पाई गई। जिन मृदा में बालू की मात्रा 60% से कम (मुख्यतः ऊपरी दियारा क्षेत्र) पाई गई, वे गेहूँ, आलू, सरसों, मसूर, मक्का तथा प्याज की खेती के लिए उपयुक्त पाई गईं।

- पशुधन एवं कुक्कुट की पहचान एवं अभिलक्षण अध्ययन के आधार पर झारखंड राज्य से संबंधित चार विशिष्ट नस्लों का पंजीकरण किया गया, जिनमें मेदिनी गाय, पलामू बकरी, माला मुर्गी तथा कोड़ो बतख शामिल हैं।

- मैथिली बत्तखों के रूपात्मक लक्षणों को दर्ज किया गया, जिसमें नर बत्तख मादाओं की तुलना में बड़े और भारी पाए गए, जो डिजिटल लक्षण-वर्णन, आनुवंशिक सुधार और संरक्षण के लिए आधारभूत आंकड़े प्रदान करते हैं।

- बकरियों के योनि माइक्रोबायोटा में नस्ल-विशिष्ट तथा प्रसव क्रम से संबंधित विविधताएँ देखी गईं, जिनमें जमुनापारी बकरियों में सूक्ष्मजीव विविधता अधिक पाई गई। ये निष्कर्ष प्रजनन क्षमता एवं गर्भ प्रबंधन के लिए संभावित सूक्ष्मजीव बायोमार्करों (Microbial Biomarkers) की पहचान की दिशा में महत्वपूर्ण संकेत प्रदान करते हैं।

- पारिस्थितिकी तंत्र सेवाओं के आर्थिक मूल्यांकन से ज्ञात हुआ कि भैंसों के जीवनकाल के दौरान पारिस्थितिकी तंत्र में उनके योगदान में प्रावधानकारी सेवाओं का सर्वाधिक योगदान रहा, विशेष रूप से मुर्रा नस्ल में। गैर-वर्णित भैंसों की तुलना में मुर्रा भैंसों में प्रावधानकारी तथा नियामक दोनों प्रकार की पारिस्थितिकी तंत्र सेवाओं का योगदान अधिक पाया गया।

- बकरी सुधार पर अखिल भारतीय समन्वित अनुसंधान परियोजना के अंतर्गत ब्लैक बंगाल बकरी की आबादी में लक्षित हस्तक्षेपों, प्रशिक्षण एवं स्वास्थ्य सेवाओं के माध्यम से वृद्धि प्रदर्शन, प्रजनन मापदंडों तथा बकरी पालकों की सामाजिक-आर्थिक स्थिति में उल्लेखनीय सुधार दर्ज किया गया।

- झारखंड की रंगवा मुर्गी में उच्च अनुकूलन क्षमता पाई गई। इस नस्ल में औसत 16.6 पक्षियों का झुंड आकार, प्रति मुर्गी प्रति वर्ष 65.57 अंडों का उत्पादन तथा वयस्क अवस्था में क्रमशः नर का 1.53 किलोग्राम एवं मादा का 1.06 किलोग्राम शरीर भार दर्ज किया गया। इसकी मध्यम वृद्धि क्षमता एवं स्थानीय परिस्थितियों के प्रति अनुकूलता इसे बैकयार्ड कुक्कुट पालन प्रणाली के लिए उपयुक्त बनाती है तथा यह ग्रामीण आजीविका एवं पोषण सुरक्षा को सुदृढ़ करने में महत्वपूर्ण भूमिका निभाती है।

- हाइब्रिड नेपियर एवं गिनी घास में उच्च वर्षा की परिस्थितियों में शून्य पौध मृत्यु दर्ज की गई, जबकि काँटारहित कैक्टस में 49.74% तक पौध मृत्यु दर्ज की गई। हाइब्रिड नेपियर ने 117 टन/हेक्टेयर की सर्वाधिक जैवभार उपज तथा करंज ने 18.95 टन/हेक्टेयर/वर्ष की उच्चतम कार्बन अवशोषण क्षमता प्रदर्शित की। अध्ययन से स्पष्ट हुआ कि एकीकृत कृषि-वानिकी प्रणाली चारा उत्पादन बढ़ाने एवं जलवायु सहनशीलता को सुदृढ़ करने की दृष्टि से अत्यंत प्रभावी है।

- विकसित ARIMA (2,1,2) मॉडल के पूर्वानुमान के अनुसार बिहार में वर्ष 2030 तक मत्स्य उत्पादन लगभग 12 लाख टन तक पहुँचने की संभावना है। इस संभावित वृद्धि को ध्यान में रखते हुए गुणवत्तायुक्त मत्स्य बीज एवं आहार (फीड) अवसंरचना के विकास तथा उपयुक्त नीतिगत सहयोग की आवश्यकता होगी।

- बायोफ्लॉक आधारित मत्स्य पालन प्रणाली में पंगासियानोडोन हाइपोफ्थैलमस के फ्राई (मत्स्य शिशुओं) ने सामान्य पालन प्रणाली की तुलना में जीवित रहने की क्षमता, वृद्धि दर एवं समग्र उत्पादन दक्षता में उल्लेखनीय सुधार प्रदर्शित किया। अध्ययन में 200 फ्राई प्रति घन मीटर की संचयन घनत्व को बीज पालन हेतु सर्वोत्तम पाया गया।

- पूर्वी भारत में 240 दिनों की पालन अवधि के दौरान मिट्टी के तालाबों में वाणिज्यिक आहार के उपयोग के साथ पाबदा–कतला–रोहू की बहु-प्रजातीय मत्स्य पालन प्रणाली सर्वाधिक उत्पादक एवं आर्थिक रूप से लाभकारी पाई गई। इस प्रणाली में पाबदा (औसत भार 0.24 ग्राम), कतला (65 ग्राम) एवं रोहू (50 ग्राम) की अनुशंसित संचयन घनत्व क्रमशः 20,000, 2,000 एवं 3,000 मछलियाँ प्रति हेक्टेयर निर्धारित की गई।

- आहार में HDPE (High-Density Polyethylene) माइक्रोप्लास्टिक की बढ़ती मात्रा से रोहू की वृद्धि दर में उल्लेखनीय कमी दर्ज की गई। यह परिणाम मत्स्य पालन की स्थिरता तथा मत्स्य स्वास्थ्य पर माइक्रोप्लास्टिक प्रदूषण के प्रतिकूल प्रभावों को रेखांकित करता है।

- "वर्ष भर निरंतर आय एवं कृषि स्थिरता हेतु सहभागी अनुसंधान अनुप्रयोग" (PRAYAS) (सिंगल विंडो अनुसूचित जाति उप योजना/ जनजातीय उप योजना कार्यक्रम) के अंतर्गत बहु-राज्यीय समेकित कृषि प्रणाली हस्तक्षेपों के प्रभाव मूल्यांकन से आय, आजीविका विविधीकरण एवं पोषण सुरक्षा में उल्लेखनीय सुधार परिलक्षित हुआ। आय में झारखंड (38.5%), बिहार (36.8%), ओडिशा (27.9%), पूर्वी उत्तर प्रदेश (21.1%), छत्तीसगढ़ (19.6%), असम (18.7%) तथा पश्चिम बंगाल (14.7%) में वृद्धि दर्ज की गई।

- बिहार में स्वैच्छिक कार्बन क्रेडिट की संभावनाओं पर किए गए अध्ययन से ज्ञात हुआ कि लघु एवं सीमांत कृषकों ने मासिक प्रतिवेदन को प्राथमिकता दी, जबकि बड़े कृषकों ने फसल मौसम के अंत में प्रतिवेदन तथा डिजिटल निगरानी को अधिक उपयुक्त माना।

- 16 सप्ताह तक चलने वाले जलवायु-सहिष्णु डेयरी कृषक फील्ड स्कूल के माध्यम से 40 लघु एवं सीमांत डेयरी कृषकों को ऊष्मा तनाव प्रबंधन, चारा नियोजन, संतुलित आहार प्रबंधन, रोग नियंत्रण तथा स्वच्छ दुग्ध उत्पादन का प्रशिक्षण प्रदान किया गया। इस प्रशिक्षण से पशुधन स्वास्थ्य, निर्णय लेने की क्षमता तथा निवारक प्रबंधन उपायों को अपनाने में उल्लेखनीय सुधार हुआ।

- कृषि विज्ञान केंद्र, बक्सर द्वारा शून्य जुताई गेहूँ तकनीक के प्रसार के माध्यम से 45,200 हेक्टेयर से अधिक क्षेत्र में जल-बचत एवं उपज वृद्धि करने वाली कृषि पद्धतियों का सफलतापूर्वक प्रसार किया गया, जिससे 50 हजार से अधिक किसान प्रत्यक्ष रूप से लाभान्वित हुए।

- कृषि विज्ञान केंद्र, रामगढ़ ने 1,210 हेक्टेयर क्षेत्र में उन्नत फसल किस्मों, जलवायु-सहिष्णु कृषि पद्धतियों, जल संरक्षण तकनीकों, समेकित कृषि प्रणाली एवं प्राकृतिक खेती का सफल प्रसार किया। इस पहल से 4,482 कृषकों एवं कृषक परिवारों को प्रत्यक्ष लाभ प्राप्त हुआ।

- वर्ष 2025 के दौरान भारतीय कृषि अनुसंधान परिषद का पूर्वी अनुसंधान परिसर, पटना द्वारा विकसित तीन नवाचारी प्रौद्योगिकियों को भारतीय कृषि अनुसंधान परिषद द्वारा प्रमाणीकरण प्रदान किया गया। ये प्रौद्योगिकियाँ कृषि पद्धतियों में महत्वपूर्ण प्रगति का प्रतिनिधित्व करती हैं तथा क्षेत्र में कृषि उत्पादकता, सततता एवं संसाधन उपयोग दक्षता को बढ़ाने की दिशा में महत्वपूर्ण योगदान देंगी।

- वर्ष 2025 के दौरान संस्थान ने उल्लेखनीय शैक्षणिक एवं वैज्ञानिक योगदान देते हुए विशेषज्ञ-समीक्षित शोध पत्रिकाओं में 119 शोध-पत्र, 9 पुस्तकें, 37 पुस्तक/ मार्गदर्शिका अध्याय, 12 तकनीकी बुलेटिन, 16 प्रसार पुस्तिका तथा 29 लोकप्रिय आलेख प्रकाशित किए। संस्थान के वैज्ञानिकों ने 50 से अधिक सम्मेलनों, संगोष्ठियों, कार्यशालाओं, विचार-विमर्श बैठकों एवं मंथन सत्रों में सक्रिय सहभागिता की, राष्ट्रीय एवं अंतर्राष्ट्रीय आयोजनों में 25 से अधिक शोध-पत्र प्रस्तुत किए तथा उन्हें छह पुरस्कारों से सम्मानित किया गया।

- वर्ष 2025 के दौरान संस्थान द्वारा 16 समझौता ज्ञापनों (MoUs) पर हस्ताक्षर किए गए। पटना मुख्यालय तथा राँची केंद्र द्वारा संयुक्त रूप से 96 क्षमता निर्माण प्रशिक्षण कार्यक्रम आयोजित किए गए, जबकि दोनों कृषि विज्ञान केंद्रों द्वारा 132 प्रशिक्षण कार्यक्रम संपन्न कराए गए। इस प्रकार वर्ष के दौरान कुल 228 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिनसे 8,805 किसानों को लाभान्वित किया गया। इसके अतिरिक्त, 30 अग्रिम पंक्ति प्रदर्शन एवं अन्य प्रदर्शन आयोजित किए गए तथा 216 जागरूकता कार्यक्रमों का आयोजन किया गया, जिससे वर्षभर व्यापक कृषि प्रसार एवं जन-जागरूकता सुनिश्चित हुई। "विकसित कृषि संकल्प अभियान" के अंतर्गत बिहार एवं झारखंड के लगभग 2 लाख किसानों को नवीन कृषि प्रौद्योगिकियों तथा कृषि क्षेत्र से संबंधित विभिन्न सरकारी योजनाओं के प्रति जागरूक एवं संवेदनशील बनाया गया।

Chapter 1
EXECUTIVE SUMMARY

The ICAR Research Complex for Eastern Region (ICAR RCER), Patna, undertakes strategic, applied, and adaptive research to address the diverse challenges and opportunities of agriculture in Eastern India. The Institute carries out its research and development activities through five major thematic areas, namely: **Regenerative and Integrated Farming Systems for Climate Resilient Agriculture; Genetic Resource Management and Improved Production Technologies; Natural Resource Management for Enhancing Land & Water Productivity; Sustainable Livestock & Fisheries Production System; and Socio-Economics, Extension and Policy Research**.

During the year 2025, the Institute focused on several flagship research and development programmes, including the greening of rice-fallow ecosystems, water smart farming for enhanced productivity, crop diversification, integrated farming systems, and the characterization and registration of indigenous livestock and poultry genetic resources. These initiatives contributed significantly towards improving agricultural productivity, resource-use efficiency, climate resilience, and livelihood security in the region. The Institute's extension efforts were implemented across seven Eastern states through its flagship outreach programmes, namely Participatory Research Application for Year-round Income and Agricultural Sustainability (PRAYAS) and *Kaushal Se Kisan Samriddhi*, a dedicated initiative under the Scheduled Caste Sub Plan (SCSP) and Tribal Sub Plan (TSP) aimed at empowering rural youth and women through skill development and entrepreneurship promotion. The institute implemented its NEH programme through four-point strategies: Institutional collaboration, knowledge sharing, capacity building, and on-ground participatory demonstrations benefiting about two thousand farmers. The major achievements of the institute in research, technology development, and extension during the year 2025 are summarized below :

- Rice-fallow management through Climate-Resilient Agriculture (CRA) involving short-duration rice (Swarna Shreya) and pigeonpea (IPA-203) during kharif, followed by short duration pulses and oilseeds under improved crop management and resource-conservation technologies during rabi at Gaya Ji district covered 733 acres and benefitted 832 farmers, contributing significantly to the greening of rice-fallow areas. The interventions recorded encouraging yields of rice (4.5-5.0 t ha^{-1}), pigeonpea (1.9-2.0 t ha^{-1}), lentil (1.24-1.37 t ha^{-1}), chickpea (1.40-1.58 t ha^{-1}), mustard (1.18-1.24 t ha^{-1}) and safflower (1.13-1.32 t ha^{-1}).
- Under crop establishment cum residue management practices in rice-fallow systems transplanted puddled rice (TPR) showed highest rice yield (5.17 t ha^{-1}), which was 24.9% and 14.5% higher than zero-till direct-seeded rice (ZTDSR) and conventional-till direct-seeded rice (CTDSR), respectively.
- A one-acre rain-fed integrated farming system emitted 4,480.31 kg CO_2-eq., but sequestered 6,710.63 kg CO_2-eq., resulting in net negative emissions of -2,230.31 kg CO_2-eq. Livestock accounted for 78.57% of emissions, while organic inputs and agroforestry enhanced carbon sequestration, making the system a net carbon sink.
- A vegetable-based integrated farming system developed at Patna, generated an annual net return of Rs. 1.56 lakh and improved soil organic carbon by 13-27% in 15 years. The system achieved an output-input energy ratio of 3.2 and exhibited negative greenhouse gas emissions (kg CO_2-eq.), demonstrating its potential as a climate-resilient and carbon-positive farming system.
- The innovative micro (250 m^2) and nano (125 m^2) homestead farming models established for women's empowerment and livelihood, comprising integration of vegetables, fruits, livestocks, mushroom etc., generated an annual net income of Rs. 45,466 and Rs. 19,150, respectively.
- The Conservation Agriculture-based zero-till direct-seeded rice-zero-till wheat-zero-till greengram

(ZTDSR-ZTW-ZTG) system at Patna, enhanced soil biological quality by supporting a bacteria-dominated soil microbiome (92-96%) with greater microbial diversity and stability than conventional tillage.

- Under natural farming conditions at Patna, the genotypes IR 102860-10:6-B-B, Swarna Purvi Dhan 2, Swarna Shreya, IR 14 L362, IR 97069-1-1-1-1, IR 14L157, IR17L1060, IR98976-20-1-2-2, IR18R1123, Swarna Shusk Dhan, IR16L1499, Swarna Shakti Dhan, IR 95781-15-1-1-4, and Swarna Unnat Dhan showed superior performance, with productivity ranging between 3.76 and 4.49 t ha^{-1}.

- The system productivity of the rice-wheat-greengram was found to be 10.35, 10.43, 12.57, and 13.40 t ha^{-1} under organic, natural, conventional and integrated nutrient management (INM), respectively during the fourth year. The performance of greengram was found better under natural farming (0.95 t ha^{-1}) and produced 14.5% higher yield than that of conventional farming (0.83 t ha^{-1}), whereas, the yield of rice and wheat were higher under INM practices and conventional system.

- Natural farming for major cropping systems in the Eastern Plateau and Hill region had higher soil organic carbon over conventional farming (0.80% vs 0.73%). Among the systems, cowpea-chickpea produced the highest system productivity (7.77 t ha^{-1}), demonstrating the potential of natural farming to enhance soil health and sustain productivity, particularly in legume-based systems.

- The rice genotypes IR18R 1179, RCPR 84, IR18R 1068, IR 132084-B-26-1-2-B-8, IR22EL1466, IR 132084-B-26-1-2-B-12, RCP 10-1, IR 97197-93-3-1-1, RCPR 100, and RCP 12-1 have been identified as promising entries for dry direct-seeded rain-fed conditions. These genotypes recorded a productivity range of 1.64-2.95 t ha^{-1}, outperforming the check varieties Sahbhagi Dhan (1.26 t ha^{-1}) and IR 64 (0.278 t ha^{-1}).

- Rice genotypes viz., IR 95781-15-1-1-4, IR18R1068, IR22EL1466, IR22EL1242, IR14L 613, IR 84899-B-185-8-1-1-1, IR 98925-11-1-2-1, RCP 10-1, IR83929-B-B-291-3-1-1, IR 97046-39-2-1-2, and IR18R1179, are identified as promising multi-stage drought tolerant with a productivity range of 2.60-3.17 t ha^{-1} compared to Sahbhagi Dhan (1.88 t ha^{-1}), and IR 64 (0.854 t ha^{-1}).

- Six promising rice genotypes (RCPR 102, RCPR 109, RCPR 110, RCPR 111, RCPR 112, and RCPR 113) have been nominated to AICRIP for multi-locational testing/evaluation during kharif 2025.

- Genetic diversity analysis of 29 maize landraces revealed significant variability in agro-morphological and nutritional traits, with genotypes IC 625163, IC 625143 and IC 625139 identified as superior for yield, IC 625181 for high iron content and IC 625168 for seed weight.

- Climate change impact assessment using MaxEnt modeling indicated that *Conopomorpha sinensis* currently shows high habitat suitability in Eastern litchi-growing regions, but future climate scenario especially under higher GHG emission pathways is likely to limit its expansion and reduce suitability across several parts of India.

- Arsenic-resistant PGPR S10P2 (*Pseudomonas anuradhapurensis*) exhibited broader metabolic versatility and multi-metal resistance, making it more suitable for bioremediation, while B14P1 showed stronger iron acquisition and phosphate metabolism traits. Both genomes were submitted to NCBI database, facilitating future research and application.

- *In situ* evaluation of 31 mulberry genotypes identified as superior genotypes, including Swarna Rasrani and HMS-1, with enhanced fruit quality and antioxidant potential for commercial cultivation and breeding.

- Evaluation of 34 vegetable soybean genotypes showed carotenoid content ranging from 4214.88-4849.91 µg/100g and antioxidant activity from 258.25-331.98 mg AEAC/100g, with Swarna Sugandha (331.25 mg AEAC/100g; 13.32 t ha^{-1}) and Swarna Vasundhara (327.23 mg AEAC/100g; 10.34 t ha^{-1}) identified as superior.

- Comparative metabolomic analysis of grafted tomato during healing revealed 60-67 metabolites upregulated and 55-62 downregulated indicating dynamic shifts in defense and antioxidant-related

metabolites, contributing to enhanced resistance against bacterial wilt.

- Metabolomic and nutritional analysis in pea identified ABL-39 recording highest anthocyanin (115.24 mg/100g) and antioxidants (273.50 mg AAE/100g), while ABL-112 showed the highest protein (80.77 mg/100g).

- Among 521 lablab bean and 215 yardlong bean genotypes evaluated at ICAR RCER, Patna, seven pole and two bush-type promising lines were identified with 130-145 pods per plant, early maturity (40-45 days to flowering), and tolerance to collar rot and yellow mosaic virus disease, showing stable performance across four agro-climatic zones of Bihar.

- Breeder seed (10.73 tonnes), nucleus seed (0.33 tonnes) and truthfully labelled seed (5.45 tonnes) of rice varieties Swarna Shreya, Swarna Shakti Dhan, Swarna Samriddhi Dhan, Swarna Unnat Dhan, Swarna Sukha Dhan, Swarna Shusk Dhan, Swarna Purvi Dhan 1, Swarna Purvi Dhan 2, Swarna Purvi Dhan 3, Swarna Purvi Dhan 4 and Swarna Purvi Dhan 5 have been produced by ICAR RCER, Patna during kharif 2025.

- Water smart farming model at Sabajpura farm, Patna, showed strong gains in land and water productivity by integrating aquaculture, horticulture, poultry, and raised-sunken bed cropping. The system produced 19.5-23.3 t ha^{-1} land productivity and 11.0-14.4 kg m^{-3} water productivity, which was 3.5-4.5 times higher land productivity and 20-25 times higher water productivity than rice monocropping.

- A machine learning framework enabled accurate estimation of daily reference evapotranspiration (ET_0) in the Middle Indo-Gangetic Plains using limited meteorological inputs. AdaBoost showed the highest predictive accuracy ($R^2 = 0.86$ for training and 0.80-0.81 for testing), while inclusion of Tmax, Tmin and BSS enhanced the robustness of the SGD model ($R^2 = 0.82$-0.83).

- The AgriPV system at ICAR RCER, FSRCHPR Ranchi improved the microclimate for broccoli and French bean by increasing soil moisture (2-4%), reducing temperature (about 2 °C), and moderating solar radiation (600-700 vs 800-860 W m^{-2}), thereby enhancing water-use efficiency and crop performance under climate stress.

- Soil texture and nutrient variability determine crop suitability in Ganga and Gandak Diara lands, where sandy soils favouring cucurbits and less sandy soils supporting field crops. Soils with less than 60% sand (mostly in upper diara) were found suitable for cultivation of wheat, potato, mustard, lentil, maize and onion crops.

- Identification and characterization of livestock and poultry culminated in registering four distinct breeds *viz.* Medini cattle, Palamu goat, Mala chicken and Kodo duck, the first of their kind in the state of Jharkhand.

- Morphological traits of Maithili ducks were recorded, with males larger and heavier than females, providing baseline data for digital characterization, genetic improvement and conservation.

- Breed-specific and parity-linked variations in goat vaginal microbiota, with higher diversity in Jamunapari goats, indicate the potential microbial biomarkers for reproductive performance and fertility management.

- Economic valuation for assessing ecosystem services indicated that provisioning services dominated the lifetime ecosystem contributions of buffalo, particularly in the Murrah breed. Both provisioning and regulating services were higher in Murrah buffalo than non-descript buffaloes.

- The AICRP on Goat Improvement revealed enhanced growth performance, reproductive parameters, and farmers' socio-economic status through targeted interventions, training, and health services in Black Bengal goat populations.

- Rangwa chicken of Jharkhand showed good adaptability with an average flock size of 16.6 birds and annual egg production of 65.57 eggs per hen. Adult body weight reached 1.53 kg in males and 1.06 kg in females, indicating moderate growth. The breed is well-suited for backyard poultry systems and contributes to rural livelihood and nutrition.

- Hybrid Napier and Guinea grass recorded zero mortality, whereas spineless cactus showed up to 49.74% mortality under high rainfall. Hybrid Napier produced the highest biomass (117 t ha^{-1}), and Karanj exhibited superior carbon sequestration (18.95 t ha^{-1} yr^{-1}), highlighting the potential of integrated agroforestry for fodder production and climate resilience.
- The developed ARIMA (2,1,2) model forecasted fish production in Bihar to reach about 12 lakh tonnes by 2030.
- The polyculture of Pabda with Catla and Rohu using commercial feed in earthen ponds was found to be the most economically viable and productive culture system in Eastern India for 240 days culture period with stocking density (No. ha^{-1}) of Pabda (0.24 g), Catla (65 g) and Rohu (50 g) as 20000, 2000 and 3000, respectively.
- Increasing dietary HDPE microplastic levels significantly reduced growth and performance of Labeo rohita, highlighting the harmful effects of microplastic contamination on aquaculture sustainability and fish health.
- Impact analyisis of multi-state integrated farming approaches under PRAYAS (single window SCSP/TSP programme) increased income, livelihood diversification, and nutrition, with gains of 38.5% in Jharkhand, 36.8% in Bihar, 27.9% in Odisha, 21.1% in Eastern Uttar Pradesh, 18.7% in Assam, 19.6% in Chhattisgarh, and 14.7% in West Bengal.
- Under the study on voluntary carbon credit potential in Bihar, it was revealed that smallholder farmers preferred monthly reporting, while larger farmers favoured end-of-season reporting and digital monitoring.
- A 16-week Climate-Resilient Dairy Farmers' Field School trained 40 smallholder farmers on heat stress management; fodder planning, ration balancing, disease control, and clean milk production, improving herd health, decision-making, and adoption of preventive practices.
- Promotion of zero-tillage wheat by KVK Buxar successfully scaled water-saving and yield-enhancing practices across more than 45,200 hectares, directly benefitting over 50 thousand farmers.
- Promotion of improved crop varieties, climate-resilient practices, water-saving technologies, integrated farming, and natural farming across 1,210 ha by KVK Ramgarh directly benefitted 4,482 farmers/farm families.
- During the year 2025, three innovative technologies of RCER Patna were certified by ICAR. These technologies represent significant advancements in agricultural practices and aim to enhance productivity, sustainability and resource efficiency in the region.
- The Institute made significant scholarly contributions by publishing 119 research papers in peer-reviewed journals, along with 9 books, 12 technical bulletins, 37 book/manual chapters, 16 folders, and 29 popular articles. Scientists from the Institute also actively participated in more than 50 conferences, seminars, workshops, symposia, meetings, and brainstorming sessions, presented over 25 papers at national and international events, and received six awards.

The institute signed 16 MoUs during the year. The headquarters at Patna and Ranchi center jointly conducted 96 capacity building training programmes, while both KVKs organized 132 training programmes. In total, 228 training programmes were conducted, benefiting 8,805 farmers. Additionally, 30 FLDs and demonstrations were conducted, alongside 216 awareness programmes, contributing to a comprehensive outreach effort throughout the year. In Viksit Krishi Sankalp Abhiyan, about 2 lakh farmers in Bihar and Jharkhand were sensitized on innovative agricultural practices and government schemes.

Chapter 2

INTRODUCTION

Photo: Institute building of ICAR RCER, Patna

The Eastern region of India covers the fertile plains of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal. It accounts for about 21.85% of the country's total land area and supports nearly one-third of its population. Despite having abundant natural resources such as fertile soil, sufficient water and ample sunlight, agricultural productivity in this region is still comparatively low, and farmers' income remains comparatively low. This is mainly due to factors like unpredictable weather, increasing population pressure, land degradation, small and scattered landholdings, limited availability of quality seeds and planting materials, and weak extension systems. Nevertheless, the region has strong potential to lead a second Green Revolution through better and more efficient use of its resources.

To tap this potential, the ICAR Research Complex for Eastern Region (ICAR RCER) was established on 22 February 2001 at Patna. The institute is located at 25°35′30″ N latitude and 85°05′03″ E longitude, with an elevation of about 52 meters above mean sea level. It operates through four major divisions at its headquarters: Division of Crop Research (DCR), Division of Land and Water Management (DLWM), Division of Livestock and Fishery Management (DLFM), and Division of Socio-Economics and Extension (DSEE). In addition, it has a Farming System Research Centre for Hill and Plateau Region (FSRCHPR) at Plandu, Ranchi. The institute also runs two Krishi Vigyan Kendras (KVKs), located at Buxar in Bihar and Ramgarh in Jharkhand.

The Institute addresses a wide range of issues including land and water resource management, integrated crop and horticultural production, agroforestry, fisheries, livestock and poultry management, agro-processing and socio-economic development. In recent years, it has also emphasized climate-resilient agriculture, integrated farming systems, natural resource conservation, agripreneurship development and digital extension approaches. Several farmer-centric initiatives such as location-specific IFS models, resource conservation technologies, and improved seed and breed dissemination programs have strengthened its regional impact.

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 the Government of India, for ensuring food security in the country.

Mission

- Transforming "Low Productivity-High Potential" Eastern region into high productivity region for food, nutritional, and livelihood security in a manner that is environmentally sustainable, socially acceptable, and monetarily profitable.
- Promote network and consortia research in the Eastern region.

Mandates

- 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.
- Promote network and consortia research in the Eastern region.

The modalities to achieve the mandate are:

- To 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.
- To provide scientific leadership and to act as a center for vocational as well as advanced training to promote agricultural production technologies.

- To act as repository of available information and its dissemination on all aspects of agricultural production systems.
- To collaborate with relevant national and international agencies in liaison with state and central government departments for technology dissemination.
- To 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

A summary of budget allocation and expenditure during the financial year 2025-26 of the complex is given below (Table 2.1). The pattern of expenditure reflects prudent financial planning and effective utilization of resources to support the institute's activities and programmes.

Table 2.1 Financial allocation and expenditure during the year 2025-26 (Rs. in lakh)

Head of accounts	Revised estimates				Actual expenditure			
	Main	SCSP	TSP	NEH	Main	SCSP	TSP	NEH
Establishment charges	3130.16	0.00	0.00	0.00	3130.16	0.00	0.00	0.00
TA	18.52	7.47	4.07	17.52	18.52	7.47	4.07	17.52
HRD	2.42	0.00	0.00	0.23	2.42	0.00	0.00	0.23
Capital	43.00	15.00	17.50	0.00	43.00	15.00	17.50	0.00
Other charges	624.29	92.53	35.93	42.25	624.29	92.53	35.93	42.25
Total	3818.39	115.00	57.50	60.00	3818.39	115.00	57.50	60.00

Staff position

The institute has a sanctioned staff strength comprising 62 scientific, 41 technical, 29 administrative, and 14 skilled supporting personnel (Table 2.2). This multidisciplinary workforce forms the backbone of ICAR-RCER, enabling the effective planning, implementation, and dissemination of research, technology development, and extension activities across the Eastern Region of India. Guided by dedication, professionalism, and a spirit of innovation, the institute's staff work collaboratively to address regional agricultural challenges, enhance productivity, promote sustainable farming practices, and improve farmers' livelihoods. Their collective expertise and commitment continue to strengthen the institute's role as a leading centre of excellence in agricultural research and development.

Table 2.2 Staff position as on December 31, 2025

Category	Position	
	Sanctioned	Filled-in
Scientific*	79	62
Technical	61	41
Administrative	46	29
Skilled supporting staff	61	14

*Including Director

Research amenities

Institute is equipped with laboratories for plant, soil and water analysis, natural resource management and a livestock and fisheries research activities (Table 2.3). Institute also offers a strong academic and extension environment for UG and Ph.D students, a well-designed auditorium and a seminar hall for scientific interactions. It also has a well-equipped library with 3,211 books along with 41 Indian and 51 foreign journals and periodicals. The farmers' hostel at Patna is thoughtfully equipped to host farmers, scientists and visitors, providing comfortable accommodation. The institute continues to deliver practical, location-specific solutions through key programmes such as rice fallow management, climate-resilient agriculture, IFS models and water smart farming system. It has also expanded into new areas such as carbon credit designs and framework, need based micro IFS models, AI-based duck characterization, agrivoltaics, and the Zero Hunger and Zero Technology Gap initiatives.

Table 2.3 List of important instruments and facilities available with ICAR RCER

Facilities	Instruments/ Equipment
Headquarters, Patna	
Soil and water analysis laboratory	Atomic absorption spectrometer, Kjeldahl distillation, spectrophotometer, flame photometer, TOC analyzer
Pressurized irrigation laboratory	Solar pump, electrical pump, sand filters, screen filters, multi parameter water quality meter, sprinklers
Plant science laboratory	UV-Vis spectrophotometer, centrifuge, deep freezer, root scanner, water purification system, canopy analyzer
Climate action facilities	Gas chromatograph, open-top chambers, rainout shelter
Conservation agriculture laboratory	Cone penetrometer, soil moisture probe, vacuum desiccator, incubator shaker
Fisheries laboratory	Trinocular research microscope, spectrophotometer, vacuum filtration unit, biofloc, eco-hatchery
Animal health laboratory	ELISA plate reader, laminar flow hood, microtome, BOD incubator, biochemical analyzer, hematoanalyzer
Livestock production and reproduction laboratory	Thermal cycler, real time PCR, BOD incubator, gel documentation system, gel electrophoresis, Nanodrop spectrophotometer
Feed analytical & biochemical laboratory	Refrigerated centrifuge, thermal cycler, spectrophotometer, nitrogen analyzer, milk analyzer, sonicator, fat analyzer, double distillation unit, fiber analyzer, bomb calorimeter
FSRCHPR, Ranchi	
Pathology laboratory	Phase contrast microscope, BOD incubator, laminar flow hood, bio-fermenter, mushroom spawn unit
Post harvest laboratory	Tray dryer, pulper, refractometer, juicer, vacuum drier, UV-Vis spectrophotometer
Honey testing laboratory	Refractometer, centrifuge, Kjeldahl apparatus, viscometer, probe sonicator, microscope, HPLC, spectrophotometer
Soil science laboratory	Atomic absorption spectrophotometer, Kjeldahl distillation unit, spectrophotometer, flame photometer
Quality analysis laboratory	Centrifuge, -20 °C deep freezer, pH meter, canopy analyzer, leaf area meter
Molecular laboratory	Refrigerated centrifuge, thermal cycler, electrophoresis apparatus, gel documentation unit, micro-centrifuge

Chapter 3

WEATHER

Photo: Evening view at ICAR RCER, Patna

Weather at ICAR RCER, Patna

Weather parameters, including air temperature, humidity, rainfall, sunshine hours, and pan evaporation, were collected from the Agri-Met Centre, Patna. The Long Period Average (LPA) of the annual total rainfall of Patna was 1127.30 mm. During 2025, Patna received a total annual precipitation of 1244.6 mm, which is 10.40% higher than the LPA, indicating an above-normal rainfall year. The total annual precipitation was distributed across 54 meteorological rainy days. The highest rainfall contribution occurred during the monsoon months, particularly in July and August, which recorded 405.2 mm and 387.7 mm rainfall, respectively. The highest monthly rainfall was recorded in July (405.2 mm), whereas no rainfall was received during February and December.

The mean monthly maximum temperature ranged from 20.6 °C in January to 36.7 °C in June, making June the warmest month of the year. Similarly, the mean monthly minimum temperature varied from 12.2 °C in January to 28.9 °C in June. Relative humidity showed considerable variation throughout the year, with the lowest monthly average recorded in March (50%) and the highest in August (83%). The monthly variations in temperature and rainfall trends are illustrated in Fig. 3.1.

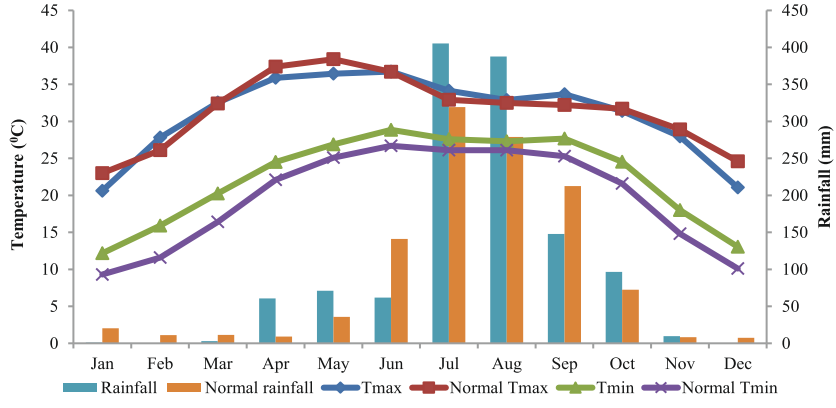

Fig. 3.1 Monthly variation in temperature and rainfall during 2025

Extreme weather observations recorded in 2025

Extremes in weather variables for the year 2025 are presented in Table 3.1. Based on daily temperature records, 26th April was recorded as the hottest day of the year with a maximum temperature of 43.0 °C, while 3rd January was the coldest day of the year with a minimum temperature of 9.1 °C. The highest single-day rainfall event (175.4 mm) was recorded on 29th July. The highest relative humidity (100%) was observed on 28th January, whereas the lowest relative humidity (13%) was recorded on 23rd April.

Table 3.1 Extreme weather events in 2025

Weather events	Value	Date
Warmest day	43.0 °C (Tmax)	26th April
Coldest day	9.1 °C (Tmin)	3rd January
Most humid day	100% (RH)	28th January
Least humid day	13% (RH)	23rd April
Most rainy day	175.4 mm (Rainfall)	29th July

Weather at FSRCHPR, Ranchi

The weather pattern during 2025 at Ranchi reflected a typical subtropical monsoonal climate with distinct seasonal variations in temperature, humidity, and rainfall. The temperature regime at Ranchi during 2025 showed clear seasonal variation (Fig. 3.2). Morning temperatures ranged from as low as 5.9 °C in December to about 21-22 °C during June-July, indicating a gradual rise from winter to monsoon followed by a decline. Afternoon temperatures peaked during the pre-monsoon months, with the highest values recorded in April (32.7 °C) and May (32.3 °C), before decreasing during the monsoon period due to increased cloud cover and rainfall. The relatively moderate temperature range during monsoon months reflects the buffering effect of precipitation and humidity.

Rainfall exhibited a strong monsoonal pattern, with the bulk of precipitation occurring between June and September. The onset of monsoon was particularly intense, with June recording 600.9 mm rainfall, far exceeding the normal (249.4 mm). Similarly, July, August, and September also received higher-than-normal rainfall, indicating a wetter-than-average monsoon season.

In contrast, pre-monsoon months showed moderate rainfall, while post-monsoon and winter months (November-January) recorded negligible precipitation, highlighting a pronounced seasonal concentration of rainfall. Relative humidity remained consistently high throughout the year, ranging from about 73% to 86%, and peaked during July (86.3%) in alignment with peak monsoon activity. Morning humidity values were generally higher than afternoon values, reflecting diurnal variation.

The number of rainy days increased progressively from May (9 days) to a maximum in August (20 days), before declining after September. The high humidity, coupled with frequent rainy days during the monsoon months, indicates prolonged wet conditions, which are critical for crop growth but may also influence pest incidence and field operations.

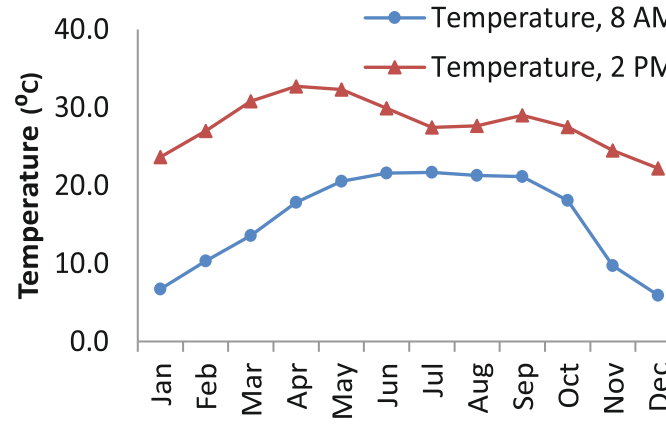

Fig. 3.2 Variations in mean monthly air temperature at Ranchi

Chapter 4

CLIMATE RESILIENT AGRICULTURE

Photo: CRA programme at Gaya Ji

Greening rice-fallow areas

Institute initiated a flagship programme entitled "Rice-fallow management through CRA practices" in June 2023 to address issues of rice-fallow areas through integrated multidisciplinary approaches. Programme is implemented at Gaya Ji, Bihar. Targeted area was selected and basic information was collected for implementing project activities. Lack of irrigation facilities during rabi was identified as primary reason for leaving land fallow. A multidisciplinary team of experts in collaboration with KVK, Gaya Ji has been collectively implementing the programme of greening rice-fallow areas (25000 ha) through suitable RCTs and ICM practices in participatory modes. To address these issues, demonstration of short duration of HYVs of rice cv. Swarna Shreya (115-120 days) and pigeon pea cv. IPA-203 during *kharif* was demonstrated at Guleriyachak, Tekari and Gajadharpur, Takuppa, Gaya Ji. Selected farmers were provided need-based training and awareness about cultivation of DSR and pigeonpea. Subsequently, short-duration pulses (chickpea, lentil)/oilseed (mustard, *toria*, safflower) crops were demonstrated during *rabi* season for greening rice-fallow areas through ICM and RCTs. Till to date 733 acre covering more than 832 farming community were covered at project site (Table 4.1).

Table 4.1 Crop input demonstrations and greening rice-fallow area at Gaya Ji district

Crop	Variety	Quantity (kg)	Farmers (No.)	Area (acre)
		***Rabi* 2023-24**		
Arhar (CT)	IPA 203	300	50	50
Lentil (ZT)	IPL 220	800	75	50
Chickpea (ZT)	GNG 2299	1600	60	50
Mustard (ZT)	DRMR-150-35	100	50	50
Mustard (FLD*)	DRMR-150-35	30	15	15
		***Kharif* 2024**		
Rice	Swarna Shreya	500	75	50
Arhar (CT)	IPA 203	360	60	60
		***Rabi* 2024-25**		
Lentil (ZT)	IPL 220	700	70	50
Chickpea (ZT)	GNG 2299	1510	60	50
Mustard (ZT)	DRMR-150-35	100	50	50
Toria (ZT)	TS-27	05	05	2.0
Safflower (ZT)	PBNS-12	05	02	1.0
		***Kharif* 2025**		
Rice	Swarna Shreya	1300	75	130
		***Rabi* 2025-26**		
Lentil (ZT)	IPL 220	600	75	40
Chickpea (ZT)	GNG 2299	1000	60	35
Mustard (ZT)	DRMR-150-35	100	50	50
	Total	**9010**	**832**	**733**

Demonstration results revealed that crop yields of rice (4.5-5.0 t ha^{-1}), *arhar*, lentil, chickpea, mustard and safflower were 1.9-2.0 t ha^{-1}, 1.24-1.37 t ha^{-1}, 1.4-1.58 t ha^{-1}, 1.18-1.24 and 1.13-1.32 t ha^{-1}, respectively on residual soil moisture and improved agronomic management practices (spraying 2% urea and 15-15-15: NPK) at farmers' fields.

Evaluation of crop establishment methods for improving productivity of rice-fallow systems

A long-term field study was initiated during rainy season of 2016 at ICAR RCER, Patna to find out most

suitable rice-winter cropping rotations and appropriate crop establishment methods and residue management practices in rice-fallow systems of Eastern India. 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 puddled rice (TPR), TDSR with rice residue retention (ZT DSRR+), CTDSR with residue retention (CTDSRR+), TPR with 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 10th year, rice yields were higher in general under TPR system. Rice productivity was 24.9% and 14.5% higher than TPR (5.17 t ha^{-1}) compared to ZTDSR (3.61 t ha^{-1}) and CTDSR (4.14 t ha^{-1}) (Table 4.2). Irrespective of tillage and cropping systems, effect of residue management on crop yield was more pronounced in all treatments.

Table 4.2 Rice yield under CERM practices in long-term CA-based pulses/oilseeds systems

CERM		Rice yield (t ha^{-1})						Mean
		Chickpea	Lentil	Safflower	Linseed	Mustard	*Toria*	
[ZTDSR-ZT] R-	CA	3.55	3.41	3.45	3.59	3.63	3.56	3.53
[ZTDSR-ZT] R+	CA	3.62	3.68	3.57	3.68	3.89	3.74	3.70
[CTDSR-ZT] R-	pCA	3.98	3.89	3.81	3.78	3.97	3.90	3.89
[CTDSR-ZT] R+	pCA	4.49	4.48	4.39	4.29	4.29	4.38	4.39
[TPR-ZT] R-	FP	5.10	5.20	5.14	5.03	5.05	5.11	5.11
[TPR-ZT] R+	FP	5.21	5.33	5.32	5.14	5.22	5.21	5.24

Interestingly, the yield of all post-rainy crops had higher in ZTDSR/CTDSR production system compared to TPR. However, TPR production system adversely impacted performance of all post-rainy pulses/oilseed crops over the time.

Livelihood decision support tool through agricultural interventions

A livelihood decision support tool (DST) was developed to estimate income of farmers from various on-farm and off-farm interventions and facilitate them to select suitable interventions based on available resources while facilitating year round income planning. The developed DST analyses monthly income from different interventions and generates a month wise income plan based on inputs provided by farmers.

Climate Resilient Agriculture Programme

Recognizing the climate change related risks, the Climate Resilient Agriculture (CRA) Programme is being implemented by ICAR RCER, Patna in Buxar and Gaya Ji to promote climate-smart technologies and strengthen farmers' adaptive capacity.

After concluding first phase of the programme, CRA activities expanded to new villages including Majhwari, Aather, Atrawana, Boxa and Rahatua in Buxar, and Pachlakh, Amaithe, Jhikatiya, Gajadharpur and Gulariachak in Gaya Ji district during *rabi* 2025-26 (Table 4.3). The programme covered a total of 1,135 acres across seasons and directly benefitted 1,226 farmers, including 305 women. Of this, 256 acres were brought under newly selected villages during *rabi* 2025-26. Long-term experiments on various cropping systems, crop diversification with inclusion of vegetable crops in cropping system and target of setting up seed hub in Phase II of CRA programme will further strengthen it at the grassroots level.

The impact of CRA interventions was clearly reflected in enhanced productivity and profitability. Zero tillage (ZT) technology emerged as a transformative practice by reducing labour and fuel costs while improving yields in Buxar. Wheat under ZT (HD 2967) recorded 49.32 q ha^{-1}, 12.94% higher than conventional methods resulting in a 21.43% higher net return of ₹92,530 ha^{-1}. Zero tillage mustard (Var. PM 30), lentil (Var. IPL 220), and chickpea (Var. Pusa 3043) also registered yield gains of 25–28% over conventional practices with profitability increases up to 30%. Summer mungbean (Var. Samrat, IPM 2-14) under ZT produced 15.65 q/ha, achieving 26.93% higher returns despite water scarcity conditions. Along with demonstrations capacity

Table 4.3 CRA villages in Buxar and Gaya Ji districts

Buxar		Gaya Ji	
Village	**Block**	**Village**	**Block**
Majhwari	Simri	Pachlakh	Khizarsarai
Aather	Nawa Nagar	Amaithe	Wazirganj
Atrawana	Itarhi	Jhikatiya	Paraiya
Boxa	Buxar	Gajadharpur	Tankuppa
Rahatua	Brahmpur	Gulariachak	Tekari

building of farmers was also continued with participation of 933 farmers in 26 training programmes and 6 exposure visits, with women constituting 18% of participants. These efforts enhanced awareness, built confidence in climate-smart technologies and encouraged wider adoption.

Development of decision support system for prioritization of rice-fallow areas

The graphical user interface (GUI) of the Decision Support System (DSS) was developed for data entry, data updating, and report generation. The database was developed using SQL, and the GUI was designed in ASP.NET (Fig. 4.1). This DSS is useful for both farmers and scientists for managing data related to cropping pattern and crop production in rice-fallow areas of Guleriachak village in Gaya Ji district of Bihar.

Impact of weather parameters on population dynamics of litchi leaf roller, *Dudua aprobola*

The influence of weather factors on the population dynamics of the litchi leaf roller, *Dudua* (=*Platypeplus*) *aprobola*, was studied at ICAR RCER, Farming System Research Centre for Hill and Plateau Region, Ranchi,

Fig. 4.1 GUI of decision support system

during the years 2024 & 2025 (Fig. 4.2). The relationship between temperature, rainfall, and leaf rollers was established. The population pattern of leaf rollers was observed more or less the same in both years. The highest incidence of the leaf roller occurred during the 40th and 41st standard meteorological weeks (SMW) in both years (1.6 to 2.5 rolled leaves per shoot). The correlation analysis between leaf roller and weather parameters showed a significant positive correlation with minimum temperature (p<0.01) and a negative correlation with rainfall (p<0.05).

Fig. 4.2 Rolled leaves of litchi by leaf roller

The linear regression model is based on weather parameters as an independent variable and leaf roller population as a dependent variable, explaining 55 to 66 per cent leaf roller population variability (Table 4.4). Environmental factors played a determining role in leaf roller population dynamics.

Climate change impact prediction on the habitat suitability of litchi seed borer, *Conopomorpha sinensis*

Maximum entropy (MaxEnt) was used to predict the

impact of climate change on habitat suitability of the litchi seed borer, *Conopomorpha sinensis,* in India. It is a major pest of the litchi fruit. Future predictions of the potential habitat of *C. sinensis* were made for three time periods (2050, 2070, 2090), four SSPs (SSP126, SSP245, SSP370, SSP585) with GCMs (MRI-ESM2, IPSL-CM6A, BCC-CM2). All four proposed scenarios were chosen to define the extremity and uncertainty in climatic variations on *C. sinensis* populations. The model performed better than random, with an average test AUC value of approximately 0.88 to 0.94 in 100 replicate tests run. The results highlight that the pest exhibits a broad ecological amplitude, occupying diverse agro-climatic zones, with particularly high suitability observed across the litchi-growing belts of Eastern India, including parts of Bihar, Jharkhand, and West Bengal (Fig. 4.3).

Table 4.4 Regression model using leaf roller, *D. aprobola* population, and weather parameters in both years (2024 & 2025).

Years	Regression equations	R^2
2024	$Y= -1.89^* + (0.09\ T_{min}) + (0.04\ T_{max}) - (0.004\ RF) + 0.36^{**}$	0.66
2025	$Y= -2.10^* + (0.003\ T_{min}) + (0.106\ T_{max}) - (0.007RF) + 0.40^{**}$	0.53

* value denotes a constant estimated from data
** random error term

These areas, already known for intense litchi cultivation, align closely with the observed field distribution of *C. sinensis*. Large regions in western and southern India remain unsuitable under current climatic conditions, likely due to limiting temperature and precipitation variables that do not support the pest's life cycle or host plant presence. The modelled scenarios reveal that increasing greenhouse gas concentrations are likely to result in a reduced expansion of suitable habitats for *C. sinensis*, particularly under the higher emission scenarios SSP370 and SSP585 (Fig.4.4). In these conditions, large areas across central, eastern, and southern India become less favorable for pest establishment, with higher suitability scores visible in the Indo-Gangetic Plains, northeastern states, and parts of the peninsular region. The predictive modeling approach presented here provides an outline for the future risk of *C. sinensis* in India under climate change scenarios, which can be used for better management strategies.

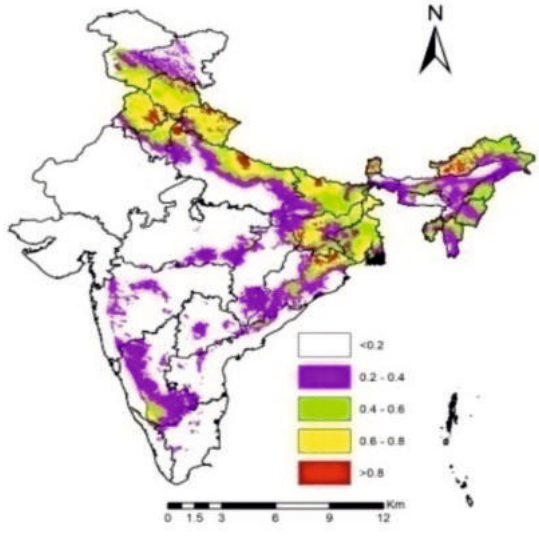

Fig. 4.3 Distribution map of *C. sinensis* in India

Simulating future climate scenarios: Crop responses to elevated CO_2 and warming

Climate change is increasingly influencing crop production systems, particularly in the Indo-Gangetic Plains of Eastern India. Projections indicate that atmospheric CO_2 concentration may reach 550 ppm with a concurrent temperature rise of 1.5-2.0 °C by 2050. Elevated CO_2 enhances photosynthesis and

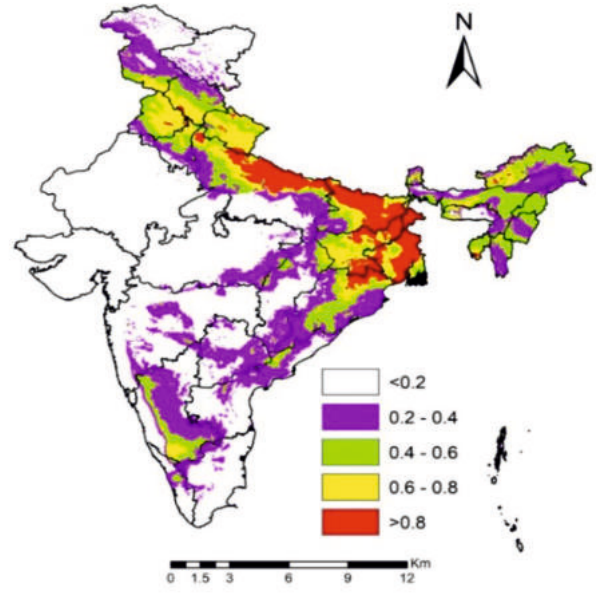

Fig. 4.4 Projected changes in the distribution map of *C. sinensis* in India during 2050

biomass production in C_3 crops such as rice and wheat; however, increased temperature often negates these benefits by shortening grain-filling duration and reducing yield stability. The study was initiated using Open Top Chambers (OTCs) to simulate future climate conditions. Treatments included ambient (OTC-1), elevated CO_2 + temperature (OTC-2), elevated CO_2 at 550 ppm (OTC-3), and elevated temperature (+2 °C) (Fig. 4.5). Thirty-two rice genotypes/varieties were evaluated under all treatments. Results showed that OTC-3 (elevated CO_2 at 550 ppm) significantly improved grain weight and yield attributes, with an increase of ~10-25% over ambient conditions across most genotypes, indicating a strong CO_2 fertilization effect. In contrast, OTC-2 (combined elevated CO_2 and temperature) resulted in an overall reduction in grain weight by ~5-20%, demonstrating that heat stress outweighed the positive effects of CO_2 enrichment. Elevated temperature alone caused the most severe yield penalties, with grain weight reductions ranging from ~15-30% compared to ambient conditions. Despite the general decline under warming, genotype-specific responses were evident. Genotypes such as RCP-12-1, IR84899-B-183-CRA-19-1, and IR18R1179 showed yield reductions limited to <5-10% under combined stress, and in some cases, maintained yields comparable to ambient conditions, indicating superior climate resilience.

Fig. 4.5 Open Top Chambers facility at ICAR RCER, Patna

Chapter 5

CEREALS

Photo: Rice at physiological maturity at ICAR RCER, Patna

Rice

Evaluation of rice genotypes under dry direct seeded rainfed conditions

Increasing water scarcity and frequent droughts are major constraints to rice productivity in rainfed and poorly irrigated ecosystems of the Indo-Gangetic Plains of India, posing a serious threat to food security. Compared to conventional puddled transplanted rice (PTR), dry direct-seeded rice (DSR) conserves water by eliminating puddling and continuous flooding, reduces irrigation and labour requirements, and lowers greenhouse gas emissions, particularly methane. Keeping this in view, a field experiment was conducted during *kharif* 2025 to identify early-maturing rice genotypes suitable for dry direct-seeded rice (DSR) conditions and drought tolerance in the middle Indo-Gangetic Plains (Fig. 5.1).

Fig. 5.1 Evaluation of rice genotypes under dry DSR condition

A total of 173 genotypes in Stage I and 50 genotypes in Stage II were evaluated under rainfed dry DSR conditions. In Stage I, grain yield ranged from 0.01 to 4.23 t ha^{-1}, with a mean yield of 0.95 t ha^{-1}. Identified promising rice genotypes *viz.* Swarna Shreya, RCPR 79, RCPR 84, Swarna Sukha Dhan, Swarna Shakti Dhan, Swarna Shusk Dhan, RCPR 12-1, IR 152030-B-48-B, IR 152029-B-93-B, RCPR 104, and RCPR 10-1 with productivity range of 1.74-3.82 t ha^{-1} compared to check variety Sahbhagi Dhan (1.16 t ha^{-1}), and Arize 6453 ST (1.53 t ha^{-1}) under stage I breeding trials. Under stage II trial grain yield of rice genotypes ranged from 1.27-4.18 t ha^{-1}, with mean grain yield of 2.61 t ha^{-1}.

Rice genotypes *viz.* RCP 12-4, RCPR 112, RCP 12-2, IR24EL3610, RCPR 45, RCPR 95, IR24EL3544, IR24EL3605, RCPR 68, Swarna Shreya have been identified as promising for rainfed dry DSR condition (stage II trial) with productivity range of 3.05-3.95 t ha^{-1} compared to check variety IRRI 264 (2.34 t ha^{-1}) and Arize 6453 ST (2.07 t ha^{-1}). Identified promising genotypes showed better seedling emergence, early vegetative vigour, phenotypic acceptability (PAcp) and drought stress tolerance.

Field evaluation of rice genotypes under rainfed direct seeded conditions

Fifty rice genotypes were evaluated under rainfed dry direct-seeded conditions during *kharif* 2025 (Fig. 5.2).

Fig. 5.2 Evaluation of rice genotypes under dry direct seeded rainfed condition

The mean grain yield was 1.38 t ha^{-1}, ranging from 0.28 to 2.95 t ha^{-1}. Genotypes IR18R 1179 (2.95 t ha^{-1}), RCPR 84 (2.27 t ha^{-1}), IR18R1068 (2.24 t ha^{-1}), IR 132084-B-26-1-2-B-8 (2.08 t ha^{-1}), IR22EL1466 (2.05 t ha^{-1}), IR 132084-B-26-1-2-B-12 (1.95 t ha^{-1}), RCP 10-1 (1.87 t ha^{-1}), IR 97197-93-3-1-1 (1.80 t ha^{-1}), RCPR 100 (1.68 t ha^{-1}), and RCP 12-1 (1.64 t ha^{-1}) were identified as promising under dry DSR conditions. These genotypes outperformed the check varieties Sahbhagi Dhan (1.26 t ha^{-1}) and IR 64 (0.28 t ha^{-1}) and exhibited better seedling emergence, early vigor, drought tolerance, and phenotypic acceptability.

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

Development of multi-stage drought-tolerant rice genotypes is essential to enhance productivity in drought-prone as well as water limited irrigated areas and ensure regional and national food security. In the present study, 36 rice genotypes were evaluated under multi-stage drought (MSD) stress in a rainout shelter

and under non-stress (irrigated) conditions during *kharif* 2025 (Fig. 5.3). Grain yield ranged from 0.854 to 3.18 t ha^{-1} under MSD and from 4.00 to 5.98 t ha^{-1} under non-stress conditions. Results of the study revealed that irrespective of genotypes, there was a significant reduction (53.37%), in mean grain yield under MSD as

Fig. 5.3 Evaluation of rice genotypes under multi-stage drought condition in Rainout Shelter

compared to non-stress. Among rice genotypes; IR 95781-15-1-1-4-1 (3.17 t ha^{-1}), IR18R1068 (3.07 t ha^{-1}), IR22EL1466 (3.02 t ha^{-1}), IR22EL1242 (2.97 t ha^{-1}), IR14L 613 (2.85 t ha^{-1}), IR 84899-B-185-8-1-1-1 (2.83 t ha^{-1}), IR 98925-11-1-2-1 (2.77 t ha^{-1}), RCP 10-1 (2.76 t ha^{-1}), IR83929-B-B-291-3-1-1 (2.68 t ha^{-1}), IR 97046-39-2-1-2 (2.67 t ha^{-1}), and IR18R1179 (2.60 t ha^{-1}), have been identified as promising for MSD tolerance compared to Sahbhagi Dhan (1.88 t ha^{-1}), and IR 64 (0.854 t ha^{-1}).

Evaluation of rice genotypes for tolerance to multiple stresses

Eight rice genotypes were evaluated under control (non-stress), vegetative stage drought (VSD, multi-stage drought (VSD+RSD), submergence, twice submergence and combined stress (submergence + drought) conditions during *kharif* 2025. The average grain yields of 6.59, 2.32, 1.988, 1.335, 1.053 and 0.741 t ha^{-1} were recorded under non-stress, VSD, multi-stage drought submergence, twice submergence and combined stress conditions, respectively. Results of the present study revealed that irrespective of the genotypes, there was a significant reduction in grain yield of rice under VSD (64.7%), MSD (69.8%), submergence (79.7%), multiple submergence (84.0%) and combined stress (88.7%) conditions as compared to non-stress (control). Among rice genotypes, IR 96321-315-323-B-3-1-3, IR 96321-558-563-B-2-1-1, and IR 96321-315-294-B-1-1-1 were found promising for different individual and combined stress condition as compared to check variety Swarna Sub 1 and Swarna.

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

Based on their superior performance in on-station trials, six promising advance breeding lines (RCPR 102, RCPR 109, RCPR 110, RCPR 111, RCPR 112, and RCPR 113) of rice were nominated to national AICRP multi-location trials under different ecologies for *kharif* 2025. Additionally, one rice genotype RCPR 104 (IET 32100), has been promoted from AVT 1-E-DS to AVT 2-E-DS trial after second year testing during *kharif* 2024, while rice genotype RCPR 94 (IET 30651), has been recommended to retesting in AVT 2-E-TP trial (irrigated trial) after third year testing under national AICRP on rice programme. Moreover, during *kharif* 2025, one hundred fifty-nine rice genotypes (comprised of advanced breeding lines and check varieties) belonging to four AICRP on rice trials (AVT 2 and 1-E-TP, IVT-E-TP, IVT-aerobic, and AVT-2 and 1-aerobic) were conducted at ICAR RCER, Patna (Fig. 5.4). Evaluation of AICRP trials were conducted at regular intervals by ICAR RCER, Patna. In addition, the scientific representatives of ICAR-NRRI, Cuttack, also participated in monitoring of AICRP on rice trials.

Frontline Demonstrations of rice varieties

The Frontline Demonstrations (FLDs) of rice varieties Swarna Shreya, Swarna Shakti Dhan, Swarna

Fig. 5.4 Evaluation and monitoring of rice trials under AICRP programme

Samriddhi Dhan, Swarna Sukha Dhan, Swarna Unnat Dhan, Swarna Shusk Dhan, Swarna Purvi Dhan 1, Swarna Purvi Dhan 2, Swarna Purvi Dhan 3, Swarna Purvi Dhan 4 and Swarna Purvi Dhan 5 were conducted by ICAR RCER, Patna during *kharif* 2025

across 58 beneficiary farmers' (including 10 women farmers) fields covering an area of 20.6 hectares in Patna, Nawada, and Gaya districts of Bihar and Ramgarh district of Jharkhand (Fig. 5.5). The demonstrated varieties consistently outperformed their respective local check varieties under farmers' field conditions. Grain yield ranged from 3.80 to 5.38 t ha^{-1}, registering a yield advantage of 4.46-23.07% over the checks. Farmers' feedback highlighted the early to medium maturity duration, high yield potential, and desirable grain quality of these varieties. Additionally, the varieties were appreciated for their tolerance to drought, diseases, and insect pests, indicating their suitability and adaptability under prevailing agro climatic conditions.

Breeder seed production of rice varieties

Breeder seeds of rice varieties, Swarna Shreya (1.08 t), Swarna Shakti Dhan (1.56 t), Swarna Samriddhi Dhan (2.09 t), Swarna Unnat Dhan (1.98 t), Swarna

Fig. 5.5 Front line demonstrations of rice varieties in different districts of Bihar and Jharkhand

Sukha Dhan (0.1 t), Swarna Shusk Dhan (0.33 t), Swarna Purvi Dhan 1 (0.2 t), Swarna Purvi Dhan 2 (0.25 t), Swarna Purvi Dhan 3 (0.25 t), Swarna Purvi Dhan 4 (0.18 t), and Swarna Purvi Dhan 5 (0.48 t) have been produced by ICAR RCER, Patna during *kharif* 2024. 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 monitoring of breeder seed production of these rice varieties (Fig. 5.6). Besides, nucleus seeds (0.33 t) of above mentioned rice varieties, Swarna Purvi Dhan 4 and Swarna Purvi Dhan 5 were also produced during *kharif* 2025. In addition, truthfully labeled (TL) seeds of rice varieties, Swarna Shreya (1.93 t), Swarna Shakti Dhan (0.2 t), Swarna Samriddhi Dhan (0.96 t), Swarna Unnat Dhan (0.43 t), Swarna Sukha Dhan (0.15 t), Swarna Shusk Dhan (0.22 t), Swarna Purvi Dhan 1 (0.2 t), Swarna Purvi Dhan 2 (0.15 t), and Swarna Purvi Dhan 3 (0.75 t), Swarna Purvi Dhan 4 (0.2 t), and Swarna Purvi Dhan 5 (0.23 t) were also produced during *kharif* 2025.

Fig. 5.6 Monitoring breeder seed production of rice

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* 2025 at ICAR RCER, Patna (Fig. 5.7). Besides, 61 advanced rice breeding material belonging to different generation (F_2-F_7) along with its parents were also raised. Uniform plants or lines of early and medium early duration have been selected based on the plant type, panicle length, effective tiller numbers, grain features, lodging resistance and tolerance to diseases and insect pests. The seeds of rice breeding materials have been retained for further evaluation and generation advancement.

Fig. 5.7 Rice cafeteria at ICAR RCER, Patna

Evaluating the performance of inbred and hybrid rice cultivars under dry-DSR conditions

Field experimentation was conducted during *kharif* 2025 at ICAR RCER, Patna to evaluate the performance of 23 rice cultivars under dry-DSR conditions for EIGPs. Cultivars included 10 varieties, 8 hybrids and 5 advanced breeding lines, grouped into short and medium-duration cultivars. Experiment was laid out in randomized block design with three replications. Our results revealed that hybrids outperformed the varieties and advanced breeding lines in terms of crop yields with hybrid 28P67 recorded the highest grain yield (6.60 t ha^{-1}) and production efficiency (50.4 kg ha^{-1} day^{-1}). Cultivars with medium duration exceeded 32% higher crop grain yield than short-duration cultivars, confirming their superiority in temporal efficiency in dry-DSR system. Advanced breeding lines of short-duration varieties showing competitive crop yields, IR22EL1055 and IR22EL1071 can be utilized in developing high-yielding short-duration cultivars suitable for diverse cropping systems. Overall performance of hybrids was better than varieties and advanced breeding lines with an average of 38.9 and 45.6% higher grain yield than varieties and advanced breeding lines, respectively. Thus, short-duration cultivars (115-125 days) with moderate yields (4.5-5.5 t ha^{-1}) and medium duration cultivars (125-135 days) with higher crop yield (5.5-6.5 t ha^{-1}) can be strategically adopted to enhance cropping intensity and overall system productivity under irrigated rice-based systems of EIGPs (Fig. 5.8).

Assessing water productivity, yield and economics of transplanted and direct seeded rice

Field experimentation was conducted during *kharif* 2025 at ICAR RCER, Patna to evaluate the impact of shifting from transplanted paddy rice (TPR) to direct seeded rice (DSR) for EIGPs. Our results revealed that DSR production system showed superior irrigation water productivity compared to TPR. The TPR with cv. *Rajendra Sweta* yielded 4733 kg ha^{-1} using 2073 m^3 of

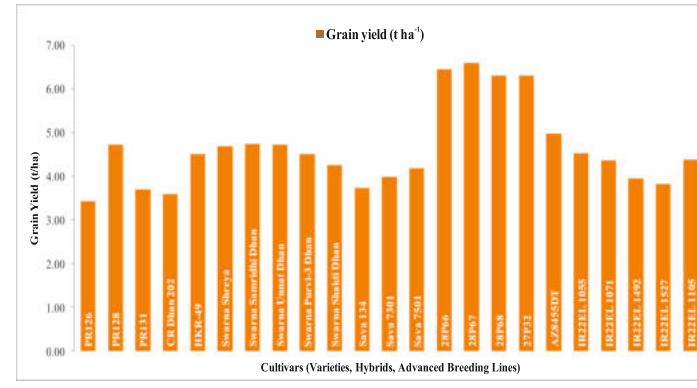

Fig. 5.8 Productivity of rice cultivars as influenced by dry-direct seeded production system

irrigation water per plot (1500 m^2), while DSR with *Arize 6555 ST* produced 5309 kg ha^{-1} with only 1697 m^3 of irrigation water. When scaled to a hectare basis, irrigation volumes were 13820 m^3 ha^{-1} for TPR and 11313 m^3 ha^{-1} for DSR. Corresponding irrigation water productivities were 0.34 kg m^{-3} for TPR and 0.46 kg m^{-3} for DSR indicating 37.1% improvement in DSR system. Relative difference in irrigation volume between treatments was -22.2% with DSR system requiring substantially less water. These results confirm that DSR not only enhances grain yield but also improves irrigation efficiency, making it a more water-conserving cultivation method under the given field conditions (Table 5.1).

Evaluation of traditional short-grain aromatic rice

Thirty-four traditional short-grain aromatic rice of eastern India, along with Rajendra Kasturi as check, were evaluated for grain yield and yield-attributing traits during *kharif* 2025. Observations were recorded on days to 50% flowering, plant height, panicle length, number of grains/panicle, grain fertility, 1000-grain weight and grain yield. There was significant variation for all the characters under observation in the set of

Table 5.1 Comparative performance of transplanted and DSR

Treatments	Grain yield (kg ha^{-1})	Relative dif. (%)	Irrigation water (m^3 $plot^{-1}$)	Relative dif. (%)	Irrigation water (m^3 ha^{-1})	IWP (kg m^{-3})	Relative dif. (%)
TPR/Rajendra Sweta	4733	-	2073	-	13820	0.342	-
DSR/Arize 6555 ST	5309	+12.2	1697	-22.2	11313	0.469	+37.1

genotypes. Although Rajendra Kasturi, as an improved variety check, produced the highest grain yield (3.0 t ha^{-1}), traditional genotypes like Boga Joha (2.92 t ha^{-1}), Kamod and Hanuman Joha (2.74 t ha^{-1} each) and Bhabeli Joha (2.63 t ha^{-1}) yielded at par.

Maize

Genetic diversity studies in maize landraces

For the assessment of genetic diversity, 29 landraces of maize, collected from ICAR-NBPGR, Ranchi and evaluated for yield and yield attributing characters during the *kharif* 2024. Analysis of variance (ANOVA) revealed that the mean sum of squares due to genotypes were significant for all agro-morphological traits suggesting the wide range of genetic variability and scope of selection of superior genotypes for these traits (Table 5.2). Genotype by trait (GT) biplot (Fig. 5.9) comprising 29 maize genotypes studied for 17 traits indicated that genotypes IC 625163, IC 625143, IC 625139 were found high yielding. Further, IC 625181 had high Fe content and IC 625168 had the highest 100 seed weight among all the genotypes. Molecular characterization using 42 SSR markers revealed substantial genetic diversity, with an average diversity index of 0.75 and an average PIC of 0.71. Markers bnlg1046 (Fig. 5.10) and bnlg1371 were themost

Table 5.2 Analysis of variance for agro-morphological and nutritional traits among 29 maize genotypes

Mean sum of square			
Trait	Replication	Genotypes	Error
Cob length (cm)	0.4432	8.7484*	4.0343
Cob girth (cm)	0.1821	0.4513**	0.1767
No. of kernel rows	0.3554	2.2970**	0.7601
No. of kernels per row	0.1400	34.9836**	6.9783
Plant height (cm)	679.4860	2040.7292*	987.6476
Ear height (cm)	610.0278	409.2425**	100.4802
Days to 50% tasseling	16.5690	63.3005**	16.9261
Days to 50% silking	1.7241	98.0936**	30.2956
Anthesis silking interval	28.9828	11.061*	12.3399
Fresh cob weight (Unit)	2998.6614	142610.8661**	8012.9594
100 seed weight (Unit)	2.9498	23.1572**	4.6932
Moisture (%)	0.6821	4.9931**	1.4888
Shelling (%)	0.0001	0.0058**	0.0014
P content (Unit)	0.0172	7.7667**	0.0002
Fe content (Unit)	2.6942	307.2574**	33.3583
K content (Unit)	17973.1207	557120.0123**	128791.8350
Grain yield (kg ha^{-1})	2849.0371	87379.7876**	13885.8160

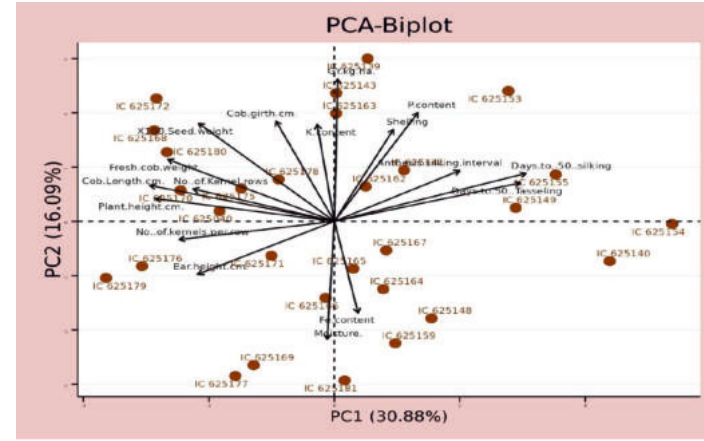

Fig. 5.9 PCA biplot for 29 maize genotypes

informative (PIC values of 0.82 and 0.85 respectively). Principal Component Analysis (PCA) explained 72% of

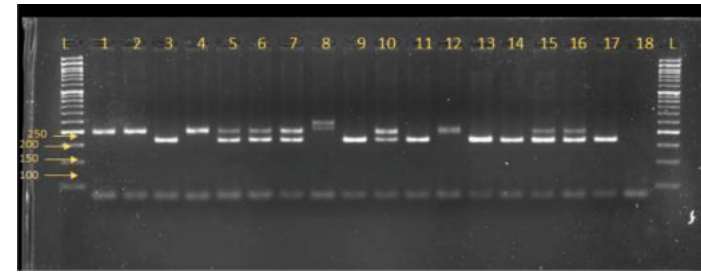

Fig. 5.10 Polymorphism generated by primer bnlg 1046 in 1-18 genotypes, with 50 bp reference ladder

the total variation, while STRUCTURE and neighbour-joining analyses identified two distinct subpopulations. AMOVA and PCoA further highlighted significant within- population variations, supported by a high Shannon information index (1.52). These findings underscore the rich genetic reservoir of these landraces, providing a robust foundation for future maize improvement and conservation programme.

Genetic analysis of yield attributing traits and resistance to maydis leaf blight in maize

Fifty inbred lines of maize collected from ICAR-NBPGR, New Delhi were used for characterizing based on morphological and yield related traits during the *Kharif* 2024. Based on D² statistics, the fifty genotypes were classified into eight distinct clusters using Tocher's method. Cluster I contained the maximum number of genotypes (31), while clusters VI, VII, and VIII each contained single genotype, indicating their unique genetic constitution. Principal component analysis explained 75.55% of the variation

across five components. Screening for maydis leaf blight (MLB) resistance under artificial epiphytotic conditions identified seven resistant inbred lines: C-2829, D-2450-1-1, PML67-B-3-1, C-78-1-1, PML-93-1, C-30-1-1 and D-2450-2-1, representing 15% of the creened genotypes. Additionally, 40.2% of the inbred lines showed moderate resistance to MLB. Notably, all resistant lines demonstrated high grain yield under diseased conditions, with yields ranging from 1980 to 3420 kg ha^{-1}, making them valuable for developing heterotic hybrids with combined high yield and disease resistance.

Molecular characterization using 20 SSR markers associated with MLB resistance revealed polymorphism among 47 lines. Eight markers showed significant association with MLB resistance. Markers p-umc1075 (Fig. 5.11) and p-umc1148 showed the highest phenotypic variance of 14.18% and 12.62%, respectively. Correlation between molecular markers and phenotypic screening revealed that resistant genotypes harboured 13-17 QTLs (mean 14.14). Genetic similarity among 47 maize inbred lines was used for generating a dendrogram based on Jaccard's similarity coefficient using the marker data of maydis leaf blight disease.

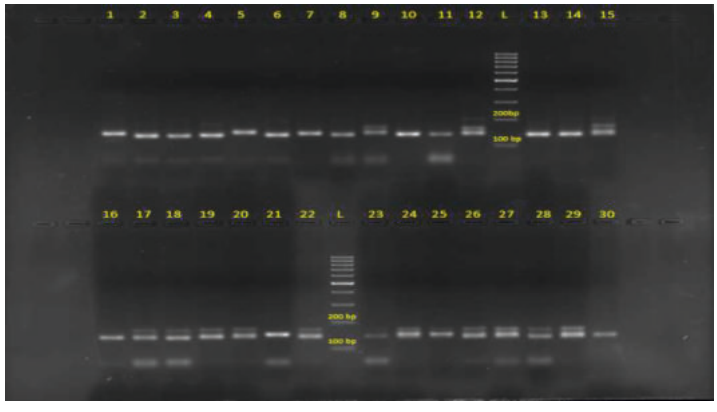

Fig. 5.11 Amplification of p-umc1075

Bio-nano sulphur formulation of methanotrophs for decarbonization and sustainable oilseed production

Field experiments were conducted during *kharif* 2024 and *rabi* 2024-25. Rice variety *Swarna Shreya* was transplanted on 18 July 2024, followed by mustard (*Brassica juncea* L.) variety *Kesari 5111*, sown on 14 November 2024. Treatments involved recommended dose of fertilizers (RDF) alone and in combination with methanotrophs, elemental sulphur, and nano-sulphur applications. Crop yield and GHG emissions (CH_4 and N_2O) were recorded to assess treatment performance. In rice, integrated application of RDF + methanotrophs + elemental sulphur (10 kg ha^{-1}) resulted in a 13.8% increase in grain yield and a 36.6% reduction in methane emissions compared to RDF alone. Methanotroph application effectively reduced both CH_4 and N_2O emissions, while elemental sulphur improved yield with a slight increase in N_2O emission. In mustard, the treatment comprising RDF + half the recommended sulphur dose + nano-sulphur (200 mg L^{-1}) recorded the highest yield, showing a 20.4% increase over conventional sulphur application, along with the lowest GWP. The study demonstrates that sulphur-based bio-nano formulations integrated with methanotrophs offer a promising climate-smart strategy for reducing greenhouse gas emissions while sustaining productivity in rice-oilseed cropping systems.

False smut management through sowing date optimization

An experiment consisting of six rice genotypes *viz.*, IR11F195, IR09L 342, Moudhamini, Swarna Shreya, Swarna Samriddhi and Swarna with six dates of sowing from 21 May 2025 to 5 August 2025 at 15 days interval was conducted. False smut severity for different dates of sowing in the respective rice genotypes sown were recorded. Disease severity for false smut was different for all the six genotypes with high severity recorded in Moudhamini and Swarna Samriddhi. Low false smut severity was observed in timely-sown condition because Tmin was higher than 25 °C during the flowering of crop. As the Tmin dropped below 25 °C accompanied by higher RH (%), false smut severity started appearing in late-sown conditions. Therefore, present findings indicate that early sowing may help in reducing the loss from false smut disease in rice.

Genomic insights into the metabolic potential of arsenic-resistant PGPR

The isolates S10P2 (*Pseudomonas anuradhapurensis*) and B14P1 (*Enterobacter hormaechei*) were subjected to

whole-genome sequencing to evaluate their metabolic potential and functional capabilities. Secondary metabolite analysis using antiSMASH showed that S10P2 harbors biosynthetic gene clusters (BGCs) for *azotobactin* and *cupriacillin*, linked to metal chelation and antimicrobial activity, while B14P1 contains BGCs for *enterobactin*, *aerobactin*, and *aryl polyene*, supporting iron acquisition, oxidative stress tolerance, and biofilm formation. PlasticDB analysis indicated that S10P2 exhibits broader plastic degradation potential, particularly for *PEG*, *PHA*, *PCL*, *PES*, and *PHBV*, whereas B14P1 showed limited degradation potential mainly toward *PEG*. Both isolates possess complete tryptophan pathway genes (*trp*A-D), suggesting indole-3-acetic acid (IAA) production capacity. B14P1 displayed stronger siderophore-mediated iron acquisition and phosphate metabolism genes (*pho*U, *pho*R, *pho*B, *pho*H, *ppk*), while S10P2 showed limited phosphate-related genes, possibly due to draft genome status.

Both isolates carry arsenic resistance genes (*ars*R, *ars*B, *ars*C), supporting adaptation to arsenic-contaminated environments. However, S10P2 demonstrated a broader metal resistance profile with additional *cad*A, *czc*D, and *cor*C genes, indicating enhanced resistance to cadmium, cobalt, and zinc. Overall, S10P2 appears more suitable for environmental applications such as bioremediation and plant growth promotion.

Identification and characterization of high yielding finger millet genotypes

Forty-four elite finger millet genotypes received from ICAR IIMR were evaluated during *kharif* 2025 under direct seeded condition. The crop was naturally exposed to water logging at early vegetative stage for one month due to incessant rain. The prolonged waterlogging caused yellowing of leaves and plant mortality. The crop regenerated after the reduction in intensity of rainfall during August-September. R-23-3058 was identified as the top yielding entry with seed yield of 2.33 t ha^{-1} followed by R-23-3052 (1.91 t ha^{-1}), R-23-3426 (1.9 t ha^{-1}), R-23-3035 (1.82 t ha^{-1}) and R-23-3055 (1.77 t ha^{-1})

One hundred forty-four accessions of finger millet germplasm received from ICRISAT were evaluated during *kharif* 2025 under direct seeding. This crop was also exposed to waterlogging during early vegetative stage for one month due to incessant rain. Observations on plant height, maturity duration, number and size of ear, 1000-grain weight and seed yield were recorded. A large variation was observed in the accessions for characters as given below. The accessions were also categorised in the low, medium and high groups for these characters for further evaluation with precision to identify suitable genotypes.

Chapter 6

PULSES

Photo: Chickpea seed production at ICAR RCER, Patna

Chickpea genotype 'DBGC 1' identified for release

DBGC 1 (Pusa 256 × WR 315), a promising *desi* chickpea genotype, has been identified for release in the state of Bihar during the *Joint Review Meeting for State Coordinated Varietal Trial (SCVT) Rabi 2025-26* held on *September 20, 2025* at *BAU, Sabour* (Bhagalpur, Bihar) (Fig. 6.1). The genotype recorded an overall mean yield of 1786 kg ha^{-1} weighted over 19 locations in the SCVT trials performed under timely sown irrigated conditions in all the three zones in the state of Bihar. However, under well managed conditions, the yield was more than 2800 kg ha^{-1} in the demonstration plots at ICAR RCER, Patna.

Besides, it also maintained satisfactory yield level (> 1500 kg ha^{-1}) under limited soil moisture condition owing to its deep root system. It has an erect plant type, excellent grain colour, size and shape, having an average 100-seed weight of 25-27 g depending on sowing time and soil moisture conditions during the seed-filling period. The genotype showed an overall

Fig. 6.1 'DBGC 1' at full bloom stage

seed yield and protein yield superiority of 8.3% and 14.16%, respectively over the best check 'BG 3043'.

Seeds of the 'DBGC 1' were found rich in protein (23.98%) and Zn (40.70 ppm) and Fe contents. The genotype was also moderately resistant to Fusarium wilt. It bears single flower/peduncle (single pod/peduncle). However, a single pod may contain 2 seeds of uniform size. The identified genotype was found well suited to cultivation in the exclusively rainfed areas of Bihar.

Breeder seed production of 'Swarna Lakshami'

During the production year 2024-25, breeder seed indent of 1700 kg was communicated by the Project Coordinator (*Rabi* pulses), IIPR, Kanpur. Over 2200 kg of breeder seed was produced against the indent. All the seed was lifted by November 2025 (Table 6.1). In addition, over 300 kg of nucleus seed of 'Swarna Lakshami' was produced, and used in the forthcoming growing season. This year, an indent of 5700 kg (> 3 times of the previous one) breeder seed of the variety has been received. Substantial increase in the indent of the breeder seed indicates that the variety is rapidly gaining popularity among chickpea farmers.

Table 6.1 Breeder seed sale of 'Swarna Lakshami' during 2025

State	Lifting agency	Quantity (kg)
Bihar	NSC, Patna	1000
	DAO, Patna	500
	KVK (Lakhisarai)	250
	Sky quest (NGO)	200
	Demonstrations	300
	PVT companies	60
	IARI-RRS, Pusa	25
	Farmers	27
Jharkhand	BAU, Kanke	25
	KVK, Ranchi	25
	FSRCHPR, Ranchi	25
	KVK, Ramgarh	10
Assam	Assam Seed Corporation	30
	NGO	25
	Total	**2502**

Field trials undertaken on pulses

Lentil: Under the NFSM funded project "Building lentil growing community resilience by the development of climate smart lentil varieties through farmers' participatory interventions", a trial comprising 100 advance breeding lines were assessed in four blocks with three checks (IPL 220, IPL 314 and IPL 534) following augmented design. Each line was grown in a plot of three rows (row length of 3 m) at an inter row spacing of 20 cm.

In block-1, only two test lines significantly out-yielded the best check 'IPL 534' (2.53 t ha^{-1}). In block-2, five test entries significantly excelled the best check (IPL 220; 2.30 t ha^{-1}). In block-3, the check 'IPL 220' (2.47 t ha^{-1}) excelled other checks. Only two test entries significantly yielded better than the check 'IPL 220'. A total of two test entries outyielded the best check (IPL 220; 2.5 t ha^{-1}) in the fourth block. During the cropping year 2024-25, no occurrence of

Stemphylium blight was observed under field conditions.

A second trial comprising 60 released cultivars of lentil was also conducted under the same project following alpha lattice design in three replications. 10% of the highest yielding (> 3.0 t ha^{-1}) varieties were 'IPL 316', 'L 472', 'Kota Masoor 2', 'IPL 81', 'JL 3' and 'RLG 5'. The final data of these two trials were sent to the coordinator of the project at IIPR, Kanpur for final compilation and onward transmission to DA and FW, Ministry of Agriculture and Farmers' Welfare, Govt of India.

Chickpea: A state varietal trial of chickpea was conducted during the year 2024-25. A total of 13 coded entries were received from the state coordinator, BAU, Sabour. The trial was conducted in the RCBD at the specified spacing and replication. The yield of entries varied from 1446 kg ha^{-1} (GCP 105) to 2547 kg ha^{-1} (DC 2306). 100-seed wt. showed wider variation (12.09-27.36 g/100 seeds) than those of yield and maturity duration. The details are mentioned in the Table 6.2.

Table 6.2 Performance of chickpea breeding lines in the state varietal trial (2024-25)

Coded entry	Genotypes (decoded)	Yield (kg ha^{-1})	100 seed wt. (g)	Maturity duration (day)
SVT 01	DBGC 1	2462	27.36	119.33
SVT 02	DC 2306	2547	26.82	119.00
SVT 03	GNG 2207 (C)	2051	13.72	115.00
SVT 04	DMHC 21-1104	1810	25.64	117.00
SVT 05	BRC 2022-11	1951	17.29	113.66
SVT 06	BRC 2024-16	2006	15.25	113.33
SVT 07	DC 2305	2004	19.20	115.33
SVT 08	BG 3043 (C)	1846	22.01	115.00
SVT 09	RCEC 6003	1724	26.85	118.33
SVT 10	DMHC 21-1108	2222	24.81	120.00
SVT 11	BRC 2024-20	1938	12.09	125.33
SVT 12	RCEC 3	2278	22.15	115.00
SVT 13	GCP 105 (C)	1446	17.76	118.66
LSD (P=0.05)		181.50	--	--

Maintenance of promising genotypes of cool season pulses

A total of 10 released varieties/advance breeding lines of *desi* chickpeas including 'DBGC 1', 'RCEC 3' and 'RCEC 6003', four lentil varieties/genotypes (DBGL 105, IPL 220 and four SPS derived from 'L4717') and one SPS derived from 'Ratan' (a low ODAP grasspea variety) were multiplied during the crop season 2024-25 for further use in the forthcoming season.

Demonstration

A demonstration of seven chickpea varieties, namely Swarna Lakshami, Sabour Chana 2, Pusa 3043, GNG 2207, GCP 105, PBG 9 and KPG 59, was conducted at the main farm, each in about 120 m^2 area. Yield of the varieties varied from 1901 kg ha^{-1} (GCP 105) to 3000 kg ha^{-1}(Swarna Lakshami). Swarna Lakshami, which was released for cultivation in the north-east plains during March 2024, showed decisive superiority over all the previously released chickpea varieties for yield and other consumers' preferred traits.

Basic genetic studies

One of the diagnostic features of the chickpea variety 'Swarna Lakshami' is its unique pod bearing characteristic, that is, presence of double flowers (pods) at a few peduncles within individual plants (Fig. 6.2). This trait in 'Swarna Lakshami' has shown incomplete penetrance and variable expressivity. This variety along with another similar variety 'Sabour Chana 2' was grown at eight different spacings, *viz.*, 20×10 cm^2, 40×10 cm^2, 30×10 cm^2, 40×20 cm^2, 30×20 cm^2, 20×20 cm^2, 45×10 cm^2 and 45×20 cm^2. It was observed that the intra-row spacing influenced expression of double poddedness in both the varieties. 'Sabour Chana 2' showed complete penetrance at three spacings, i.e., 20×20 cm^2, 30×20 cm^2 and 40×20 cm^2. 'Swarna Lakshami', on the other hand, did not exhibit complete penetrance in any spacings, although over 90% penetrance was observed at larger spacings, *viz.*, 40×20 cm^2, 45×10 cm^2 and 45×20 cm^2. The preliminary observation noted during 2024-25 will be ratified during the next cropping season.

Pulses seed hub

Under the 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 (Swarna Lakshami, Pusa 3043, GNG 2299 and GNG 2207) was taken up at ICAR RCER, Patna during the year 2024-25. In addition, the "Nucleus" seed of a newly released chickpea variety "Swarna Lakshami" was also produced in sufficient quantity (> 300 kg). In lentil, breeder and T/L seeds of biofortified varieties, namely 'IPL 220' and 'L 4717' were also produced. In addition, quality (certified and T/L) seeds of mungbean (Virat, Shikha, IPM 2-3, IPM 2-14 and Samrat) were also taken up at ICAR RCER, Patna. At KVK, Buxar, quality seed production of chickpea (Swarna Lakshami, GNG 2299 and GNG 2207), lentil

Fig. 6.2 Single and double flowers (pods) per peduncle on the same plant

(IPL 220) and green gram (Shikha) were taken up in participatory mode. Details of quality seeds produced are presented in the Table 6.3.

Table 6.3 Quality seeds of pulses produced under pulse seed hubs (2024-25)

Crop	Variety	Class of Seed	Seed production (q)
Green gram	Virat	T/L	3.35
	IPM 2-14	T/L	1.95
	Shikha	T/L	8.50 0.15*
	Samrat	T/L	0.40
	IPM 2-3	T/L	1.60
Chickpea	Pusa 3043	B/S	2.50
	GNG 2299	B/S F/S	3.40 15.00*
	GNG 2207	B/S C/S	2.35 30.00*
	Swarna Lakshami	Nucleus and B/S B/S and T/L	25.00 4.00*
Lentil	IPL 220	B/S and T/L F/S and C/S	9.00 68.40*
	L 47178	B/S and T/L	7.50
Pigeonpea	IPA 203	B/S	23.08
	IPA 206	T/L	1.50
		Total	**177.68**

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

Physico-mechanical characterization of edamame (soybean genotypes)

The physico-mechanical characterization of edamame (soybean genotypes) revealed significant variability ($p<0.05$) in yield, moisture, and structural traits, highlighting the role of genetic background in processing and utilization. Moisture content ranged from 64-68%, with Swarna Vasundhara showing the highest seed yield (50.76%) and Swarna Sugandha the lowest (41.83%). Pods averaged 60 mm in length, while seeds measured about 15 mm with a mean weight of 0.60 g, traits favourable for mechanized handling. Colorimetric analysis showed that seeds were lighter (L values 56-60) than pods (27-37), with green (negative a) and yellow (positive b) tones linked to consumer appeal and biochemical quality.

Mechanical testing further emphasized genotype-specific resistance. Horizontal pod orientation required higher forces, with S. Sugandha recording the maximum bio-yield point (259.24 N) and AGS338 the lowest (123.74 N), while vertical orientation showed reduced resistance, with AGS402 highest (77.05 N).

Seed texture analysis revealed AGS338 as most amenable to dehulling (39.71 N) and S. Sugandha the most resistant (71.44 N) (Table 6.4). Overall, integrating physical, colorimetric and mechanical traits provides a robust framework for selecting soybean genotypes, supporting breeding, processing, and post harvest strategies to balance productivity, consumer preference, and industrial applicability.

Table 6.4 Textural evaluation of fresh edamame pods (soybean genotypes)

Genotypes	Fresh Edamame Pods				Fresh Edamame Seeds	
	Horizontal orientation		Vertical Orientation			
	Bio-yield point (N)	Distance (mm)	Bio-yield point (N)	Distance (mm)	Bio-yield point (N)	Distance (mm)
AGS338	123.74 ± 18.42	2.39 ± 0.24	67.01 ± 21.17	7.52 ± 1.63	39.71 ± 7.27	1.81 ± 0.23
AGS402	135.03 ± 17.30	2.82 ± 0.35	77.05 ± 14.98	6.06 ± 0.73	50.41 ± 8.84	2.28 ± 0.34
AGS404	153.70 ± 25.56	2.82 ± 0.22	47.51 ± 10.24	6.08 ± 1.00	44.06 ± 7.12	1.89 ± 0.26
S.Sugandha	259.24 ± 56.58	4.05 ± 0.40	53.78 ± 6.48	5.67 ± 1.46	71.44 ± 18.38	2.03 ± 0.24
S.Vasundhara	140.93 ± 50.28	3.14 ± 1.08	43.76 ± 13.70	3.82 ± 1.15	41.23 ± 8.89	1.81 ± 0.25

Chapter 7

FRUITS

Photo: Litchi at ICAR RCER, Patna

Utilization of major fruit seeds and underutilised fruits for the development of functional food products

Characterization of seed starch: Seeds of jackfruit (*Artocarpus heterophyllus* Lam.) and monkey jack (*Artocarpus lacucha* Lam.) were processed into starch by wet extraction method. This starch was evaluated for physico-chemical characteristics. The starch of jackfruit seed recorded higher solubility up to 70 °C. After 70 °C, solubility of jackfruit starch reduced below that of monkey jack seed. The water holding capacity and solubility of jackfruit seed starch was lower than monkey jack. Jackfruit starch contains OH, CH_2 groups, CCH- stretch, and C–O–H bends.

The scanning electron microscopy analysis showed that jackfruit starch granules were found to be round and bell shaped with size ranged from 5 to 8 µm. Some of them were irregular in shape showing cuts in their surface, which appeared to be characteristic of these starches. Starch particle size for monkey jack was relatively smaller. Light microscopy revealed that jackfruit starch was relatively stable and maintained good structural integrity with absorbing water up to 75 °C along with little birefringence (Fig. 7.1).

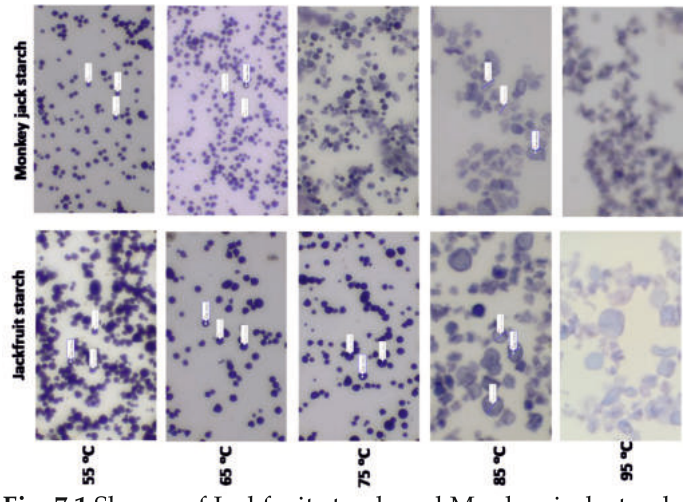

Fig. 7.1 Shapes of Jackfruit starch and Monkey jack starch at 55 ^{0}C to 95^{0}C

In situ characterization of mulberry genotypes (*Morus indica* L.)

The study aimed to characterize 31 mulberry genotypes *in situ*, focusing on tree morphology and fruit quality traits to assess genetic variability and identify superior genotypes in this region. Morphological observations were recorded *in situ* in six districts: Ranchi, Khunti, Lohardaga, Gumla, Ramgarh, and Hazaribagh. Among 31 genotypes, traits such as plant vigour, stem girth, plant height, internodal distance shown more variability. Among leaf traits, narrow ovate leaves, green colours, acuminate leaf apex, acute leaf angle, glabrous, unlobed leaves were found dominant. For biochemical traits, wide variation was observed for TSS ranged from 9.03-32.38°Brix, acidity 0.17% to 0.97%, ascorbic acid 3.98 mg/100g to 14.60 mg/100g, total sugar 3.73% to 19.03%, reducing sugar 3.47% to 15.92%, non-reducing sugar 0.26% to 5.95%, total phenol content (TPC) 28.80 to 399.73 mg GAE/100g, total flavonoid content (TFC) 8.33 to 185.47 mg CE/100 g, total anthocyanin content 18.69 to 168.27 mg/100 g, and total antioxidants activity through FRAP ranged from 0.56 to 7.55 µmolTE/g, through DPPH method 0.78 to 25.47 µmolTE/g and by using ABTS 9.23 to 79.67 µmolTE/g. In cluster analysis, all 31 genotypes grouped into five clusters, with clusters IV and V were the largest clusters having 10 and 9 genotypes followed by others. The PCA extracted nine principal components (PC1–PC9) with eigen values greater than 1, collectively accounting for 84.89% of the total variance in the dataset. Swarna Rasrani showed the best overall performance and showed the highest values for most morphological and fruit quality traits among 31 genotypes. Genotype HMS-1 was found superior for some traits such as TPC, TFC and total antioxidants activity. These genotypes may serve as potential resources for commercial exploitation.

Characterization of litchi genotypes based on bioactive compounds and quality parameters

The study aimed to characterize 31 litchi genotypes based on bioactive compounds, fruit parameters and mineral content. Significant variation was observed in fruit weight, length, and width, with Swarna Madhu producing the largest fruits and Swarna Roopa the smallest. Biochemical analysis revealed differences in total soluble solids, acidity, total phenolic content, antioxidant activity, and sugar profiles, with Late Bedana exhibiting the highest antioxidant activity and Swarna Madhu recording maximum phenolics. Among flavonoids and phenolic acids, rutin and t-cinnamic acid

were most abundant, respectively, while fructose and glucose predominated among sugars. Mineral content varied widely, with the highest potassium in genotype 8/1, phosphorus and copper in Purbi, calcium in Bombiya, magnesium in Yogda, iron in Tarkoliya, and zinc in L-9/109. Correlation analysis showed strong positive associations between fruit size and bioactive content. Cluster analysis grouped genotypes into four distinct categories based on fruit quality, antioxidant potential, and mineral composition, while Principal Component Analysis highlighted traits contributing to 82.46% of total variance with seven principal component groups (Table 7.1).

producing uniformly dried bulbs.

This optimized protocol demonstrates how jackfruit,

Fig. 7.2 Conversion of ripe jackfruit into osmo-dried jackfruit bulbs

often underutilized, can be transformed into a stable, consumer-friendly product, contributing to sustainable fruit processing, product diversification, and enhanced economic opportunities.

Table 7.1 Principal component analysis (PCA) based on morphological and biochemical parameters

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Fruit weight (g)	0.46	-0.12	0.04	-0.19	-0.29	-0.02	-0.05
Fruit length (mm)	0.13	0.33	0.38	-0.07	-0.48	0.03	-0.21
Fruit width (mm)	0.46	-0.12	0.08	0.02	-0.26	-0.20	-0.01
Total soluble solid	-0.27	-0.25	0.18	0.10	-0.07	0.19	-0.46
Titrable acidity (%)	-0.11	-0.16	0.58	0.03	-0.20	0.17	-0.04
TPC (mg GAE/100g)	0.29	-0.45	-0.09	0.17	0.14	-0.21	0.07
TAA (mg AAE /100g)	0.38	-0.05	0.19	-0.23	0.20	-0.04	0.26
Potassium (mg/100g)	0.19	0.34	0.23	0.03	0.46	0.35	0.03
Phosphorus (mg/100g)	0.2	0.30	0.03	0.20	0.33	-0.25	-0.57
Calcium (mg/100g)	0.05	0.05	-0.16	0.64	-0.28	0.37	0.31
Magnesium (mg/100g)	0.27	0.07	-0.41	0.25	-0.17	0.11	-0.39
Iron (mg/100g)	0.2	-0.16	0.37	0.46	0.27	0.11	0.07
Zinc (mg/100g)	-0.24	0.01	0.21	0.36	-0.06	-0.69	0.09
Copper (mg/100g)	0.04	0.58	0.00	0.08	-0.11	-0.17	0.29
Eigen value	3.35	2.10	1.82	1.36	1.10	0.93	0.88
Variance %	23.95	15.01	13.03	9.71	7.89	6.62	6.26
Cumulative % Variance	23.95	38.95	51.98	61.69	69.57	76.19	82.46

Post harvest management and value addition of jackfruits

The osmo-drying of jackfruit bulbs was optimized by evaluating osmotic concentration, process duration, and drying conditions (Fig. 7.2). Fresh bulbs with high moisture (≈79.7% w.b.) and low soluble solids (≈20°Brix) required pre-treatment, and trials showed that a 40°Brix sucrose solution for 6 hours achieved the target 30°B TSS efficiently. Subsequent drying experiments identified 60 °C for 9-10 hours as optimal,

Field efficacy of different newer insecticide molecules against litchi seed borer

The litchi seed/fruit borer, *Conopomorpha sinensis* Bradley (Lepidoptera: Gracillariidae), a significant economic insect pest of litchi (*Litchi chinensis*), is known to cause substantial damage to litchi crops in Bihar and Jharkhand. Larvae of this pest burrow into the fruit,

feeding on the seed and causing premature fruit drop, quality degradation, and reduced marketability, leading to considerable yield loss. For effective management of this pest, five molecules (Lambda-cyhalothrin 5% EC, Flubendiamide 39.35% SC, Spinetoram 11.7% SC, Chlorantraniliprole 18.5% SC, and Azadirachtin 10,000 ppm) were evaluated at the recommended dosages. Two foliar sprays were applied, one at the fruit pea stage and the second at 15 days after the first spray, and the per cent fruits infested with seed borer reduction over the control was recorded. Application of Spinetoram 11.7% SC @ 0.4 mL, caused 89.98 % reduction of pest infestation, followed by Flubendiamide 39.35% SC @ 0.4 mL (84.75%) (Table 7.2). Thus, based on the present study results, Spinetoram and Flubendiamide were found effective against seed borer, *C. sinensis,* and can be recommended for the management of *C. sinensis* on a rotational basis in litchi orchards.

Table 7.2 Bioefficacy of different insecticides against litchi seed borer, *C. sinensis,* in litchi

Mean percent reduction of fruit borer infestation							
Treatment	**Dosage (mL or g/lit)**	**I Spray**			**II Spray**		
Lambda-cyhalothrin 5%EC	1.0 mL	16.80^{b}	37.35^{ab}	74.29^{b}	17.95^{a}	37.28^{ab}	76.31^{a}
Flubendiamide 39.35% SC	0.4 mL	20.73^{bc}	43.31^{c}	80.18^{c}	23.26^{ab}	40.34^{b}	84.75^{b}
Spinetoram 11.7% SC	0.4 mL	24.44^{d}	45.56^{c}	84.93^{cd}	26.10^{b}	42.95^{bc}	89.98^{c}
Azadirachtin 10,000 ppm	5 mL	14.64^{a}	35.33^{a}	51.50^{a}	14.35^{a}	32.49^{a}	73.60^{a}
Chlorantraniliprole 18.5% SC	0.4 mL	18.06^{b}	40.03^{b}	80.23^{c}	20.24^{a}	36.32^{a}	82.32^{b}
P value		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Percent reduction within a column followed by a different letter in uppercase differ significantly (HSD)

Chapter 8

VEGETABLES

Photo: Swarna Vishist Sem variety at ICAR RCER Patna

Evaluation of vegetable soybean genotypes for nutritional quality and antioxidant potential

Thirty four genotypes of vegetable soybean were evaluated for total carotenoid content. The total carotenoid content ranged from 4214.88 to 4849.91 µg/100g edible shelled green beans. The aromatic line AGS-456 (4849.91 µg/100g edible shelled green beans) performed the best, followed by aromatic variety Swarna Sugandha (4819.63 µg/100g edible shelled green beans) and non–aromatic variety Swarna Vasundhara (4710.97 µg/100g edible shelled green beans) (Fig. 8.1 & Fig. 8.2). The antioxidant activity, when estimated for these 34 vegetable soybean genotypes, ranged from 258.25 to 331.98 mg AEAC/100g shelled green beans. The maximum antioxidant activity was recorded in Swarna Sugandha (331.25 mg AEAC/100g shelled green beans), followed by Swarna Vasundhara (327.23 mg AEAC/100g shelled green beans) and aromatic line AGS-461 (320.80 mg AEAC/100g shelled green beans). Swarna Sugandha (13.32 t ha^{-1}) and Swarna Vasundhara (10.34 t ha^{-1}) also demonstrated superior performance in terms of green pod yield potential.

Fig. 8.1 Swarna Sugandha

Fig. 8.2 Swarna Vasundhara

Metabolomic insights into graft healing for bacterial wilt management in tomato

Metabolite profiles of grafted and ungrafted tomato plants during the healing process were compared using LC-MS/MS-based untargeted metabolomics to identify metabolic shifts associated with enhanced resistance to bacterial wilt (Figs. 8.3 and 8.4). Compared with ungrafted plants, grafted plants at 3 days after grafting showed 67 upregulated and 61 downregulated metabolites. Similarly, plants at 7 days after grafting

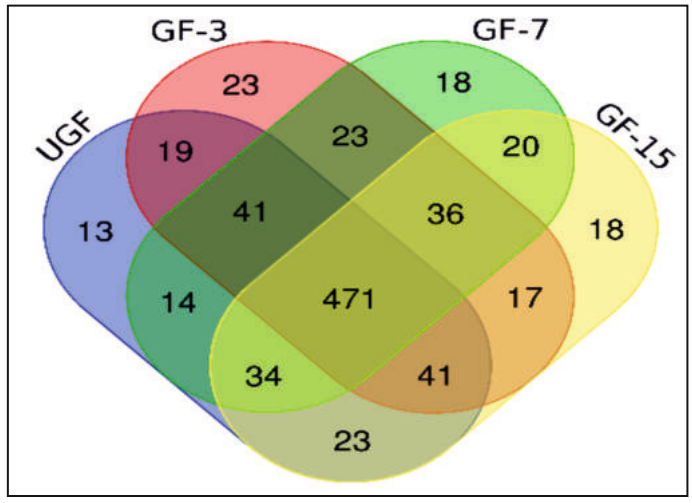

Fig. 8.3 Venn diagram of differential metabolites

showed 60 upregulated and 55 downregulated metabolites, while plants at 15 days after grafting showed 60 upregulated and 62 downregulated

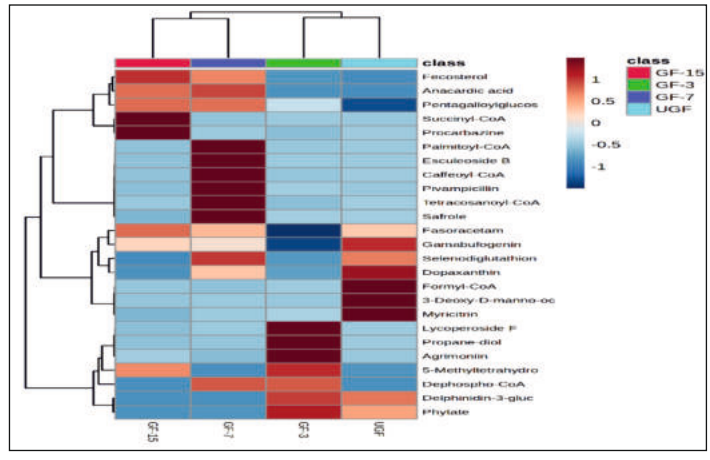

Fig. 8.4 Heat map illustrating up and down regulation of different

metabolites. Metabolites such as DTDP-3,4-dioxo, monardaein, toluene, fucose, and cisapride gradually increased in GF3 and were detected at lower levels in ungrafted plants. Early-stage grafted plants (GF3) showed elevated levels of antioxidant- and signalling-related compounds such as lycoperoside F, propane-1,2-diol, agrimoniin, 5-methyltetrahydro-, and dephospho-CoA, whereas late-stage grafted plants (GF15) showed greater accumulation of membrane- and defence-related metabolites such as fecosterol, succinyl-CoA, and procarbazine. These metabolic adjustments highlight the complexity of the plant response to grafting and its adaptive strategies for survival and improved resilience to pathogens.

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Fig. 8.5 Lablab bean at fruiting state

(4710.97 µg/100g edible shelled green beans) (Fig. 8.1 & Fig. 8.2). The antioxidant activity, when estimated for these 34 vegetable soybean genotypes, ranged from 258.25 to 331.98 mg AEAC/100g shelled green beans. The maximum antioxidant activity was recorded in Swarna Sugandha (331.25 mg AEAC/100g shelled green beans), followed by Swarna Vasundhara (327.23 mg AEAC/100g shelled green beans) and aromatic line AGS-461 (320.80 mg AEAC/100g shelled green beans). Swarna Sugandha (13.32 t ha^{-1}) and Swarna Vasundhara (10.34 t ha^{-1}) also demonstrated superior performance in terms of green pod yield potential.

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Fig. 8.6 Morphological characteristics of different grass pea genotypes

metabolites. Similarly, plants at 7 days after grafting showed 60 upregulated and 55 downregulated metabolites, while plants at 15 days after grafting showed 60 upregulated and 62 downregulated metabolites. Metabolites such as DTDP-3,4-dioxo, monardaein, toluene, fucose, and cisapride gradually increased in GF3 and were detected at lower levels in ungrafted plants. Early-stage grafted plants (GF3) showed elevated levels of antioxidant- and signalling-related compounds such as lycoperoside F, propane-1,2-diol, agrimoniin, 5-methyltetrahydro-, and dephospho-CoA, whereas late-stage grafted plants (GF15) showed greater accumulation of membrane- and defence-related metabolites such as fecosterol, succinyl-CoA, and procarbazine. These metabolic adjustments highlight the complexity of the plant response to grafting and its adaptive strategies for survival and improved resilience to pathogens.

Genetic enhancement of selected vegetable legumes

In this project, 521 lablab bean and 215 yardlong bean genotypes were evaluated during 2025 with the objective to identify promising lines with desirable traits such as high yield, disease resistance, and adaptability. Promising seven pole and two bush-type lablab bean lines were identified (Fig. 8.5). Notable among these were RCPD-14 (pole type, light green attractive pods, 130-140 pods/plant, photo-insensitive, collar rot tolerant), RCPD-15 (140-145 pods/plant, pole type, anthocyanin-rich, collar rot resistant) and RCPD-16 (extra-early, suitable for rice- fallow areas, dwarf, photo-insensitive, 95-110 pods/plant). Promising genotypes

Fig. 8.7 Field view of organic farming experiment

Evaluation of diara land farming for sustainable food production

Two sites of Ganga River (Buxar and Begusarai) and two sites of Gandak River (East Champaran and Vaishali) were selected to evaluate the sustainable food production system in diara land. Soil quality in Ganga and Gandak diara plays a crucial role in determining crop production pattern. Mostly sandy to sandy loam soils are available in diara land. Soil nitrogen values varied from 53-126 kg ha^{-1} whereas potassium content varied from 73-945 kg ha^{-1} and phosphorous content from 3-20 kg ha^{-1} for different categories of soils. Watermelon and muskmelon were typically cultivated in soils containing more than 80% sand. In soils with 60–80% sand content, vegetables like sponge gourd, bottle gourd, pumpkin, chilly and tomato were commonly grown (Fig. 8.8). Soils having less than 60% sand (mostly in upper diara) were found suitable for cultivation of wheat, potato, mustard, lentil, maize and onion. Crop-livestock integration in diara land is not much strong, however, diara land provides green grass for livestock, and in turn livestock provide milk and meat for human consumption and organic manure for crop production. Weed diversity of diara land has been assessed and it has been observed that *Kush* grass contributed to the highest percentage on weight basis

Fig. 8.8 Vegetable production in diara land (Buxar)

(42.6%) followed by Cynodon (13.1%) and *Fimbristylis aestivalis* (11.2%).

Evaluation of brinjal hybrids for bacterial wilt resistance and yield related characters

Thirty six crosses of brinjal developed with nine parents *viz*., HAB-933, HAB-934, HAB-935, HAB-936, HAB-937, HAB-938, HAB-931, HAB-932 and HAB-381 in half diallel fashion during 2023-24 were evaluated for bacterial wilt resistance and yield related characters along with the parents in a randomized block design with two replications (Table 8.1). Among them, seven crosses were found promising with respect to yield, per cent plant survival and fruit quality traits (Table 8.2).

Evaluation of tomato hybrids for bacterial wilt resistance and yield related characters

Among the thirteen crosses identified during 2023-24, three crosses *viz*., HADT-7 x HADT-296 (728.75 q ha^{-1}),

Table 8.1 Half diallel analysis of 36 Brinjal hybrids along with nine parents

Characters	Range	ANOVA for combining ability	Genetic variance
Percent plant survival against wilt	20 - 100	GCA significant SCA significant	Additive dominance
Yield (q ha^{-1})	33.30 - 303.13	GCA significant SCA significant	Additive dominance
No. of fruits/plant	3.00 - 41.5	GCA significant SCA significant	Additive dominance
Avg. Fruit weight (g)	51.00 - 268.86	GCA significant	Additive
Avg. Fruit Length (cm)	5.55 -16.12	GCA significant	Additive
Avg. Fruit diameter (cm)	12.28 - 24.53	GCA significant	Additive

Table 8.2 Best crosses identified in brinjal

Crosses	Plant survival against wilt (%)	Yield (q ha^{-1})	No. of fruits/ plant	Avg. fruit weight (g)	Avg. fruit length (cm)	Avg. fruit diameter (cm)	Fruit shape and colour
HAB-933 x HAB-932	90	303.13	14	126.95	12.5	17.13	Light purple, oblong
HAB-938 x HAB-932	90	273.44	12	233.4	10.34	17.9	Light purple, oblong
HAB-933 x HAB-938	80	198.44	9	264.15	11.23	24.53	Light purple, round
HAB-933 x HAB-936	100	187.19	10	143.86	8.75	21.50	Dark purple, round

HADT-7 x Swarna Lalima (845.5 q ha^{-1}) and RCDT-1608 x Swarna Lalima (688.15 q ha^{-1}) showing 95% plant survival against bacterial wilt were found promising with respect to yield and fruit quality characters.

Evaluation of bacterial wilt resistant chilli germplasms for fruit yield and quality

Six bacterial wilt resistant chilli genotypes *viz*., IC-214965, EC-378632, EC-390029, EC-566920, IC-561622, IC-561626 were evaluated for fruit yield and quality in replicated trial (Table 8.3). Fifteen half diallel crosses were developed from these six promising lines.

Table 8.3 Evaluation of promising germplasm of chilli for fruit yield and quality

Genotype	Days to 50% flowering	Fruit diameter (cm)	Fruit length (cm)	Avg. fruit weight (gm)	Yield (q ha^{-1})
IC-214965	36	3.82	9.98	6.95	64.45
EC-378632	35	2.82	7.13	2.49	62.96
EC-390029	42	3.89	8.07	5.46	109.25
EC-566920	40	3.63	8.59	4.48	115.54
IC-561622	53	3.42	6.73	3.09	82.58
IC-561626	42	2.71	8.83	2.82	58.14
CD	-	0.25	2.03	0.42	NA
CV	-	3.95	13.41	17.27	9.00

Deciphering purple pigmentation and nutrient profiles in *Pisum* spp. via metabolomics

To elucidate the mechanism of purple pod color development in pea (*Pisum sativum* L.) using an LC-MS-based metabolomics approach combined with bioinformatics, green and purple pod tissues were analysed. A total of 297 differentially accumulated metabolites (DAMs): primarily flavonoids were identified, with 157 upregulated and 140 downregulated in purple versus green pods; additionally, 44 PsGST (Glutathione S-transferase) gene family members were also mapped on seven chromosomes via genome-wide *in silico* screening (Fig. 8.9). Among the 157 metabolites, 11 compounds traced for anthocyanin biosynthesis, and among those, four key compounds Cyanidin 3-O-glucoside; Cyanidin 3-O-(6-O-p-coumaroyl) glucoside-5-O-glucoside; Cyanidin 3-O-beta-D-sambubioside and Delphinidin 3-O-beta-D-sambubioside were identified through KEGG (Kyoto Encyclopedia of Genes and Genomes) pathway enrichment analysis.

A total of fifteen coloured podded advanced breeding lines (ABLs) selected for evaluation of nutritional traits, ABL-39 recorded the highest anthocyanin (115.24 mg/100 g FW) and antioxidants (273.50 mg AAE/100 g), ABL-112 showed maximum protein (80.77 mg/100 g dry wt.) and calcium (2.79 mg/100 g), ABL-08

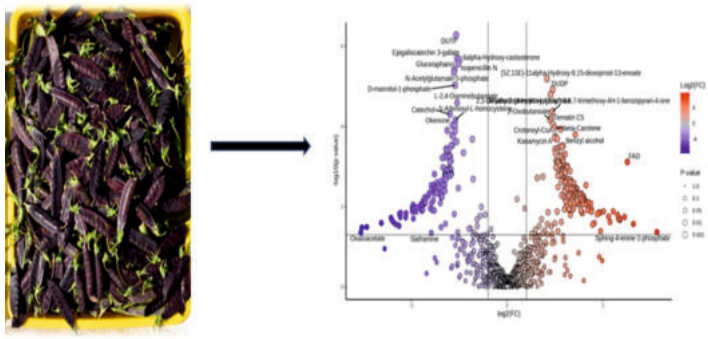


Fig. 8.9 Upregulated and downregulated metabolites in red vs. green pod of *Pisum* spp.

exhibited peak iron (638.43 mg/100 g), magnesium (5.87 mg/100 g), and phosphorus (4.87 mg/100 g), while ABL-104 led in zinc (85.23 mg/100 g) and F_3-92 in manganese (110.90 mg/100 g).

All India Coordinated Research Project (Vegetable Crops) Solanaceous vegetables: Tomato, Brinjal, Chilli, Capsicum

A total of 10 trials were performed in solanaceous vegetables under AICRP (VC). Two trials were conducted in cherry tomato, one in high temperature tolerant and one in interspecific grafting in tomato during 2024-25. Under Cherry Tomato Varietal AVT-I, 2023/TOCVAR-4 was highest yielding (63 q ha^{-1}) and in Cherry Tomato Varietal under protected cultivation IET, 2024/TOCVAR-8 was highest yielding (29.2 q ha^{-1}). Under Tomato Varietal High temperature IET, 2024/TOHTRES-10 (82 q ha^{-1}) was highest yielding in Ranchi conditions. An interspecific grafting trial involving nine rootstocks and three scions (27 treatments) was evaluated for bacterial wilt resistance. Scions with rootstocks 2024/VPRSBR-2 and 2024/VPRSBR-5 showed 100% mortality due to bacterial wilt. Scions with rootstock 2024/VPRSBR-4 showed susceptible reaction to wilt. Maximum fruit yield was obtained in 2024/VPRSBR-1+VPSCOTO-2 (508.1 q ha^{-1}) followed by 2024/VPRSBR-8+VPSCOTO-2 (466.8 q ha^{-1}) and 2024/VPRSBR-9+VPSCOTO-3 (439.8 q ha^{-1}) rootstocks, respectively. Entry 2022/CHIVAR-5 (115.8 q ha^{-1}) among eleven entries under Chilli Hot pepper Varietal AVT-II, 2023/CHIVAR-7 (92.5 q ha^{-1}) among eleven entries under Chilli Hot pepper Varietal AVT-I, 2024/CHIVAR-1 (123.3 q ha^{-1}) among nine entries under Chilli Hot pepper Varietal IET, 2023/CHIHYB-3 (142.5 q ha^{-1}) among eight entries under Chilli Hot pepper Hybrid AVT-I, 2024/CHIHYB-5 (151.2 q ha^{-1}) among seven entries under Chilli Hot pepper Hybrid IET and 2022/CAPVAR-5 (77.5 q ha^{-1}) among nine entries under Capsicum Varietal AVT-II were found promising during 2024-25.

Three trials were carried out under biotic stress in solanaceous vegetables during 2024-25. Under Brinjal bacterial wilt resistant rootstock IET, entries 2024/ DMR SBR- 1, 6, 8, 10 were found resistant and 2024/ DMR SBR-4 &7 were found immune. All entries were susceptible to bacterial wilt under Tomato Bacterial wilt resistant AVT-I.

Cruciferous vegetables and root vegetables: Cabbage, Cauliflower and Carrot

During 2024-25, trials were conducted in Cabbage, Cauliflower and Carrot. Entries 2022/CABHYB-5 (397.5 q ha^{-1}) under Cabbage Hyb AVT-II, 2023/CAUMLHYB-4 (440 q ha^{-1}) under Cauliflower Hyb (Mid Late) AVT-I, 2022/CAUEHYB-3 (208.8 q ha^{-1}) under Cauliflower Hybrid (Early) AVT-II, 2022/CAUMHYB-5 (406.7 q ha^{-1}) under Cauliflower Hybrid (Mid) AVT-II, 2023/CAULHYB-3 (292.5 q ha^{-1}) under Cauliflower Hybrid (Late) AVT-I, 2024/CAULVAR-6 (349.2 q ha^{-1}) under Cauliflower Varietal (Late) IET, 2023/CAULVAR-7 (375 q ha^{-1}) under Cauliflower Varietal (Late) AVT-I were high yielding. Entries 2022/CARTRVAR-2 (357.7 q ha^{-1}) under Carrot Tropical AVT-II, 2022/CARTRVAR-4 (201 q ha^{-1}) under Carrot Temperate AVT-II were found promising during 2024-25.

Cucurbitaceous vegetables

A total of sixteen trials were conducted in cucurbitaceous vegetables under AICRP (VC) during 2024-25. Among five entries under Summer Squash Varietal AVT-II, 2022/SSQVAR-3 (321.3 q ha^{-1}) was highest yielding. Among six entries under Cucumber Hyb AVT-II, 2022/CUCUVHYB-5 (310 q ha^{-1}), among five entries under Cucumber Hybrid AVT-I, 2023/CUCUHYB-3 (246 q ha^{-1}) and among five entries in Cucumber Varietal AVT-I, 2023/CUCUVAR-3 (121.3 q ha^{-1}) were found promising.

Among eight entries under Sponge gourd Varietal AVT-II, 2022/SPGVAR-7 (156 q ha^{-1}), and among six entries under Sponge gourd Varietal AVT-I, 2023/SPGVAR-5 (41.8 q ha^{-1}) were high yielding.

Entries 2022/PUMVAR-6 (100.5 q ha^{-1}) under Pumpkin under Cauliflower Hybrid (Late) AVT-I, 2024/CAULVAR-6 (349.2 q ha^{-1}) under Cauliflower Varietal (Late) IET, 2023/CAULVAR-7 (375 q ha^{-1}) under Cauliflower Varietal (Late) AVT-I were high yielding. Entries 2022/CARTRVAR-2 (357.7 q ha^{-1}) under Carrot Tropical AVT-II, 2022/CARTRVAR-4 (201 q ha^{-1}) under Carrot Temperate AVT-II were found promising during 2024-25.

Varietal AVT-II, 2024/PUMVAR-1 (91.3 q ha^{-1}) under Pumpkin Varietal IET were found promising. Entries 2023/BOGHYB-6 (119 q ha^{-1}) under Bottle gourd Hybrid AVT-I, 2024/BOGVAR-8 (356 q ha^{-1}) under Bottle gourd Hybrid AVT-I,2024/BIGVAR-6 under Bitter gourd Varietal IET, 2023/BIGVAR-6 under Bitter gourd Varietal AVT-I, 2023/BIGHYB-2 (44.8 q ha^{-1}) under Bitter gourd Hybrid AVT-I were found promising. Entries 2024/MMVAR-1 (70.8 q ha^{-1}) under Muskmelon Varietal IET, 2023/MMVAR-2 (60 q ha^{-1}) under Muskmelon Varietal AVT-I, 2022/MMVAR-3 (97 q ha^{-1}) under Muskmelon Varietal AVT-II, and 2022/MMHYB-3 (132.5 q ha^{-1}) under Muskmelon Hybrid AVT-II were found promising.

New entries in AICRP (VC) 2025-26

HC-25 in Chilli Varietal and RCBR-935 in Brinjal (Bacterial wilt) were accepted for IET during 2025-26.

Mushroom collection and identification of wild mushroom germplasm

Surveys were conducted in the forest areas and local markets of Ranchi district of Jharkhand during 2025. Twelve wild edible germplasm were collected, identified, and preserved (Fig. 8.10 & Table 8.4).

Evaluation of oyster and milky mushroom strains on wheat straw

An experiment was conducted during December 2024 to May 2025 to evaluate high-yielding strains of oyster mushroom (*Pleurotus spp.*) and milky mushroom (*Calocybe indica*) on wheat straw under controlled conditions. Among the five oyster mushroom strains, DMRP-136 recorded the highest yield (65.20 kg per 100 kg dry straw), which was statistically at par with DMRP-392 (65.07 kg) (Fig. 8.11 & Table 8.4). DMRP-136 also exhibited superior performance in terms of

Macrolepiota mastoidea

Agaricus semotus

Termitomyces mammiformis

Termitomyces clypeatus

Amanita caesarea

Amanita chepangiana

Schizophyllum commune *Astraeus hygrometricus* *Amylosporus campbellii*

Fig. 8.10 Strains of mushrooms collected, characterised, and preserved

average fruit body weight (10.72 g) and earliness, requiring the minimum time for first harvest (26.88 days). These traits indicate its higher biological efficiency and faster substrate colonization.

In the case of milky mushroom, strain CIP-24-03 outperformed others with the highest yield (60.40 kg per 100 kg dry straw), maximum fruit body weight (17.56 g), and earliest harvest (8.96 days after casing). The performance of CIP-24-03 was significantly better than CIP-24-02 and comparable with CIP-24-01.

Overall, the results revealed that DMRP-136 and CIP-24-03 were found promising strains for commercial cultivation on wheat straw due to their higher yield potential, larger fruiting bodies, and shorter crop duration. These strains can enhance productivity and profitability for mushroom growers in the region.

Table 8.4 Performance of oyster and milky mushroom strains on wheat straw

Strains	Yield kg/100kg dry straw	Time to first harvest (days)	Average fruit body weight (g)
Oyster mushroom			
DMRP-115	61.97	30.04	9.20
DMRP- 116	63.84	28.24	10.04
DMRP- 136	65.20	26.88	10.72
DMRP- 205	62.40	28.84	9.48
DMRP- 392	65.07	27.24	10.52
CD (0.05)	1.731	0.686	0.376
***Calocybe indica* strains**			
CIP-24-01	57.73	9.80	16.12
CIP-24-02	51.07	10.76	15.08
CIP-24-03	60.40	8.96	17.56
CD (0.05)	2.710	0.460	0.869

DMRP-115 **DMRP-116** **DMRP-136** **DMRP-392**

Fig. 8.11 Promising strains of oyster mushroom

Chapter 9

MEDICINAL & AROMATIC PLANTS

Photo: Medicinal plants-based agroforestry model at Ranchi

Need-based development of multipurpose trees and medicinal plants-based agroforestry models

The study was undertaken to develop need-based agroforestry models for the Eastern Plateau and Hill Region, with a focus on identifying suitable medicinal plant species for degraded lands under rainfed conditions. Since such lands often face poor soil fertility, limited moisture availability, and low productivity, the integration of medicinal plants with multipurpose tree species was explored as a practical approach for improving land use efficiency and generating additional income opportunities.

Initially, 23 medicinal plant species were screened for their adaptability, survival, growth, and yield performance under field conditions. Based on their overall performance, four promising medicinal species-Hadjor (Cissus quadrangularis), Shatavari (Asparagus racemosus), Giloe (Tinospora cordifolia), and Sarpgandha (Rauvolfia serpentina)-were selected for integration into multipurpose tree-based agroforestry systems.

Among the tested models, the Teak (Tectona grandis) + Karanj (Pongamia pinnata)-based agroforestry system was found to be the most successful, based on the overall yield and performance of the system. The dry biomass-based economic yield was recorded as 175.10 kg ha^{-1} for Hadjor, 1,273.35 kg ha^{-1} for Shatavari, 259.20 kg ha^{-1} for Giloe, and 287.85 kg ha^{-1} for Sarpgandha. Shatavari recorded the highest productivity among the medicinal components, showing its strong potential for inclusion in need-based agroforestry models on degraded rainfed lands. The findings indicate that medicinal plants can be effectively integrated with multipurpose tree species to improve the productivity and economic value of degraded lands. Such models may provide a sustainable option for rainfed areas by supporting soil conservation, resource use efficiency, and livelihood improvement.

Table 9.1 Performance of tree component under agroforestry system (TEAK + KARANJ)

TEAK					
Volume (m^3)	Above ground biomass (tonnes ha^{-1})	Below ground biomass (tonnes ha^{-1})	Carbon stock (tonnes ha^{-1})	Carbon sequestered (tonnes ha^{-1})	Carbon sequestration potential (tonnes ha^{-1} yr^{-1})
0.06	3.75	1.05	2.26	8.29	0.92
KARANJ					
Volume (m^3)	Above ground biomass (tonnes ha^{-1})	Below ground biomass (tonnes ha^{-1})	Carbon stock (tonnes ha^{-1})	Carbon sequestered (tonnes ha^{-1})	Carbon sequestration potential (tonnes ha^{-1} yr^{-1})
1.48	90.72	25.40	54.57	200.30	22.25

Fig. 9.1 Glimpses of multipurpose trees and medicinal plants-based agroforestry models

Chapter 10

CONSERVATION AGRICULTURE & NATURAL FARMING

Photo: Long-term Natural Farming trial at ICAR RCER

Impacts of long-term CA on productivity of rice-based system under irrigated agroecosystem

A long-term field experiment has been undertaken in Cereal Systems Initiative for South Asia (CSISA) Project Phase-I since 2009 (*rabi*) on CA-based-cum-best management practices (BMPs) of rice-wheat systems at ICAR-RCER, Patna. After seven years of experimentation, ZTDSR-ZT mustard-ZT maize system in CA-based system faced a severe problem of rice mealy bug, hence, this field was divided into four equal plots (ZTDSR, CTDSR, PTR, UPTR). After 2 years of CT, these plots were again converted into ZTDSR.

Table10.1. Rice yield as influenced by different tillage-cum-crop-establishment methods under long-term CA system in irrigated agro-ecosystem (Mean)

Crop scenario	Crop establishment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Residue load (t ha^{-1})	Root biomass (t ha^{-1})	Total biomass (t ha^{-1})
S1: TPR-CTW-Fallow	Random transp.	5.56	8.51	-	1.22	15.29
S2: CTMTR-ZTW-ZTM	Machine transp.	5.68	8.13	2.24	1.42	17.47
S3: ZTDSR-ZTW-ZTM	Zero-till/ZT	4.71	5.95	2.35	1.56	14.57
S4: ZTDSR-ZTMu-ZTMa	Zero-till/ZT	4.45	6.27	2.08	1.37	14.17

* TPR-Transplanted rice; CTW-conventional tillage wheat; CTMTR-conventional tillage machine transplanted rice; ZTW- zero-till wheat; ZTM-zero-till mung bean; ZTDSR- zero-till direct-seeded rice; ZTMu- zero-till mustard; ZTMa- zero-till maize

After 16th year of experimentation, maximum rice yield was recorded with CTMTR (5.68 t ha^{-1}) which was at par with TPR (6.56 t ha^{-1}) (Table 10.1). Similar trends were observed in case of total biomass production also. The lowest rice yield was recorded in ZTDSR production system (4.45 t ha^{-1}).

Weed seed bank dynamics, resource-use efficiency and greenhouse gas footprint under diverse tillage production systems

Conservation agriculture (CA) can improve productivity and environmental sustainability of rice-based systems in EIGP, though weed interference remains a major constraint (Table 10.2). A three-year field experiment (2021-2024) at ICAR RCER, Patna, evaluated tillage and crop establishment practices integrated with herbicide-based weed management in a rice–wheat–greengram system. In rice, pre-emergence pyrazosulfuron-ethyl (25 g ha^{-1}) followed by post-emergence cyhalofop-butyl + penoxsulam (100 + 25 g ha^{-1}) at 20 DAS achieved 89.4% weed control efficiency and 91.8% weed control index. In wheat, clodinafop-propargyl + metsulfuron-methyl (60 + 5 g ha^{-1}) at 25 DAS recorded a 93.2% weed control index, while in greengram, pendimethalin (1000 g ha^{-1}) followed by imazethapyr (100 g ha^{-1}) resulted in 78.1% weed control efficiency. The CA-based zero-till direct-seeded rice–zero-till wheat–zero-till greengram (ZTDSR–ZTW–ZTG) system produced 5.9% higher rice grain equivalent yield than conventional systems (Table 10.2). It increased SOC by 35.9%, 15.7%, and 26.7% in 0–7.5, 7.5–15, and 15–30 cm layers, improved soil moisture, and moderated temperature (Fig. 10.1). Methane emissions and global warming potential were reduced by 33.5%. Economically, ZTDSR–ZTW–ZTG

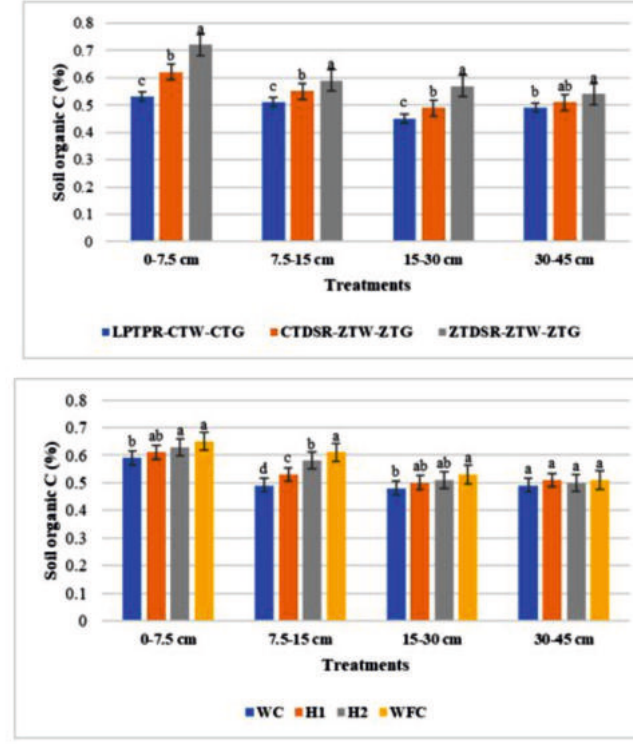


Fig. 10.1 Soil organic carbon in different soil depths (0-7.5 cm, 7.5-15 cm, 15-30 cm and 30-45 cm) across treatments in rice-wheat-greengram system

Table10.2 Effect of tillage and weed management practices on crop yields and system productivity in rice-wheat-greengram system

Treatments	Grain yield (t ha^{-1})			System productivity (Rice grain equivalent yield) (t ha^{-1})
	Rice	Wheat	Greengram	
Tillage practices*				
LPTPR-CTW-CTG	6.14^{a}	4.33^{c}	0.85^{c}	13.81^{b}
CTDSR-ZTW-ZTG	5.03^{c}	4.83a	0.95^{b}	13.59^{b}
ZTDSR-ZTW-ZTG	5.37^{b}	5.12a	1.05^{a}	14.62^{a}
Weed management practices				
WC	2.25^{c}	3.27^{c}	0.45^{d}	7.31^{d}
H1	6.17^{b}	4.96^{b}	0.98^{c}	14.99^{c}
H2	6.73^{a}	5.35^{a}	1.14^{b}	16.56^{b}
WFC	6.91^{a}	5.47^{a}	1.22^{a}	17.16^{a}

* Treatments described in Table [LPTPR: Line puddled transplanted rice; CTW: Conventional-till wheat; CTG: Conventional-till greengram; CTDSR: Conventional-till direct seeded rice; ZTW: Zero-till wheat; ZTG: Zero-till greengram; ZTDSR: Zero-till direct seeded rice; WC: Weedy check; H1: Application of Pyrazosulfuron-ethyl + bispyribac-sodium in rice *followed by* application of sulfosulfuron+ metsulfuron methyl in wheat *followed by* application of pendimethalin in greengram; H2: Application of pyrazosulfuron-ethyl + cyhalofop-butyl + penoxsulam in rice *followed by* application of clodinafop-propargyl + metsulfuron methyl in wheat *followed by* application of pendimethalin + imazethapyr in greengram; WFC: Weed free check]; Mean values followed by different lower-case letters within a column are significantly different at $P \leq 0.05$.

generated 8.8–15.2% higher net returns. CA with residue retention and targeted herbicides reduced weeds, increased carbon sequestration, and sustained productivity in the EIGP.

Evaluation of rice and wheat genotypes under natural farming

The experiment aimed to identify rice and wheat genotypes suitable for natural farming systems. During *kharif* 2025, sixty rice genotypes, including advanced breeding lines and high-yielding varieties, were evaluated under natural farming conditions. The mean grain yield was 3.47 t ha^{-1}, with a range of 2.37 to 4.49 t ha^{-1}. Among rice genotypes, IR 102860-10:6-B-B (4.49 t ha^{-1}), Swarna Purvi Dhan 2 (4.37 t ha^{-1}), Swarna Shreya (4.14 t ha^{-1}), IR 14 L362 (4.094 t ha^{-1}), IR 97069-1-1-1-1 (4.02 t ha^{-1}), IR 14L157 (3.97 t ha^{-1}), IR17L1060 (3.97 t ha^{-1}), IR98976-20-1-2-2 (3.88 t ha^{-1}), IR18R1123 (3.87 t ha^{-1}), Swarna Shusk Dhan (3.83 t ha^{-1}), IR16L1499 (3.83 t ha^{-1}), Swarna Shakti Dhan (3.83 t ha^{-1}), IR 95781-15-1-1-4 (3.82 t ha^{-1}), and Swarna Unnat Dhan (3.76 t ha^{-1}) have been found promising for natural farming condition. Under wheat trial, 27 wheat genotypes were evaluated under natural farming condition during 2024-2025. The mean grain yield recorded was 2.504 t ha^{-1} with the range being 1.827-3.128 t ha^{-1}. Among wheat genotypes, HD 3407 (3.128 t ha^{-1}), HD 2967 (3.127 t ha^{-1}), DBW 187 (3.111 t ha^{-1}), HD 2046 (3.00 t ha^{-1}), HD 3086 (2.986 t ha^{-1}), PBW 826 (2.918 t ha^{-1}), HD 3118 (2.758 t ha^{-1}), HD 3226 (2.701 t ha^{-1}), and DBW 222 (2.59 t ha^{-1}) have been identified as promising under natural farming conditions.

Characterization and appraisal of soil microbiome under conservation agriculture

Characterization and appraisal of the soil microbiome under conservation agriculture (CA) are vital for understanding how sustainable practices affect soil health and ecosystem services. Across tillage systems, high sequencing quality and classification efficiency indicated reliable microbiome assessment. The conventional tillage system (LPTPR–CTW–CTG) showed high read classification (~99.6-99.9%) and strong bacterial dominance (~95-97%). Slightly higher

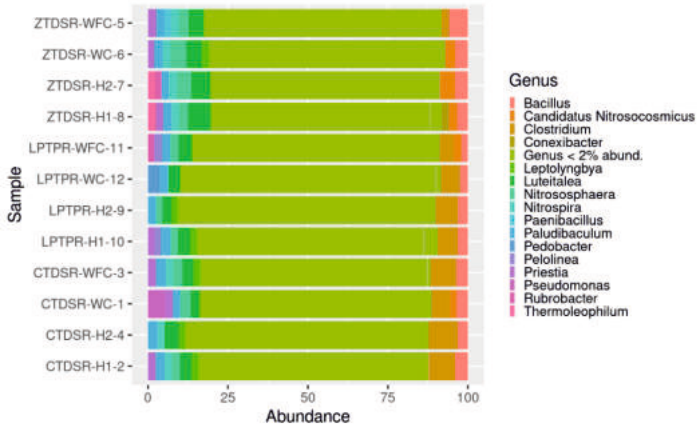


Fig. 10.2 Genus level identified bacterial microbes across tillage practices [LPTPR: Line puddled transplanted rice; CTW: Conventional-till wheat; CTG: Conventional-till greengram; CTDSR: Conventional-till direct seeded rice; ZTW: Zero-till wheat; ZTG: Zero -till greengram; ZTDSR: Zero-till direct seeded rice]

unclassified fractions in some samples indicated moderate community complexity. The conservation-based CTDSR-ZTW-ZTG system recorded nearly complete classification (~100%) with similar bacterial dominance and negligible fungal presence, suggesting a stable, bacteria-driven microbiome (Fig. 10.2). The CA-based ZTDSR-ZTW-ZTG system also maintained high classification efficiency (~99.5-100%), with bacterial abundance ranging from 92-96%. Some samples showed lower bacterial proportions, reflecting relatively higher microbial heterogeneity. Overall, conservation tillage systems positively influenced microbial community structure compared to conventional tillage. Both CA systems supported diverse and well-classified microbial communities with clear diversity patterns. ZTDSR-ZTW-ZTG, in particular, demonstrated greater variability in composition, indicating enhanced heterogeneity. Alpha and beta diversity analyses confirmed differences among systems. CA practices demonstrated greater effectiveness in maintaining diverse, stable, and functionally relevant soil microbial communities, thereby enhancing soil biological quality and supporting long-term agroecosystem sustainability under conservation agriculture systems.

Studies on efficacy of natural farming and its comparison with existing farming systems

The rice–wheat–greengram cropping system was evaluated under different cultivation practices, *viz.*, natural farming, organic farming, integrated nutrient management (INM), and conventional practices, to assess the efficacy of natural farming in comparison with other systems. Farming practices showed significant differences in the yield of all crops, *i.e.*, rice, wheat, and greengram. Rice yield was significantly higher under INM (5.50 t ha^{-1}), followed by the conventional system (5.10 t ha^{-1}), while lower yields were recorded under organic farming (4.60 t ha^{-1}) and natural farming (4.33 t ha^{-1}). Wheat and gram were intercropped under natural and organic farming, whereas wheat was grown as a sole crop under conventional and INM practices. Wheat yield under organic (2.07 t ha^{-1}) and natural farming (2.03 t ha^{-1}) was at par but lower than that under INM (4.52 t ha^{-1}) and conventional practices (4.35 t ha^{-1}). Greengram performed better under natural farming (0.95 t ha^{-1}),

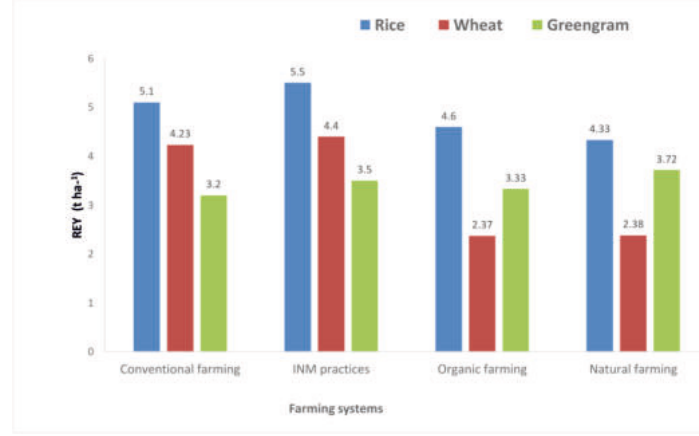


Fig. 10.3 Rice equivalent yield of R-W-GG under different farming practices

producing 14.5% higher yield than conventional farming (0.83 t ha^{-1}). Based on rice equivalent yield (REY), system productivity was highest under INM (13.40 t ha^{-1}), followed by conventional (12.57 t ha^{-1}), natural farming (10.43 t ha^{-1}), and organic farming (10.35 t ha^{-1}) (Fig. 10.3). After three crop cycles, available nitrogen decreased under all farming practices, while soil organic carbon was higher under organic farming (0.63%) followed by natural farming (0.61%).

Natural farming model farm

The institute's one-acre Natural Farming Model Farm has been designed as a diversified, integrated production system demonstrating low-input, ecologically resilient agriculture. Field crops occupied 1,520 m^2 under strip and row intercropping. Chickpea

and wheat were cultivated in 2 m and 1 m alternating strips (800 m²), while lentil was grown in a 3:2 row ratio with mustard (720 m²) to enhance biodiversity, nutrient use efficiency, and risk buffering. A 500 m² vegetable block was systematically divided into six equal plots (81.25 m² each) for tomato, cabbage, broccoli, cauliflower, palak, and methi, ensuring seasonal continuity and crop rotation. Berseem fodder was raised in 250 m² to support livestock integration. An 800 m² fruit block had been developed using raised (2 m) and sunken (2.75 m) bed systems to address seasonal waterlogging. Four raised beds each 40 m in length were made to accommodate two rows each of guava and banana, ensuring efficient drainage and optimal root growth. Pigeonpea was planted along the entire boundary in two rows on a 1.0 m bund, serving as a biological fence and nitrogen source. Additionally, 200 m² was earmarked for a plant cafeteria and approximately 180 m² for an animal shed with paddock, strengthening crop-livestock integration and promoting a holistic natural farming model (Fig. 10.4). Three farmers have also been selected at Patna, Buxar and Ramgarh for developing natural farming model farm at farmers' fields.

Evaluation of natural farming in Eastern plateau and hill region

A field experiment was conducted to evaluate Natural Farming (NF) across major cropping systems of the Eastern Plateau and Hill Region in comparison with Conventional Farming (CF). The study was laid out in a split-plot design with four replications, comprising 32 plots (20 m² each). The cropping systems evaluated included paddy–lentil, black gram–niger, finger millet–mustard, and cowpea–chickpea using indigenous varieties.

Results revealed that NF improved soil health parameters over CF. Soil pH and EC did not differ significantly across treatments; however, soil organic carbon (SOC) was significantly higher under NF (0.80%) compared to CF (0.73%). Biological properties such as dehydrogenase activity (DHA: 142.1 µg TPF (g^{-1} day^{-1}) and soil microbial biomass carbon (SMBC: 281.5 µg g^{-1}) were also higher under NF, indicating enhanced microbial activity. Conversely, available nitrogen was higher under CF due to external fertilizer inputs (Table 10.3).

Cropping system productivity varied across systems. In *kharif*, paddy–lentil and black gram–niger performed better under CF, whereas finger millet–mustard (36.60 q ha^{-1}) and cowpea–chickpea (53.00 q ha^{-1}) performed better under NF. In *rabi*, NF recorded higher productivity in paddy–lentil (14.40 q ha^{-1}) and cowpea–chickpea (24.70 q ha^{-1}). Overall system productivity was higher under NF for paddy-lentil (29.52 q ha^{-1}), finger millet-mustard (52.92 q ha^{-1}), and cowpea–chickpea (77.73 q ha^{-1}), while black gram–niger performed better under CF (Table 10.4).

Microbial population was significantly enhanced under NF, particularly in cowpea-chickpea, with higher bacterial, fungal, and actinomycetes populations. Long-term results indicated that NF increased SOC and SMBC by 9.58% and 8.31%, respectively, while bacterial population increased by 80.43%. In legume-based systems, Natural Farming enhanced soil biological health and sustained the productivity.

Fig. 10.4 Natural farming experiment at ICAR Patna

Table 10.3 Soil chemical & biological properties under natural and conventional farming (2024-25)

Treatments	Soil pH			Soil EC (dS m^{-1})			SOC (%)			Available N (Kg ha^{-1})			DHA (µg TPF g^{-1} d^{-1})			SMBC (µg g^{-1})		
	NF	CF	Mean	NF	CF	Mean	NF	CF	Mean	NF	CF	Mean	NF	CF	Mean	NF	CF	Mean
Black gram-Niger	5.29	5.03	5.16	0.66	0.63	0.65	0.80	0.75	0.77	126.1	181.3	153.7	145.8	140.2	143.0	219.5	266.5	243.0
Paddy-Lentil	5.15	5.10	5.12	0.75	0.68	0.72	0.78	0.70	0.74	117.6	172.6	145.1	136.8	134.2	135.5	306.3	254.0	280.1
Cow Pea-Chick pea	5.24	5.50	5.37	0.73	0.72	0.72	0.84	0.77	0.81	133.8	183.6	158.7	147.1	144.8	145.9	354.1	303.5	328.8
Finger Millet-Mustard	5.15	5.01	5.08	0.71	0.77	0.74	0.77	0.71	0.74	123.2	168.0	145.6	138.8	132.9	135.8	246.1	215.5	230.8
Mean	5.21	5.16		0.82	0.70	0.76	0.80	0.73		125.2	176.3		142.1	138.0		281.5	259.9	
	F	C	F × C	F	C	F × C	F	C	F × C	F	C	F x C	F	C	F × C	F	C	F × C
LSD(P≤0.05)	NS	NS	NS	NS	NS	NS	0.03	NS	NS	7.62	10.78	15.25	NS	8.5	NS	21.2	30	42.4

* Interaction (F × C): Non-significant

Table 10.4 Productivity and efficiency of cropping systems in natural and conventional farming (2024-25)

Treatments	*Kharif* REY (q ha^{-1})		*Rabi* REY (q ha^{-1})		Cropping system productivity (q ha^{-1})		Land use efficiency (%)		*Kharif* system production efficiency (kg ha^{-1} day^{-1})		*Rabi* system Production Efficiency (kg ha^{-1} day^{-1})		Cropping system production efficiency (kg ha^{-1} day^{-1})	
	NF	CF	NF	CF	NF	CF	NF	CF	NF	CF	NF	CF	NF	CF
Black gram-Niger	15.10	19.50	14.40	9.30	29.52	28.78	63.00	60.30	0.80	0.75	145.8	140.2	12.80	13.10
Paddy-Lentil	17.90	18.50	12.60	16.00	30.61	34.58	55.30	56.20	0.78	0.70	136.8	134.2	15.20	16.90
Cowpea-Chickpea	36.60	30.00	15.60	22.30	52.92	52.38	63.00	57.50	0.84	0.77	147.1	144.8	23.00	24.90
Finger Millet-Mustard	53.00	49.90	24.70	23.50	77.73	73.43	63.30	57.70	0.77	0.71	138.8	132.9	33.80	35.00
Mean	30.70	29.50	16.80	17.80	47.69	47.29	61.10	57.90	0.80	0.73	142.1	138.0	21.20	22.50
	F	C	F	C	F	C	F	C	F	C	F	C	F	C
LSD (p ≤ 0.05)	NS	4.60	NS	4.10	NS	7.10	NS	NS	0.03	NS	NS	8.5	NS	3.20

* Interaction (F × C): Non-significant

Chapter 11

FARMING SYSTEM RESEARCH

Photo: IFS model at ICAR RCER, Patna

Development of vegetable based Integrated Farming System

A vegetable based Integrated Farming System (IFS) comprising of rice (*kharif*), vegetables, goat (20 nos.), year round mushroom (Oct-March: Oyster/button mushroom; April- Sept: Milky/straw mushroom), poultry (200 nos. X 7 cycles), Horticulture (Fig. 11.1) (Guava and Lemon: 900 m^2) has been established at ICAR RCER, Patna in one-acre area (Fig. 11.1) in which the major cropping systems were 1. Rice- Cauliflower-

Fig. 11.1 Vegetable based Integrated Farming System at ICAR RCER, Patna

Cowpea 2. Rice- Tomato- Red spinach 3. Rice- Potato-Onion were followed. In 1000 m^2, raised and sunken beds were made on which rice was grown in the sunken beds and soybean crop on the raised beds during *kharif* season while in *rabi* maize was grown in sunken beds and broccoli, peas and cauliflower were grown on raised beds. All the farm wastes were recycled within the system due to which about 27 % of chemical fertilizers were saved and cost of production was curtailed by 23 %. An area of 700 m^2 was also kept for fodder raising in which M P Chari-Berseem-cowpea and Cowpea-maize-oat system were followed to meet the green fodder demand of the goats. Component wise area and income is given in Table 11.1. Due to waste recycling within the system, the organic carbon of the soil enhanced by 13-27 % in different cropping systems. Output/Input energy ratio of the developed model was found to be 3.2 and in terms of GHG emission the model was found negative in terms of Kg CO_2 eq.

Table 11.1 Net returns of vegetable based Integrated Farming System

Component	Area (ha)/ No.	Net returns
Field crop	0.1 ha	10,435
Vegetable crops	0.1 ha	35,200
Hort. block	0.09 ha	18,500
Poultry	1400 No.	26,800
Mushroom	0.02 ha	12,300
Goat	20 + 2 No.	30,770
Composting unit	0.01 ha	8,540
Nutri-cum-kitchen garden	0.02 ha	9,990
Boundary plantation	0.04 ha	3,750
Total		1,56,285

Optimization of IFS model design

A resource survey and data collection were conducted in two villages, *viz.*, Raisa and Rajanbigha, for the already developed IFS model. The major components of the IFS model in both villages include crops, horticulture, livestock (2+2), and fish. Optimization for maximum profit was carried out for the 2-acre IFS model in Raisa and Rajanbigha villages using Python software (PuLP algorithm) in the Anaconda Spyder environment. The optimization model can be applied to different combinations of IFS components according to farmers' needs. In Raisa village, the gross income of the farmer before optimization was ₹331,360, which

Table 11.2 Gross income before and after optimizatio of land allocation of Sri Dhananjay Kumar, Raisa, Mahakar, Panchayat, Chandi, Nalanda (2 acre IFS model)

Components/ Enterprises	Area (acre)	Income (Rs.)	Optimized area (acre)	Optimized income (Rs.)
Cereal+Fodder	1.5	87500	1.0	58330
Horticulture+B.P.*	0.25	70540	0.50	132410
Livestock (Buffalow & calf 2+2)	0.02	115450	0.02	115450
Fish	0.23	57870	0.48	112980
Total	2.0	331360	2.0	419170

increased to ₹419,170 after land area optimization, resulting in an increase of ₹87,810 (26.5%) (Table 11.2). Similarly, in Rajanbigha village, the gross income increased from ₹315,970 to ₹413,450 after optimization,

Table 11.3 Gross income before and after optimization of land allocation of Sri Anil Kumar Sinha, Rajanbigha, Chandi, Nalanda (2-acre of IFS model)

Components/ Enterprises	Area (Acre)	Gross income (Rs.)	Optimized area (acre)	Optimized gross income (Rs.)
Cereal+fodder	1.5	91750	1.0	61160
Horticulture+B.P.	0.25	66850	0.56	149740
Livestock (Cow & calf 2+2)	0.02	102670	0.02	102670
Fish	0.23	54700	0.42	99880
Total	2.0	315970	2.0	413450

* B.P.: Boundary Plantation

GHG emission and carbon sequestration of One-Acre rainfed IFS model

Greenhouse gas (GHG) emissions from various enterprises of the IFS model were quantified using data of daily farm activities, resource use patterns, and standard emission coefficients, and were compared with the system's carbon sequestration potential (Table 11.4). The total GHG emission from all components of the IFS model was estimated at 4,480.31 kg CO_2-eq.

Table 11.4 GHG emissions and Carbon Sequestration in One-Acre rainfed IFS model

Carbon Sources	Enterprises	CO_2-eq.(kg)
Carbon sink	Field crops	611.37
	Vegetable crops	61.96
	Fruit crops	259.82
	Fodder crops	26.96
	Livestock (cattle)	3520.20

Among the different enterprises, livestock (cattles) contributed the highest share (78.57%), followed by field crops (13.65%), fruit crops (5.80%), vegetable crops (1.38%), and fodder crops (0.60%). The high contribution from livestock was mainly due to enteric methane emissions and manure management practices, which are influenced by feed quality, intake levels, and animal physiology. Crop-based enterprises recorded comparatively lower emissions, reflecting better management practices and lower emission intensity; however, field crops contributed a notable share due to their larger cultivated area and associated agronomic operations.

The IFS model demonstrated considerable carbon sequestration potential, estimated at 6,710.63 kg CO_2-eq., primarily through biomass incorporation and agroforestry interventions such as boundary plantations of *Melia azedarach*. Organic inputs, including farmyard manure, vermicompost, and crop residues, contributed the largest share (6,350.64 kg CO_2-eq.), while agroforestry systems accounted for 359.99 kg CO_2-eq. (Fig. 11.2).The overall net GHG balance of the system was –2,230.31 kg CO_2-eq., indicating that the IFS model functions as a net carbon sink.

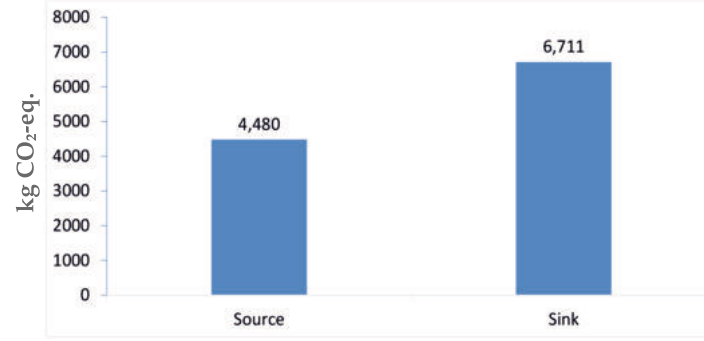


Fig 11.2 GHG emissions and balance in rainfed IFS

Micro (250 m^2) and Nano (125 m^2) homestead farming model for peri-urban and marginal farmers

ICAR RCER, Patna, has designed an integrated framework for small land units as Micro model (2 *Katha* ~ 250 m^2) and Nano model (1 *Katha* ~ 125 m^2). The model integrates horticulture, nutrigarden, fodder production, backyard poultry and goat components, and mushroom cultivation in view of organic waste recycling. Such integrated homestead systems are widely recognized for improving household dietary diversity, input recycling and resilience in smallholder agriculture. Micro unit produced 283 kg napier fodder along with red amaranth (17.2 kg), tomato (2.0 kg), okra (3.621 kg), onion (6.6 kg), *simba* (25.755 kg), *nenua* (18.07 kg), spinach (10.83 kg), brinjal (17.30 kg), *lauki* (15.1 kg), mint (6.02 kg), cabbage (11.5 kg), broccoli (8.0 kg), cauliflower (7.74 kg), mushroom (9.77 kg) and papaya (4.70 kg) (Fig. 11.3). Crop-wise comparison highlights higher biomass production and wider crop diversity in the micro model (Fig. 11.4). Similarly, nano

unit produced 283 kg napier fodder along with *boro* (10.2 kg), *lauki* (18.48 kg), *nenua* (19.01 kg), okra (9.5 kg),

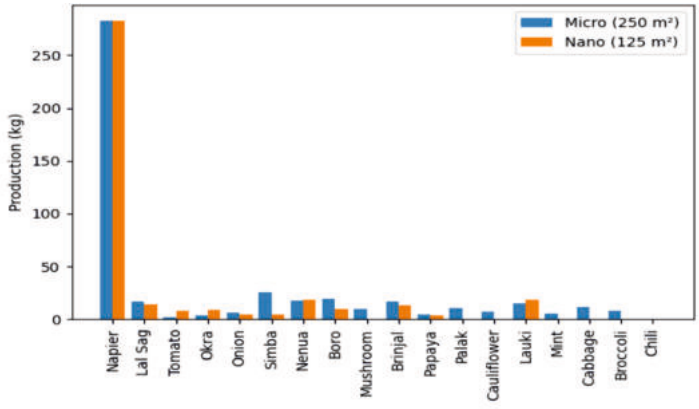


Fig. 11.3 Crop-wise production comparison between micro and nano homestead models

tomato (7.96 kg), brinjal (13.13 kg), onion (5.1 kg), red amaranth (14.72 kg), *simba* (5.1 kg), papaya (4.2 kg) and chilli (0.26 kg). When productivity was expressed per

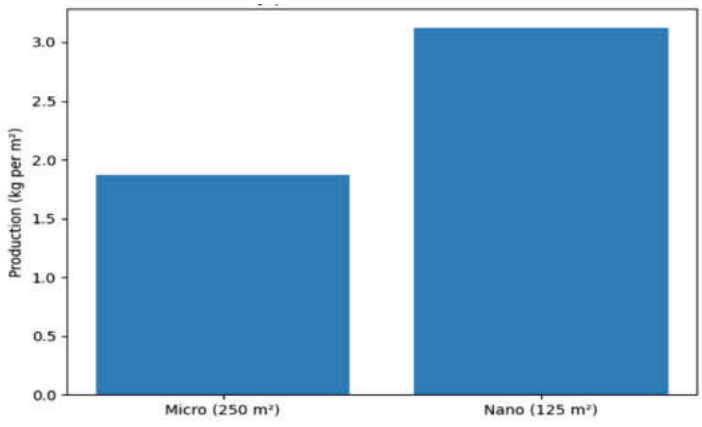


Fig. 11.4 Productivity per unit area (kg m^{-2}) of micro and nano homestead models

unit area, the nano model exhibited higher land-use efficiency compared to the micro unit (Fig. 11.4), indicating efficient resource utilization under land-constrained conditions. Micro and Nano unit generated annual net income of Rs. 45,466 and Rs. 19,150, respectively.

Development of sustainable agroforestry models for seasonally water-stressed agro-ecosystem of Bihar

An agroforestry model was established in July 2024 over a one-hectare area to restore and enhance the efficient utilization of natural resources in waterlogged areas by planting 288 trees at 8 m × 4 m spacing. Four tree species, *viz.*, Arjun, Mahogany, Kadamb, and Jamun, were integrated with a Rice-Lentil-Moong cropping sequence. The experiment was laid out in a randomized block design with three replications, comprising sole tree plantations, sole cropping, and intercropping systems. By the second year, all species exhibited good growth under both agroforestry and sole plantation systems, with slightly better performance under agroforestry. Kadamb recorded the highest mean height (4.2 m) and collar diameter (9.6 cm), followed by Arjun (3.8 m; 8.2 cm), Mahogany (3.6 m; 7.8 cm), and Jamun (3.2 m; 5.2 cm). Survival ranged from 92-96%, indicating successful establishment under water-stressed conditions. Above-ground biomass and carbon sequestration were highest in Kadamb (1.13 t ha^{-1} and 0.47 t ha^{-1}) and lowest in Jamun (0.45 t ha^{-1} and 0.17 t ha^{-1}). Lentil (0.88-0.93 t ha^{-1}) and moong (0.77-0.82 t ha^{-1}) yields under agroforestry remained comparable (within 5-8%) to sole cropping. Soil properties up to 100 cm depth showed no significant changes in physico-chemical parameters at this stage. Overall, the system demonstrated promising tree-crop compatibility without any adverse effect on crop yield.

Development of spineless cactus and MPTs-based silvi-pastoral system

The study focused on the development of a spineless cactus and MPTs-based silvi-pastoral system by evaluating the performance of perennial fodder species, including spineless cactus *(Opuntia ficus-indica)*, guinea grass, and Hybrid Napier, under Teak + Karanj and Mahogany + Karanj systems in rainfed conditions. Initial results indicated that guinea grass and Hybrid Napier achieved zero percent mortality, whereas spineless cactus faced significant losses, i.e., about 16.87% in the Teak + Karanj system and 49.74% in the Mahogany + Karanj system, due to heavy post-planting rainfall. Yield performance varied significantly, with Hybrid Napier yielding 117 t ha^{-1} under control conditions, while guinea grass reached 79 t ha^{-1}. Spineless cactus produced lower yields, ranging from 2.51 ± 0.14 t ha^{-1} in the Mahogany + Karanj system to 4.61 ± 0.07 t ha^{-1} under control conditions. Soil analysis revealed that the Teak + Karanj system maintained a higher pH (5.47 ± 0.2) compared to the Mahogany + Karanj system (4.53 ± 0.06). Initial observations from the two systems showed that Karanj clearly outperformed both Teak and Mahogany in biomass production and carbon sequestration. In the Teak + Karanj system, Karanj stored 18.95 t ha^{-1} yr^{-1} compared to Teak with 0.35 t ha^{-1} yr^{-1}, and it also performed strongly in the Mahogany + Karanj system with 16.92 t ha^{-1} yr^{-1}.

Chapter 12

CROP DIVERSIFICATION

Photo: Crop diversification at ICAR RCER, Patna

Diversification of rice through alternate crops

A pilot project on crop diversification is being implemented in the East and West Champaran districts of Bihar for enhancing agricultural productivity, promoting sustainable agriculture, and improving livelihoods in the region. West Champaran was selected for the first phase (2023-24) and East Champaran in the second phase of the programme (2025-26), covering a total area of 200 hectares during the *kharif* season of 2025. The project showcased a transformative impact compared to benchmark data, particularly in terms of productivity, resource efficiency, and income enhancement. Traditional rice crop was replaced with the alternate crops like maize (Shaktiman-5), soybean (P-1241), pigeon pea (IPA-203), and finger millet (Rajendra Madua-1) in West Champaran district, while in the East Champaran district rice crop was replaced with maize (Bio 9544), bajra (FBC-16), ragi (RAU-8) and pigeon pea (IPA-203). The details of the diversified crops and output are presented in Table 12.1.

Diversified crops resulted in water savings up to 35-60%, an increase in net income up to 116%, and a 46.0% increase in production compared to the traditional rice crops. An impact assessment study (Fig. 12.1) was also conducted in West Champaran district and it was found that an average area of maize and pigeon pea had increased by 37% and 26% in the target villages, while farmers of the targeted area did not show any interest to grow ragi, bajra and soybean crops.

Table 12.1 Production and economics of diversified cropping system

Kharif 2025		Baikunthawa	Rulhi	Senuw-ariya	Dubauli-ya	
Name of crop	**Rice**	**Maize, finger millet, soybean and Pigeon pea**	**Maize, finger millet, soybean and Pigeon pea**	**Maize and finger millet**	**Maize and soybean**	**Total**
Total area covered (ha)	100	48	33	14	5	100
Total number of farmers involved	10	38	31	16	5	90
Marginal farmers	-	10	10	5	2	27
Small farmers	-	20	15	8	2	45
Other farmers	10	8	6	3	1	18
Total production (kg)	380000	273600	176880	75600	28650	554730
Total Water used (m^3)	240000	59198	40699	25200	8500	133597
Total Net income (Rs)	3030000	3334944	1908555	919562	380125	6543186
B:C ratio	1.61	2.06	2.38	2.38	2.72	2.33
					Percent increase in production	46.0
					Percent increase in income	116

Table 12.2 Percentage change in crop area from 2024 to 2025

Crops	Crop area (2024)	Crop area (2025)	% change
Maize	57 ha	75 ha	+ 31.6
Pigeon pea	15 ha	19 ha	+ 26.7
Soyabean	12 ha	8 ha	- 33.3
Ragi	16 ha	12 ha	- 25.0
Rice	100 ha	86 ha	- 14.0

Additional land was also brought under maize and pigeon pea cultivation, while the area under rice decreased by 14% in the targeted villages (Table 12.2).

Standardization of agro-techniques for enhancing nutri-cereals productivity

A long-term field experiment was initiated during *kharif* 2020 at ICAR RCER, Patna with an objective to design the most productive, profitable, sustainable climate resilient cropping system for Indo-Gangetic Plains. Altogether seven nutri-cereals including jowar and bajra as major nutri-cereals and five minor nutri-cereals ragi, barnyard millet, foxtail millet, proso-millet and kodo-millet were evaluated under three different planting. Planting window up to 15 July resulted in higher crop productivity. Among nutri-cereals, jowar (3.43 t ha^{-1}) and bajra (2.89 t ha^{-1}) as major and barnyard millets (2.06 t ha^{-1}), ragi (1.93 t ha^{-1}) and kodo-millet (2.05 t ha^{-1}) as minor nutri-cereals were identified as most productive. Based on the local preferences, bajra (Progro-9001), ragi (RAU-8) and barnyard (DHBM-93-2) have been identified as potential crops/cultivars.

Among weed management, two hand weeding (25 and 45 DAS) had higher yields of bajra (3.08 t ha^{-1}), ragi (2.29 t ha^{-1}) and barnyard millet (1.61 t ha^{-1}) being at par with atrazine @0.5 kg ha^{-1} (PE) followed by one hand weeding (30 DAS). Among the nutrient management, application of 100% RDN recorded significantly higher yields of bajra (2.83 t ha^{-1}), ragi (2.25 t ha^{-1}) and barnyard millet (1.54 t ha^{-1}) being at par with 75% RDN (IN) and 25% RDN (FYM). During $5^{th}/6^{th}$ years, most resilient and productive nutri-cereal systems were bajra-chickpea (7.58 t ha^{-1}) and Ragi-Chickpea (8.31 t ha^{-1}) (Table 12.3).

(a)

(b)

(c)

(d)

Fig. 12.1 Alternate crops grown in rice-based production systems. (a) Maize (b) Ragi (c) Pigeonpea-soybean intercropping and (d) Maize-pigeon pea intercropping

Table 12.3 Performance of millet-based cropping systems under rainfed condition

Cropping systems	*Kharif* crops yield (t ha^{-1})	*Rabi* crops yields (t ha^{-1})	REY WC (t ha^{-1})	SBEY (t ha^{-1})	KREY (t ha^{-1})	WCREY (t ha^{-1})	SREY (t ha^{-1})	SPE (kg ha^{-1} d^{-1})	LUE (%)
Bajra-based cropping systems									
Bajra-Lentil	2.66	1.30	3.18	5.84	3.04	3.63	6.67	18.3	52.3
Bajra-Chickpea	2.79	1.86	3.85	6.64	3.18	4.40	7.58	20.8	64.9
Bajra-Safflower	2.58	0.89	1.97	4.55	2.94	2.24	5.19	14.2	68.2
Bajra-Mustard	2.49	1.29	2.78	5.27	2.84	3.17	6.01	16.5	65.5
Ragi-based cropping systems									
Ragi-Lentil	1.89	1.55	2.32	4.21	3.53	4.33	7.86	21.5	56.7
Ragi-Chickpea	1.98	1.95	2.47	4.45	3.69	4.61	8.31	22.8	69.6
Ragi-Safflower	1.78	1.15	1.55	3.33	3.32	2.90	6.22	17.0	71.5
Ragi-Mustard	1.71	1.45	1.91	3.62	3.19	3.56	6.75	18.5	69.3

REY: rice equivalent yield; WC: winter crops; SBEY: system bajra equivalent yields; SPE: system production efficiency; LUE: land use efficiency

Chapter 13

CARBON SEQUESTRATION & NUTRIENT DYNAMICS

Photo : Straw mulching in vegetable crop trial

Effect of tillage and crop establishment methods on soil properties in *kharif* rice and finger millet

A field experiment comprising eleven scenarios (SC-1 to SC-11) was conducted to evaluate the effect of tillage and crop establishment methods under rice and millet-based systems (Fig. 13.1). Treatments included conventional tillage (CT), partial conservation agriculture (pCA), and conservation agriculture (CA) with varying fertilizer doses and irrigation levels.

Fig. 13.1 Field view of tillage and crop establishment experiment

After *kharif* harvest, soil pH remained non-significant across treatments (6.10–6.36). However, soil organic carbon (SOC) improved significantly under CA, with the highest value recorded in SC-4 (5.45 g kg^{-1}). Available nitrogen was higher in SC-7 (235.3 kg ha^{-1}), while available phosphorus and potassium were highest in SC-5 (41.0 and 195.5 kg ha^{-1}, respectively). Biological properties also improved significantly under CA treatments.

In terms of productivity, rice yield was highest in SC-2 (4.56 t ha^{-1}) under pCA, followed by SC-4 (4.43 t ha^{-1}) under CA. Conversely, finger millet performed better under conventional tillage, with maximum yield in SC-11 (3.50 t ha^{-1}). Rice equivalent yield in finger millet based systems was higher under CT and pCA systems for millet, while CA enhanced rice productivity (Fig. 13.2 & 13.3). Post-harvest soil analysis improved markedly under CA, as indicated by higher soil microbial biomass carbon (SMBC: 267 µg g^{-1}) and dehydrogenase activity (DHA: 377 µg TPF g^{-1} day^{-1}) in SC-4 (Table 13.1).

Soil properties after mustard harvest showed further improvement in soil health under CA. SOC was the

highest in SC-6 (6.77 g kg^{-1}) at surface soil, while available nitrogen and phosphorus were also superior under CA treatments. Mustard yield was maximum in SC-6 (1.62 t ha^{-1}), while water productivity was higher under reduced irrigation (60-80% ET), indicating efficient water use (Fig. 13.2 & 13.3).

Overall, conservation agriculture practices improved soil health, nutrient availability, and water productivity, while maintaining competitive crop yields, demonstrating their suitability for sustainable intensification.

Table 13.1. Effect of tillage and crop establishment methods on soil properties in kharif crops

Scenario		Soil pH	SOC (g kg^{-1})	Available N (kg ha^{-1})	Available K (kg ha^{-1})	Available P (kg ha^{-1})	SMBC (µg g^{-1})	DHA (ug TPF g^{-1} day^{-1})
SC-1	CT	6.12	4.62	175.5	177.6	33.5	187.7	267.0
SC-2	pCA	6.13	4.66	180.2	181.3	35.5	214.0	304.3
SC-3	pCA	6.36	4.69	190.7	185.0	39.7	189.8	288.3
SC-4	CA	6.26	5.45	223.6	188.2	36.3	267.0	377.0
SC-5	CA	6.10	5.09	220.8	195.5	41.0	197.7	373.5
SC-6	CA	5.98	5.35	219.3	188.0	34.6	248.4	353.2
SC-7	CA	6.17	4.94	235.3	193.1	40.2	198.1	335.7
SC-8	CA_m	6.20	5.15	177.3	186.4	38.2	247.7	343.0
SC-9	CA_m	6.14	4.61	187.2	195.3	39.3	220.5	357.4
SC-10	pCA_m	6.10	4.60	175.7	176.0	37.0	209.6	298.6
SC-11	CT_m	6.17	4.40	158.3	167.3	31.7	186.0	256.1
LSD (P≤0.05)		NS	0.35	16.5	16.3	5.4	23.5	30.8

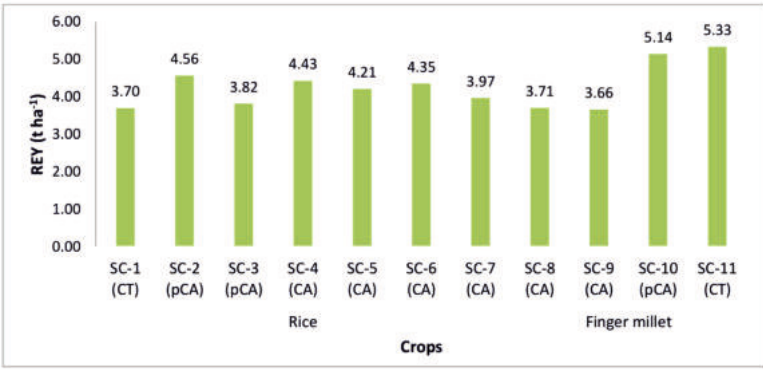


Fig. 13.2 Effect of tillage and crop establishment methods on rice equivalent yield

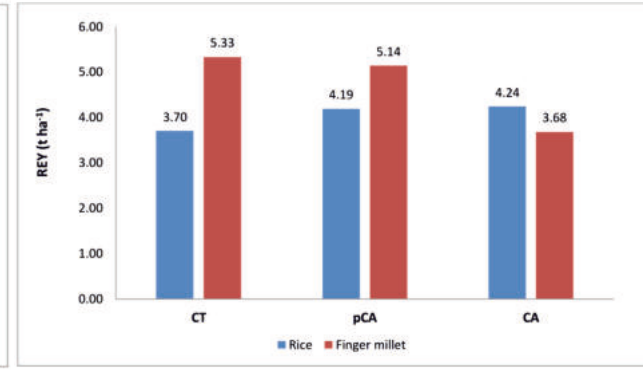


Fig. 13.3 Mean effect of tillage and crop establishment methods on rice equivalent yield

Chapter 14

SOIL & WATER CONSERVATION

Photo : Water smart farming at Sabajpura farm

Water smart farming for enhancing land and water productivity

Enhancing water productivity through water smart farming (WSF) is critical for addressing the growing challenges of water scarcity, food insecurity, and climate change. This study evaluated a WSF model at Sabajpura Farm (Fig. 14.1), ICAR RCER, Patna, integrating aquaculture, horticulture, poultry, and raised-sunken bed (RSB) cropping systems to improve resource-use efficiency, productivity, and system resilience. The modified raised-sunken moisture conservation bed-based diversified cropping systems recorded very high annual land productivity (195-233 q ha^{-1}) and water productivity (11.0-14.4 kg m^{-3}). Compared with rice monocropping (45-55 q ha^{-1}; 0.4-0.6 kg m^{-3}), these systems achieved 3.5-4.5-fold higher land productivity and 20-25-fold higher water productivity. Even relative to the conventional rice-wheat system (90-110 q ha^{-1}; 1.0-1.3 kg m^{-3}), land productivity increased by 2-2.5 times and water productivity by 9-12 times, highlighting the efficiency gains from diversification and improved water management. The aquaculture component comprised composite fish culture stocked at 10,000 fingerlings ha^{-1} in a 35:30:20:10:5 ratio and fed floating pelleted feed (28% crude protein) at 4% of body weight. Grass carp exhibited the highest growth (850 g at 270 days), while *Pangasianodon hypophthalmus* showed the lowest growth (160 g). Total fish production reached 0.84 kg m^{-2}, with a fish water productivity of 0.56 kg m^{-3}. The poultry component involved rearing 24 ducks under pond-integrated conditions with a daily feed allowance of 130 g $bird^{-1}$, resulting in higher body weight (up to 1.3 kg) and improved egg production compared to conventional indoor rearing. Horticultural components, including mango (*Mangifera indica* cv. Amrapali) and banana (*Musa* spp. cv. G9), achieved >80% survival. Pond water quality parameters remained within acceptable limits throughout the study period. Efficient recycling of water, nutrients, and organic residues improved resource-use efficiency, water productivity, income diversification, and system resilience, highlighting the WSF model as a sustainable

Fig.14.1 Multiple use of water model at Sabajpura farm

option for smallholder farming in water-limited areas of eastern India.

Portable soil and water control structure under field-to-field irrigation practice

Field- to- field irrigation practices are mostly prevalent in eastern India particularly in Bihar and Jharkhand. In this practice, the field bund is usually cut directly to transfer water from the upstream (u/s) field to the

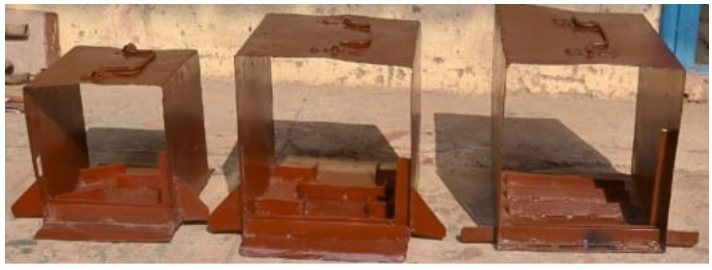


Fig. 14.2 Water controlling structure (size: 8", 10" and 12")

downstream (d/s) field without using any water transfer technique or structure. Under such conditions, field-to-field irrigation affects the productivity of fields due to reduced drainage time, poor distribution of water within the field, soil erosion in the upstream field, and sediment deposition in the downstream field. It also leads to soil nutrient loss and low efficiency of production inputs. Based on the surveys and measurements of existing bunds at different locations in Eastern India, the width and height of field bunds varied from 8-13" and 6-12", respectively. A field trial was conducted at ICAR RCER, Patna to estimate soil loss during field-to-field irrigation using the pipe channel technique. The results indicated that soil loss from one field to another ranged between 0.03 and 0.04 g m^{-2} min^{-1}. A prototype of water controlling device (sizes: 8", 10" and 12") has been designed (Fig. 14.2). The developed structures were tested in the field conditions, and the design was subsequently modified.

Data-driven machine learning framework development for accurate reference evapotranspiration (ET_0) estimation under limited weather data

A data-driven machine learning-based model framework was developed for accurate estimation of daily reference evapotranspiration (ET_0) in the Middle Indo-Gangetic Plains under limited weather data conditions. The framework evaluates multiple input combinations and algorithms to ensure reliable performance with minimal meteorological parameters (Fig. 14.3). Performance evaluation showed that under limited weather data conditions, AdaBoost performed best using only Tmax (Training $R^2 = 0.86$; Testing $R^2 = 0.80$-0.81), outperforming RF and GB. However, when both Tmax and Tmin were used as inputs, model performance declined substantially for RF and AdaBoost in terms of correlation and efficiency metrics, although very high agreement indices were observed. In contrast, when Tmax, Tmin, and BSS were combined, performance improved significantly for the SGD model, which achieved strong training and testing accuracy ($R^2 = 0.83$ and 0.82, respectively), indicating better generalization capability. Although RF and AdaBoost showed very high agreement indices (0.96-0.99), their correlation values were comparatively low under this combination. Overall, the results indicate that AdaBoost performed best under limited single-variable (Tmax) conditions, while inclusion of additional relevant predictors such as BSS improved model robustness, particularly for SGD. These result showed the potential of optimized machine learning models for reliable ET_0 estimation in the Middle Indo-Gangetic Plains under data-scarce scenarios.

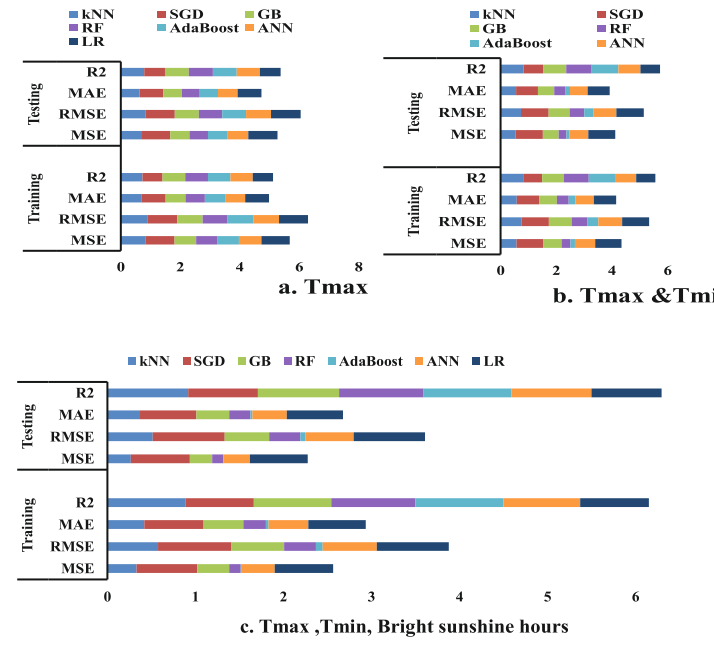


Fig. 14.3 Performance evaluation of machine learning models for daily reference evapotranspiration (ET_0) estimation under limited weather data conditions

Chapter 15

LIVESTOCK PRODUCTION & HEALTH

Photo: Palamu goat, Medini cattle, Kodo duck & Mala chicken registered by ICAR RCER

Identification and characterization of Chotanagpuri buffaloes

Chotanagpuri buffaloes were found distributed across the Chotanagpuri Plateau region of Jharkhand, extending from Ranchi and Khunti districts in the West to Dhanbad, Dumka, and Pakur districts in the East. These buffaloes are generally maintained in small herds, with herd sizes ranging from 1 to 20 animals and an average herd size of 5.7 (Fig.15.1 a & b). The estimated

(a)

(b)

Fig. 15.1 (a) Chotanagpuri buffalo (b) Chotanagpuri herd

population of Chotanagpuri buffalo was found to be 3.15 lakh. The animals were of medium body size and predominantly black in coat colour. The face was narrow, and the body was characteristically barrel-shaped. Chotanagpuri buffaloes appeared relatively tall, with a mean height at withers recorded as 136.26±0.30 cm in adult males and 126.42±0.31 cm in adult females. The estimated mean body weights of adult males and females were 475.13±0.28 kg and 452.45±0.24 kg, respectively. These buffaloes were observed to be low milk producers, with a standard lactation milk yield of 896.13±0.56 kg and an average peak milk yield of 4.58±0.22 kg.

Buffalo improvement programme

Network Project on Buffalo Improvement, with an objective of testing the genetic merit of Murrah bulls, maintained a herd strength of 90 buffaloes at Patna centre. The calf mortality in the herd during the reported period was 2.1 per cent and the low mortality was achieved by following intensive health care and routine preventive measures. The Total Lactation Milk Yield and Standard Lactation Milk Yield were found to be 2483.56±20.42 kg and 2214.72±16.48 kg, respectively. The Wet Average, Herd Average and Peak Yield were observed as 6.47, 5.12 and 10.68, respectively. The Excel-based Herd Monitoring System developed by our institute was used to streamline the reproduction parameters.

Genetic polymorphisms of candidate genes associated with production traits in goats in the Eastern region

The genetic diversity in Black Bengal and Palamu goats were assessed using PCR-RFLP analysis of targeted nuclear (*ADFP* and *ATBF1*) and mitochondrial (Cyt-b and D-loop) genes. Among nuclear markers, *ADFP* gene fragments of 303 bp (*HaeIII*) and 223 bp (*PstI*) and *ATBF1* fragments of 365 bp (*MspI*) and 1064 bp (*PstI*) showed polymorphism in Palamu goats, indicating moderate nuclear genetic variability associated with lipid metabolism and growth regulation (Fig. 15.2). For mitochondrial DNA, fragments of 609 bp (Cyt-b) and 1213 bp (D-loop) were successfully amplified in both breeds (Fig.15.2). Black Bengal goats exhibited comparatively low variation with polymorphism detected only at the SNP1-AluI locus, whereas Palamu goats showed higher heterozygosity with polymorphic SNP1-AluI and SNP2-DraI loci, reflecting richer maternal lineage diversity. The findings indicate that

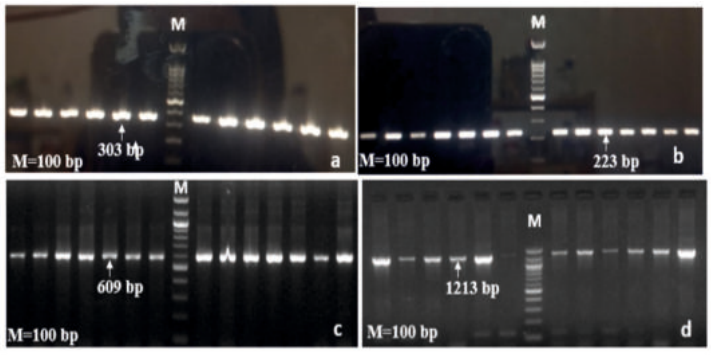


Fig. 15.2 Genetic polymorphisms in goats of the Eastern region

appreciable genetic diversity between and within the studied breeds.

Assessment of antimicrobial drug resistance in bacteria of animal origin

The characterization of prevalence, phylogenetic profile, and antimicrobial resistance (AMR) of bacterial isolates from livestock and poultry were performed. A total of 170 *E. coli* strains were isolated from faecal samples and classified using extended quadruplex PCR (Fig. 15.3). Additionally, 92 milk samples from cattle and buffaloes yielded 55 *Staphylococcus aureus*, 21 *Staphylococci* spp., and 18 *Streptococcus* spp. Phenotypic analysis revealed a

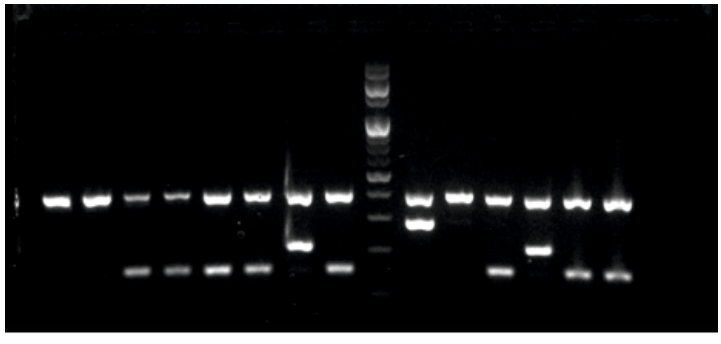


Fig. 15.3 Quadruplex PCR profiles of E. coli isolates

significant presence of multidrug-resistant (MDR) strains, with 39.4% (67/170) of *E. coli* confirmed as Extended Spectrum β-lactamase (ESBL) producers. Genotypic screening via PCR identified diverse resistance genes targeting for fluoroquinolones (*qnrA-S*), trimethoprim (*dfr1, 5, 7/17*), aminoglycosides (*strA-strB, aphA1, aac(3)-II*), and tetracyclines (*tetA-C*). Notably, the *mec*A gene was detected in 17 *S. aureus* and 8 *Staphylococci* spp. isolates, indicating the presence of methicillin resistance.

Identification and characterization of common zoonotic pathogens in domestic animals

A total of 45 *E. coli* isolates were identified and were screened for confirmation of species by primers USPA F & R and presence of virulence factors were determined by PCR with primers for VTcom, VT1, VT2 and *eae* genes. Representative isolates positive for *stx1 and 2* genes were sequenced by Sanger sequencing. The obtained sequences were aligned with the sequences *stx1 and 2* available in the public domain and phylogenetic trees were constructed by the maximum likelihood method. These sequences form a monophyletic group, indicating derivation from a single common ancestral Shiga toxin gene. These indicate possible clonal expansion reflecting recently emerged or locally circulating *E. coli* lineage with potential epidemiological linkage or shared source of origin. However, stx1 sequences from our study show greater genetic distance from *Shigella* origin shiga toxin 1 genes and other *E. coli* isolates, indicating host-associated divergence, and independent evolutionary trajectories of *stx1* genes after host specialization.

Transcriptome and metagenome approach to characterize genetic basis of prolificacy in goats

To investigate differences in vaginal microbiota between single and multiple-ovulating does, vaginal swabs were collected during estrus and subjected to high-throughput 16S rRNA gene sequencing for comprehensive microbial profiling. In parallel, aerobic culturable bacteria were isolated by inoculating swabs in general and selective media, followed by incubation at 37 °C for 24-48 hours. Bacterial identification was performed based on colony morphology and Gram staining, where forty-five isolates have been characterized. Amplicon sequencing of samples from Jamunapari and Black Bengal goats revealed a detailed overview of the vaginal microbial landscape. Distinct breed-specific microbial signatures were observed-genera such as Streptobacillus, Enhydrobacter, and Roseomonas were enriched in Black Bengal goats, whereas Stenotrophomonas, Kocuria, Bacteroides, Streptococcus, and Pseudomonas were more prevalent in Jamunapari goats. Jamunapari goats exhibited higher alpha diversity at both genus and species levels, indicating a richer and more complex vaginal microbial ecosystem. Further analysis of parity within

Black Bengal goats demonstrated that reproductive history had minimal influence on overall microbial community structure. However, a slight reduction in microbial diversity was noted in multiparous does. Genera including Enhydrobacter and Aeromonas were more abundant in third-parity goats, while Aquabacterium, Streptococcus, and Bifidobacterium were enriched in zero-parity animals. The findings highlight the influence of host genetics and reproductive status on vaginal microbial composition, and therefore, microbes are the potential biomarkers for reproductive performance and fertility management in goats.

Assessment of ecosystem services rendered by indigenous livestock and poultry species and breeds

This study employs economic valuation methods, including market price, replacement cost, and hedonic pricing, to assess the lifetime value of provisioning, regulating, supporting, and socio-cultural services, while also accounting for associated disservices. The major disservices include methane emissions from enteric fermentation and manure, water quality deterioration, and soil erosion. It has been assessed that provisioning services contributed 68.26% of total ecosystem services, whereas, social and cultural services, regulating services and supporting services contributed 29.37, 1.89 and 0.48%, respectively in a female Murrah buffalo on an individual life-cycle basis. However, ecosystem services of buffalo on the basis of breed, it has been observed that provisioning services were higher in Murrah buffalo (68.76%) than non-descript (35.34%). For regulating services also, Murrah buffalo showed highest values (24.20%) as compared to non-descript. These findings emphasize the economic and ecological significance of indigenous buffalo, which need the adoption of sustainable management strategies to optimize benefits and mitigate adverse effects.

AICRP on goat improvement

All India Coordinated Research Project on goat improvement was started at ICAR RCER, Patna in the year 2018-19. The centre continued its activities in the four clusters of Bihar based on Black Bengal goat population density. The average body weights at 3, 6, 9 and 12 months of age were recorded as 4.35 ± 0.02 kg, 6.95 ± 0.02 kg, 10.30 ± 0.03 kg and 12.78 ± 0.04 kg, respectively. Age at first mating was increased to 280 days in 2025 as compared to 196 days in base year 2018-19. A significant increase in the socio-economic conditions of goat farmers was observed under the project. Average lactation milk yield was recorded as 23.05 kg at 90 days of lactation period. Two trainings of three days duration were organized for the skill development of goat farmers. Further, a total of ten health camps (Fig. 15.4 a & b) were organized to provide health care support to goat rearers.

(a)

(b)

Fig. 15.4 (a) Skill development training at ICAR RCER, Patna and (b) Health camp for goat farmers at Katihar

Characterization and evaluation of chicken germplasm of the Eastern region

Rangwa chickens were found widely distributed across Jharkhand and were well adapted to the subtropical climate with flock sizes ranging from 2 to 30 birds and an average of 16.6 birds per household. Phenotypically,

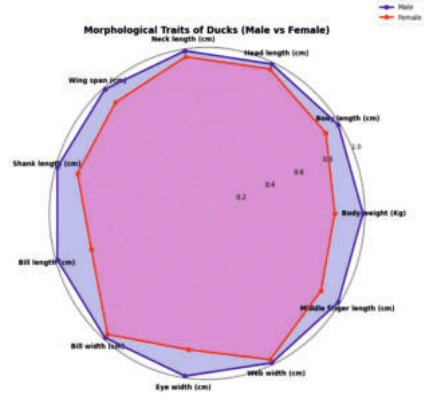
Rangwa chickens exhibit predominantly brown to dark red plumage, with a distinctive mixture of black and red coloration in the tail feathers (Fig. 15.5 a, b & c). These birds are hardy, well adapted, and show high survivability under low-input management conditions. In terms of growth performance, adult males attained an average body weight of 1.53 kg, while females reached 1.06 kg, indicating moderate growth and clear sexual dimorphism. Reproductively, hens reached sexual maturity at an average age of 196 days. The annual egg production averaged 65.57 eggs per hen under backyard conditions. The eggs and meat are highly preferred by local consumers due to their superior taste and quality. The meat is particularly tender and juicy, fetching premium prices in local markets. Overall, Rangwa chickens possess significant economic and genetic potential for sustainable rural poultry development for smallholder farmers.

(a) (b) (c)

Fig. 15.5 **(a)** Rangwa male **(b)** Rangwa female with chicks **(c)** Rangwa flock

Biodiversity of duck germplasm in Bihar using machine learning models

Under this project, six major poultry rich districts such as Purnea, Katihar, Araria, Darbhanga, Nawada, and West Champaran were identified for detailed study. A pilot survey was conducted in Araria district to validate the survey format, followed by enumerator training to ensure uniform data collection (Fig. 15.6 a & b). A random stratified sampling strategy was adopted for representative coverage. In Narpatganj block of Araria, five villages were surveyed, covering 60 duck-rearing households with flock sizes ranging from 6 to 20 birds. About 70-80% of the population belonged to indigenous Maithili ducks. Morphological traits of ducks along with weight data were collected from 125 ducks along with photographs and management information. The data were digitized, checked, and subjected to preliminary descriptive analysis. Sex-wise analysis showed a clear sexual dimorphism. Males were heavier with higher body weight (3.10 kg) and body length (27.99 cm) compared to females (2.54 kg and 25.37 cm). Males also showed slightly greater head, neck, and wingspan measurements and significantly longer bill length. Eye width, web width, and middle finger length were marginally higher in males, indicating stronger skeletal development and



(a)

(b)

Fig. 15.6 (a) Comparison of male and female ducks germplasm (b) Duck germplasm survey in Araria district of Bihar

better adaptation for swimming. However, females showed relatively longer shank length. These findings provide baseline information on the morphological diversity of indigenous ducks for further genetic and conservation studies.

Impact of phytobiotics on swine health and productivity

Under the project, antioxidant activity and bioactive nutrient composition of selected indigenous phytobiotic plants, namely *Ficus geniculata (Phutkal)* and *Litsea glutinosa* (Pozosaal/Meda Pata), were evaluated using standard biochemical assays (Fig 15.7). The results revealed significant variation in total phenolic content (TPC) among plant species and plant parts. The highest TPC was recorded in *Ficus geniculata* (red leaf; 358.44 mg GAE/100 g), followed by *Litsea glutinosa* leaves (341.25 mg GAE/100 g). The antioxidant potential, assessed through DPPH radical scavenging activity, ranged from 59.96% to 86.48%, with maximum activity observed in *Ficus geniculata* (red leaf). This indicates a strong positive correlation between phenolic content and antioxidant capacity. Mineral analysis further demonstrated notable differences between the two plants. *Litsea glutinosa* exhibited higher concentrations of iron (15.5 mg/100 g) and manganese (4.02 mg/100 g) compared to *Ficus geniculata* (1.45 and 1.02 mg/100 g, respectively). In contrast, zinc (4.63 mg/100 g) was detected only in *Ficus geniculata*. Overall, the findings highlight that these indigenous phytobiotic plants possess considerable antioxidant properties along with essential micronutrients, indicating their potential as natural feed additives for enhancing animal health, immunity, and productivity under sustainable livestock production systems.

(a) (b)

Fig 15.7 (a) *Litsea glutinosa* (Pozosaal/Meda Pata)
(b) *Ficus geniculata (Phutkal)* with leaf buds

Chapter 16

FISHERIES RESOURCE MANAGEMENT & AQUACULTURE

Photo: Fish harvesting at ICAR RCER, Patna

Optimization of stocking density for seed rearing of *Pangasianodon hypophthalmus* in biofloc systems

The experiment was conducted with four biofloc treatments and one control in circular tanks with a capacity of 5,000 L. Different stocking densities were tested: T1BF (150 fry m^{-3}), T2BF (200 fry m^{-3}), T3BF (250 fry m^{-3}), T4BF (300 fry m^{-3}), and T5N (as control with 150 fry m^{-3}). The study was carried out for 93 days. Water quality parameters of tanks and the growth performance as well as haematological parameters of fish, were analysed. The highest survival rate (69.8%) was recorded in the biofloc system at 150 fry m^{-3} (T1BF), whereas the lowest survival (45.51%) was observed in the normal outdoor system (T5N) (Fig. 16.1).

Total biomass production per tank was nearly similar at stocking densities of 200, 250, and 300 fry m^{-3}. The result indicates that T2BF (200 fry m^{-3}) is the most suitable stocking density for seed rearing of *Pangasianodon*

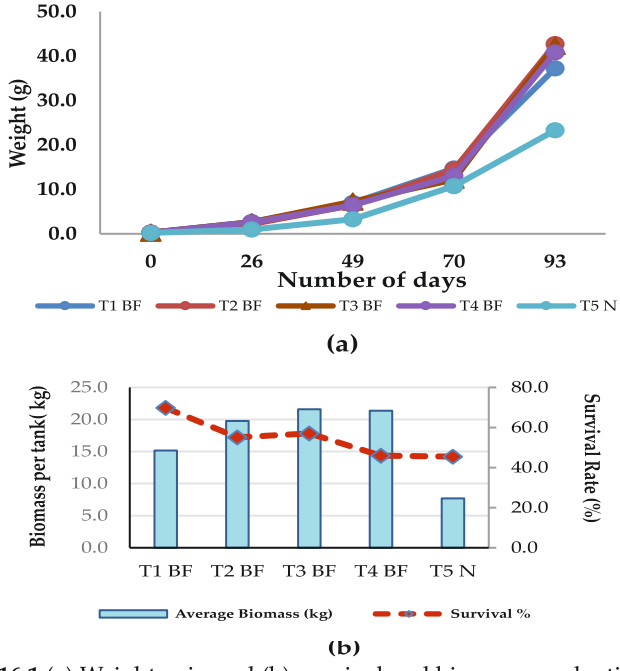


Fig. 16.1 (a) Weight gain and (b) survival and biomass production of *Pangasianodon hypophthalmus* in biofloc system

hypophthalmus in biofloc systems. Higher average body weight, specific growth rate (SGR%), and percentage weight gain were observed in the T3BF and T4BF. Overall, fry reared in the normal system showed lower performance across all studied parameters compared with those reared in biofloc systems, suggesting that biofloc technology can be effectively used for seed rearing to address seed scarcity in the Eastern region.

Standardization of culture technique of Pabda (*Ompok bimaculatus*)

An experiment was designed to standardize the culture technique for Pabda in Eastern India at ICAR RCER, Patna. To evaluate the growth performance of Pabda, three culture systems were studied: monoculture, polyculture, and fish-cum-cattle integrated farming in earthen pond (1000 m^2) for 240 days (Table 16.1). Within acceptable ranges of water quality parameters in all fish farming systems, the study found that polyculture of Pabda with Catla (*Catla catla*) and Rohu (*Labeo rohita*) on supplementation with commercial feed is economically feasible in Eastern India.

Table 16.1 Comparative production parameters of Pabda-based culture systems

Particulars	Monoculture	Polyculture	Fish-cum-cattle farming
Stocking density (No. ha^{-1})			
Pabda (0.24 g)	60000	20000	20000
Catla (65 g)	Nil	2000	2000
Rohu (50 g)	Nil	3000	3000
Feed source	Commercial	Commercial	Cow dung manure
Feeding rate	5% body weight	5% body weight	3 kg day^{-1}
Final average weight (g)			
Pabda	51	59	39
Catla	Nil	917	857
Rohu	Nil	560	520

Resource assessment and management framework for sustainable fisheries

The population dynamics of *Puntius sophore* in Kasaraiya Dhar Wetland, Bihar, revealed continuous recruitment and prolonged breeding, as indicated by multiple cohorts in length-frequency analysis (Table 16.2). Growth parameters estimated through the von Bertalanffy model ($L\infty$ = 102.90 mm, K = 0.65 yr^{-1}, t_0 = -0.177 yr) demonstrated moderate growth. The length-weight relationship (R^2 = 0.9345) showed positive allometric growth, while condition factors (>1) reflected favourable habitat conditions. Mortality analysis indicated natural mortality (0.93 yr^{-1}) exceeded fishing mortality (0.81 yr^{-1}), with an exploitation ratio (E = 0.40). The stock appears healthy and resilient, supported by dense macrophyte cover that provides refuge. Sustainable management through habitat conservation and regulated macrophyte management is recommended to maintain ecological balance and stock productivity.

Table 16.2. Stock assessment parameters of *Puntius sophore* in Kasaraiya Dhar wetland, Bihar

Parameters	Observation	Interpretation
Length-frequency analysis	Multiple distinct cohorts observed	Continuous recruitment and extended breeding period throughout the year
Asymptotic length (L∞) in ELEFAN-I method	102.90 mm	Small-sized cyprinid in this wetland ecosystem
Growth coefficient (K)	0.65 yr^{-1}	Moderate growth rate
Length at zero age (t_0)	-0.177 yr	Theoretical age when length is zero
Length-weight relationship	$W = 2 \times 10^{-6} L^{3.4091}$ ($R^2 = 0.9345$)	Positive allometric growth; strong correlation and healthy growth pattern
Relative condition factor (Kn)	1.0169	Indicates good physiological condition
Fulton's condition factor (K)	1.0446	Reflects favourable habitat conditions
Natural mortality (M)	0.93 yr^{-1}	Mortality due to natural causes
Fishing mortality (F)	0.81 yr^{-1}	Lower than natural mortality
Total mortality (Z)	1.75 yr^{-1}	Combined natural and fishing mortality
Exploitation ratio (E)	0.40	Stock is underexploited

Assessment of wetlands for food production and ecosystem services

The fisheries contribution of three kinds of wetland ecosystems in Bihar was studied. These wetlands were selected as well managed (Sonmar Chaur, Samastipur), semi-managed (Kanwar Lake, Begusarai) and unmanaged (Kasaraiya Dhar, Khagaria) (Fig. 16.2).

(a) (b)

Fig. 16.2 Fisheries in (a) Sonmar Chaur and (b) Kasaraiya Dhar

Sonmar Chaur wetland has about 50% fisheries area where scientific fish farming practices were adopted under private ownership and community management by around 40 land owners. The wetland showed very low fish diversity (6 species) but very high fish production (~6 tons ha^{-1} $year^{-1}$) due to intensive Indian Major Carp culture practices. Kanwar Lake had about 30% fisheries area where fishing was mainly carried out using traditional methods. It supported very high fish diversities (48 species) but very low fish production (40 kg ha^{-1} $year^{-1}$). Kasaraiya Dhar had about 90% fisheries area and was mainly government-owned, with fishing rights are managed by a cooperative society using traditional fishing practices. The wetland showed very high fish diversities (63 species) but low fish production (~70 kg ha^{-1} $year^{-1}$). Agriculture occupied about 10% of the surrounding area (cereals, mustard, and pulses).

Geospatial distribution and characteristics of microplastics in the riverine ecosystems

Under the project, a 90-day experimental trial was conducted to evaluate the impact of dietary microplastic exposure on the growth and physiological performance of Rohu (*Labeo rohita*). Juvenile fish with an average weight of 10 g were stocked in 300 L fiberglass-reinforced plastic (FRP) tanks at a density of 10 individuals per tank. Five experimental diets were formulated, incorporating varying concentrations of high-density polyethylene (HDPE) microplastics. The fish were fed twice daily at a rate of 5% of their body weight. The findings revealed a significant inverse relationship between microplastic concentration and fish performance. As the dietary HDPE levels increased, growth parameters, including weight gain, showed a marked decline (Fig. 16.3). This deterioration suggests that microplastic ingestion likely causes physical interference with nutrient absorption, hindering the overall development of the species.

These results emphasise the detrimental effects of plastic contamination in aquatic feed systems. Given the commercial importance of *L. rohita* in South Asian aquaculture, this study highlights an urgent need for

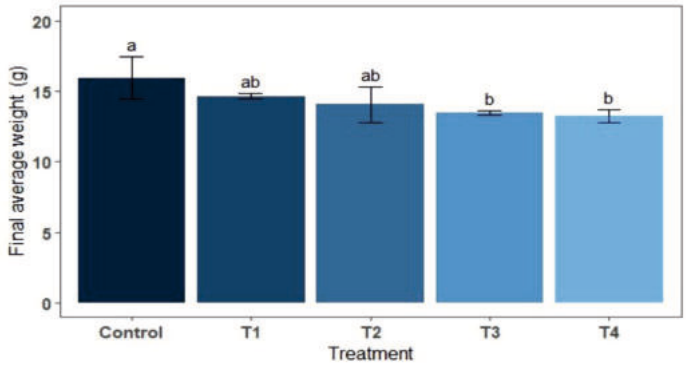


Fig. 16.3 Growth performance of Rohu fed diets containing microplastics

stricter monitoring of microplastic pollutants in fish meal and water bodies to ensure sustainable production and food safety.

Effect of environmental exposure of arsenic in *Ctenopharyngodon idella*

A 90-day experimental trial was conducted using grass carp (*Ctenopharyngodon idella*) fingerlings across four treatments (Control, T1, T2, and T3) to evaluate the mitigating effects of dietary turmeric on arsenic-induced toxicity. The fish were provided a daily ration of 5% of their body weight, using a formulated commercial diet. The weights of the fishes were recorded and the blood samples were collected for estimation of haemoglobin and haematocrit value from all the groups at the end of the experiment. Fish liver samples from the control, T2, and T3 groups were collected for gene expression analysis of metallothionein, tumor necrosis factor-α (TNF-α), and NF-κB (Nuclear Factor-κB) p65 genes, where RNA was isolated from the liver cells, followed by cDNA synthesis. Our results showed that arsenic causes decrease in weight gain, haemoglobin and PCV level, which were partially compensated by turmeric feeding. A significant increase in mRNA expression of metallothionein, TNF-α and NF-κB p65 genes in arsenic treatment group was observed, which was improved due to turmeric feeding. Our results indicate that turmeric may have the potential to ameliorate arsenic toxicity.

Advanced predictive analytics for smart and enhanced fish productivity

Fisheries production in Bihar has undergone a remarkable transformation over the past six decades, increasing from 0.46 lakh tons in 1960 to 8.73 lakh tons in 2024. In the early decades, production growth was relatively modest and characterized by moderate volatility, largely due to dependence on traditional capture fisheries, limited technological adoption, and vulnerability to climatic variability. However, the post-2010 period marked a clear turning point, with significant annual growth rates driven by rapid aquaculture expansion, improved seed and feed systems, infrastructure development, and proactive policy interventions. During 1960-1970, fisheries production grew at a modest compound annual growth rate (CAGR) of 2.24% per annum improved to 3.89% during 1970-1980, indicating gradual sectoral expansion. During 1980-1990, the CAGR was 6.50%, largely attributable to the initial scaling up of aquaculture activities and improved institutional support mechanisms. The subsequent decades, 1990-2000 and 2000-2010, experienced moderate growth rates of 3.33% and 2.66%, respectively. The most significant surge was observed during 2010-2020, when fisheries production expanded at an impressive CAGR of 8.97% per annum, reflecting structural modernization and intensified production systems. The recent period of 2020–2024 continues to demonstrate strong performance, with a CAGR of 6.31 percent, indicating sustained momentum despite short-term percentage fluctuations. Developed ARIMA (2,1,2) based forecasting suggests that this upward trajectory is likely to continue, with production projected to exceed 12 lakh tons by 2030 (Fig. 16.4). Overall, the decade-wise growth pattern underscores a clear transition from low-growth traditional fisheries to a dynamic, aquaculture-driven.

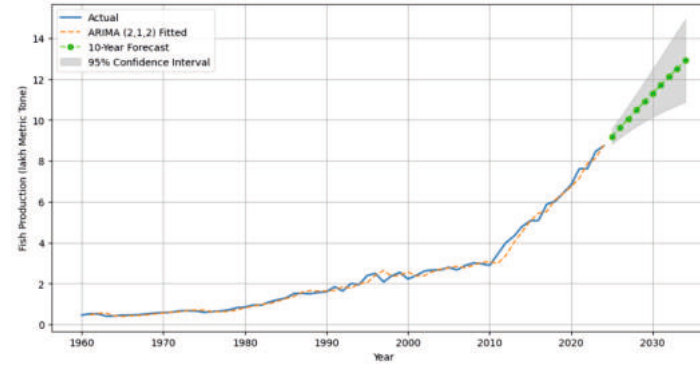


Fig. 16.4 Fish production forecast in Bihar up to 2030 using an ARIMA (2,1,2) model

Chapter 17

FARM MECHANIZATION & AGRI-PHOTOVOLTAIC SYSTEMS

Photo: AgriPV System at FSRCHPR, Ranchi

Development of solar photovoltaic powered agricultural machinery

A solar-powered maize sheller was successfully developed using three 335 Wp solar panels and a 500 W PMDC motor (Fig. 17.1). The throughput capacity of

Fig. 17.1 Development and evaluation of solar-powered maize thresher

the maize thresher was 155±7 kg h^{-1}. The cost of threshing was estimated at approximately ₹1.07 per kg when used for 3 h per day for 100 days. Income, profitability, and payback period were analyzed under different custom hiring rates. A 2000 W PWM motor speed controller has been procured to optimize motor speed and efficiency. Work is in progress on the development of a solar-operated animal feed mixing machine. Efforts are underway to convert a seed treatment drum into an animal feed mixing unit to reduce initial investment cost.

Energy flow, carbon balance and water footprints of dominant cropping systems under different agro-ecological regions of Eastern India

Rice-based cropping systems across different states exhibited considerable variation in system energy ratios (6.15–11.82), with diversified crop rotations demonstrating higher energy-use efficiency. System productivity was the highest in high-value cropping sequences such as rice–potato in West Bengal (39.15 t ha^{-1}) and rice–mustard–maize in Bihar (14.73 t ha^{-1}). Crop diversification substantially improved land-use efficiency, exceeding 90% in Bihar and Eastern Uttar Pradesh. Traditional rice–fallow systems consistently recorded lower productivity and reduced land-use efficiency. Integration of pulses, oilseeds, and cereals within rice-based rotations enhanced overall resource-use efficiency and crop productivity, supporting

sustainable intensification in rice-dominated agro-ecosystems.

Microclimate variations under agri-photovoltaic systems

A field experiment was conducted at ICAR RCER to assess microclimate variations and crop performance of broccoli and French bean under an Agri-Photovoltaic (AgriPV) system compared to open field conditions. A 5 kWp AgriPV structure was installed over a 12 × 18 m² plot and evaluated alongside an equal-sized open plot. The study included two main treatments-AgriPV shaded (S1) and open field (S2) - with two nutrient levels (100% and 75% recommended dose of fertilizers) arranged in a replicated design. Fertigation was applied uniformly based on crop growth stages.

Soil moisture observations at 10-20 cm depth indicated a clear advantage under the AgriPV system (Fig. 17.2). During October-November, moisture content under panels ranged from 12.5-15.9% in broccoli and 13.4-16.4% in French bean, compared to lower values in the open field (10.3-14.0% and 9.4-14.8%, respectively). The 2-4% higher moisture under AgriPV was more pronounced during early growth stages, suggesting improved moisture conservation due to partial shading. Although differences reduced during December-January, moisture levels remained more stable beneath the panels.

Microclimatic monitoring revealed that AgriPV significantly moderated environmental conditions. Peak afternoon temperatures were consistently higher in the open field, reaching 30.15°C, whereas below-panel temperatures remained around 28.1-28.3°C, showing a reduction of nearly 2°C (Fig. 17.3). Intermediate temperatures were observed between and at the edges of panels. Similarly, solar radiation was highest in the open field (800-860 W m^{-2}), while it declined under panels (600-700 W m^{-2}) and dropped to about 200 W m^{-2} in fully shaded areas. Thus, the AgriPV system is creating a buffered microclimate favorable for crop growth.

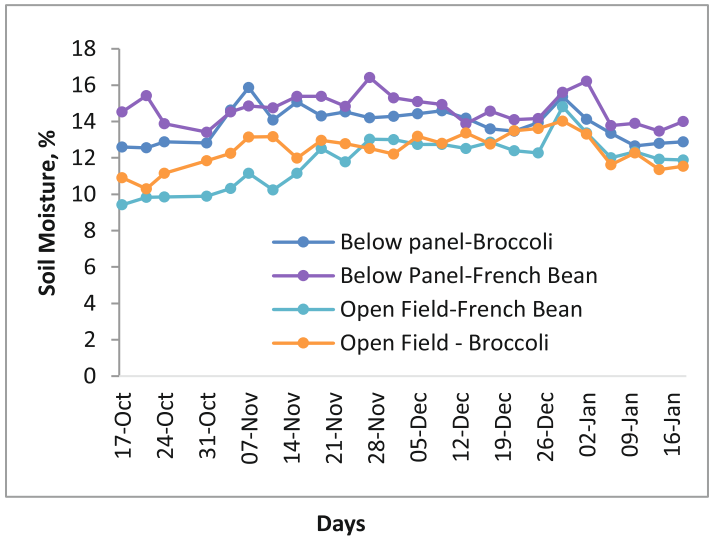


Fig. 17.2 Soil moisture (% weight basis) variaion under Agri-PV and open field conditions

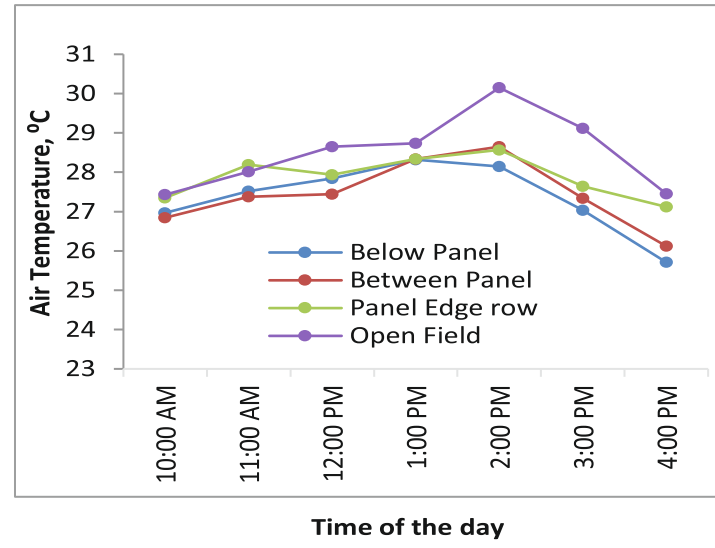


Fig. 17.3 Hourly air temperature variations under Agri-PV and open field conditions

Chapter 18

SOCIO-ECONOMIC STUDIES & TRANSFER OF TECHNOLOGY

Photo: Strengthening the voice of women by ICAR RCER

Assessing the impact of climate resilient agricultural interventions in enhancing farmers' adaptive capacity

This ongoing project aims to evaluate the effectiveness of climate-resilient agricultural interventions in strengthening farmers' adaptive capacity under variable climatic conditions in Gaya Ji and Buxar districts of Bihar. The assessment was based on the Livelihood Vulnerability Index (LVI–IPCC) framework, incorporating three major components-exposure, sensitivity, and adaptive capacity-across marginal, small, and semi-medium farm categories (n=50 in each category per district). The baseline findings indicated that Gaya Ji district exhibited comparatively higher vulnerability than Buxar across all farm categories and vulnerability dimensions (Fig. 18.1). Marginal farmers in Gaya

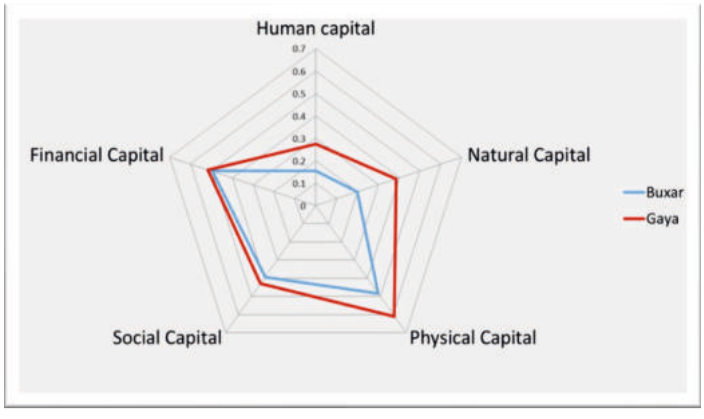


Fig. 18.1 Livelihood vulnerability of CRA farmers in Gaya Ji and Buxar districts

recorded the highest LVI-IPCC score (0.443), followed by small (0.206) and semi-medium farmers (0.116). In contrast, Buxar showed lower vulnerability levels, with LVI-IPCC scores of 0.345 (marginal), 0.082 (small), and 0.010 (semi-medium). The trend consistently demonstrates that marginal farmers remain the most vulnerable group in both districts.

Based on these findings, the project has prioritized interventions focusing on climate-smart crop management, water resource optimization, strengthening physical infrastructure, and promoting financial inclusion mechanisms such as microcredit and risk mitigation instruments.

Unlocking green gains: an assessment of voluntary carbon credit (VCC) potential in Bihar

Preferences for data collection and monitoring methods by smallholder farmers' participation in VCC were executed. Smallholder farmers disproportionately favored monthly reporting, while larger farmers preferred end-of-season reporting (Fig. 18.2). This

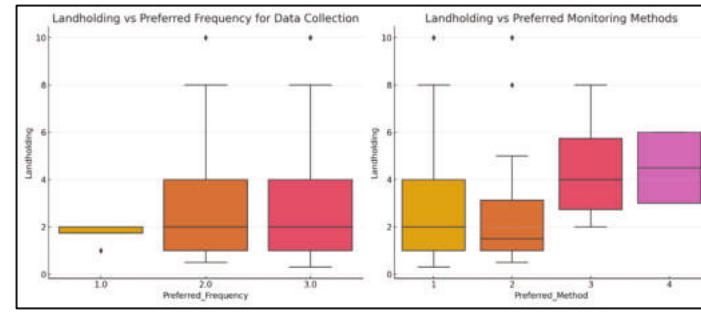


Fig. 18.2 Box plot of landholding size by preferred frequency for data collection and preferred monitoring method

Note: 1.0 = Weekly, 2.0 = Monthly, 3.0 = End of Season; 1 = Expert Field Visits, 2 = Farmer-Led Self-Reporting, 3 = Remote Sensing/Drones, 4 = Mobile App-Based Reporting

pattern likely reflects differences in transaction cost sensitivities and data management capacities. The researcher also examined preferences for carbon monitoring methods: (i) expert field visits, (ii) farmer-led self-reporting, (iii) remote sensing or drone-based monitoring, and (iv) mobile app-based reporting. The figure reveals that smallholders strongly preferred expert-led and self-reported approaches, while larger landholders favored remote sensing and mobile apps. These preferences align with prior studies highlighting smallholders' digital literacy barriers and reliance on trusted human intermediaries.

Assessing agri-business value chains of fruits and aromatic rice in Bihar (AGRIFAB)

Assessing Agri-business Value Chains of Fruits and Aromatic Rice in Bihar (AGRIFAB) was initiated in August 2025 at ICAR RCER, Patna, addressing fragmented value chains and limited market integration for Bihar's high-value agricultural commodities like fruits (litchi, mango, banana etc.) and selected aromatic rice variety (e.g., Sonachur). Initial results revealed a significant geographic and socioeconomic variation in fruit consumption, where

results indicated that the West Bengal households exhibited substantially higher fruit expenditure than Assam, ₹ 180.50 versus ₹ 91.56 per month, respectively. Urban households consumed 2.66 times more fruit than rural counterparts. Income elasticity of fruit consumption was (+) 0.487, indicating normal good status. Fruit-specific price elasticity vary substantially across fruit types. Price elasticity varies for mango and pineapple were (-) 0.756 and (-) 0.689, respectively, banana was relatively much inelastic (-0.418), whereas the price elasticity of litchi was (-) 1.124, indicating the nature of luxury product (Fig. 18.3). Consequently,

Fig. 18.3 Price elasticity of various fruit crops of Eastern India

targeted interventions to boost up income for rural, especially low-expenditure households, supply chain investments to reduce price volatility, and nutrition education campaigns are recommended to leverage these behavioral insights for improving fruit access and consumption in Eastern India. The project findings of the first year create the benchmark for consumer preference surveys, premium packaging pilots (2026-27), and sustainability benchmarking tool development, progressing towards expected outcomes of enhanced value chain efficiency.

Development of zero hunger and zero technology gap village through innovative interventions

Under the project, varietal demonstrations were laid out to showcase the superiority of improved crop varieties over existing farmer practices at village Chhotka Dhakaiach, Buxar. Demonstration of Quality Protein Maize variety Shaktiman-5 recorded 48.5 q ha^{-1} yield with 13.8% increase over farmers' practice. High yielding pigeonpea variety IPA-203 exhibited the highest yield enhancement of 50.3% with productivity of 21.8 q ha^{-1} across 26 demonstrations. Mid-duration paddy variety BPT-5204 achieved 46.4 q ha^{-1} yield with 19.28% increase over local practices. In addition, Moong bean variety Shikha was demonstrated for crop intensification in rice–wheat cropping systems to enhance system productivity and sustainability. Overall, varietal demonstrations covered 14.5 ha benefiting 74 farmers and significantly contributed towards improving productivity, profitability, and adoption of improved agricultural technologies in the village. Additionally, capacity building programs were organized for developing nutri garden, mushroom production and backyard poultry. Whatsapp group was formed for providing timely advisories to farmers of adopted village.

Building resilience model for the vulnerable hotspots to climate change in smallholder dairy production system

Climate-vulnerable dairy hotspots were identified through GIS-based spatial analysis and participatory Fuzzy Cognitive Mapping to understand risk linkages affecting smallholder dairy systems. Interventions were implemented in selected villages of Patna (Rampur; 50 participants), Buxar (Gagaura-Balapur; 85 participants), Gaya Ji (Guleriachak; 66 participants), and Sitamarhi (Sursand, Pupri; 35

Fig. 18.4 Climate resilient dairy farmers' field school at Bhelura Rampur, Patna

participants), covering a total of 236 dairy farmers.

A major capacity-building initiative was the 16-week Climate Resilient Dairy Farmers' Field School (Fig.18.4) (August-November 2025), complemented by animal health awareness camps.

The Farmers' Field School (FFS) approach significantly enhanced the adaptive capacity of smallholder dairy farmers by promoting experiential learning, peer-to-peer knowledge exchange, and season-long field demonstrations. The participatory learning platform also fostered collective action and institutional linkages with veterinary and extension agencies.

Sustainable improvement in livelihood of scheduled caste community in Nawada district

The project began with participatory livelihood mapping and farmers consultations to identify constraints and opportunities through baseline survey of 200 farmers from adopted villages. A major milestone during 2025-26 was the construction of two Science and Technology Innovation (STI) hubs in the district with seating capacity of 35-40 farmers and is equipped with computers, printers, a projector, camera, and digital display board. These hubs serve as knowledge and advisory centres providing real-time information on weather, market prices, and improved farming practices.

Demonstrations on improved crop varieties provided substantial yield advantages over farmers' practices (Fig. 18.5). Wheat varieties Karan Vandana and HD 2967,

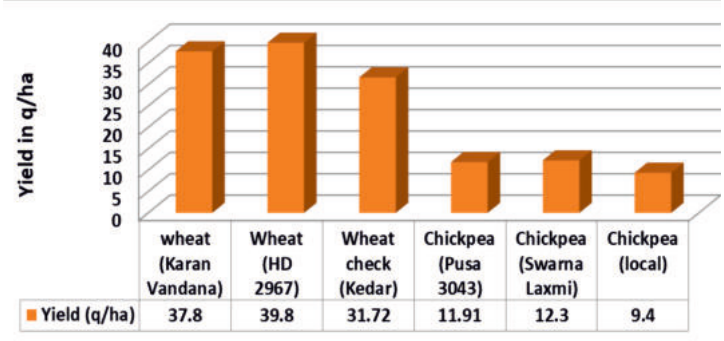


Fig. 18.5 Performance of improved varieties of wheat & chickpea in farmers' field demonstrations in Nawada

recorded an average yield of 39.8 and 37.82 q ha^{-1} reflecting about 19-25% yield improvement over farmers' practice. Chickpea variety Pusa 3043 and Swarna Lakshami, tested in 85 demonstrations, registered around 27–31% higher yield over traditional practice.

Further, livelihood diversification was strengthened through the distribution of 50 Black Bengal goats and 800 Vanraja poultry chicks to 66 small, marginal, and landless SC farmers. Notable body weight gains were observed, indicating improved income prospects from eggs, meat, and milk. Capacity building remained central, with over 500 farmers participating in 2 trainings, 2 awareness programmes, 1 exposure visit to ICAR RCER Patna, and 2 field days.

Impact of e-NAM on improving marketing of agricultural produce in Eastern India

Assessment of marketing through e-NAM platform was studied in Bihar state in terms of volume as well as value of trade. Bihar state has registered 5,198 farmers and 1,102 traders on the e-NAM platform, while 225 FPOs have been onboarded to facilitate digital trading. A total of 41 commodities were traded through the platform, including major crops such as makhana, paddy, wheat, maize, banana, potato, onion, parwal, and cauliflower (Fig. 18.6). The total volume of trade recorded was 1,92,771 quintals, with a total trade value of approximately ₹ 14.8 crore.

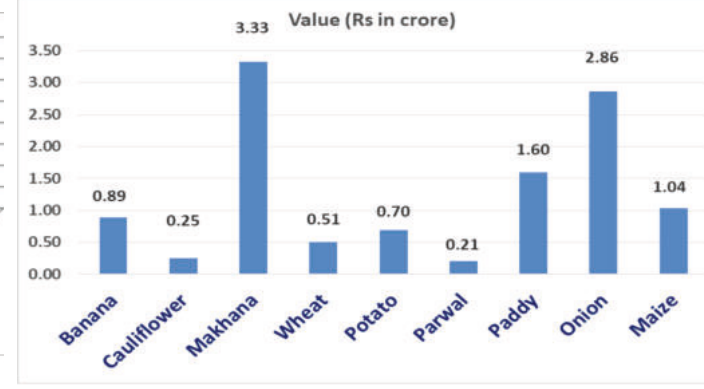


Fig. 18.6 Value of e-NAM trade (Rs. crore) of major commodity in Bihar

Developing simulation model of technology diffusion (Tech-SIM), adoption and impact for forecasting using techno-socio-psycho-economic-ecological factors

The Tech-SIM project aims to develop a comprehensive simulation model to forecast agricultural technology diffusion and impact by integrating techno-socio-psycho economic-ecological determinants of adoption. A detailed baseline survey was conducted in selected villages of Buxar district to assess households' economic status, existing technology usage, and behavioral orientation towards innovation. The project evaluated both varietal and non-varietal technologies under field conditions. Varietal technologies included improved crop varieties: Rice (BPT 5204, Swarna Samriddhi Dhan), Wheat (Shreeram 303), Greengram (Virat), and Okra (Namdhari 862). Non-varietal technologies encompassed Insecticide 505 (Chlorpyriphos 50% + Cypermethrin 5%), Fungicide (Amritsar Top), and Weedicides (Roundup, Bispyribac Sodium). Additionally, Resource Conservation Technology through Direct Seeded Rice (DSR) was assessed for cost and water-use efficiency.

Preliminary findings revealed significant variation in adoption patterns among marginal, small, and semi-medium farmers, influenced by resource endowment, risk perception, peer networks, and access to extension services. Peer influence and informal information flow emerged as critical accelerators of early adoption, particularly for visible and performance-driven technologies. The ongoing simulation framework will enable scenario-based forecasting of technology diffusion trajectories and impact under varying socio-economic and ecological conditions, supporting evidence-based policy and extension planning.

Supply chain of pulses in major pulse producing states of India with focus on eastern states

The project is being implemented under the aegis of the Department of Consumer Affairs, Government of India, and is centrally coordinated by Indian Institute of Pulses Research (IIPR), Kanpur. During the reporting year, ICAR RCER, Patna centre focused on mapping the pulse supply chain in Eastern states, particularly Bihar and adjoining regions. The study examined production clusters, aggregation mechanisms, market arrivals, storage infrastructure, transportation channels, processing units, and retail distribution networks (Fig. 18.7).

Fig. 18.7 Data collection of Mungbean producer

After completion of field data collection, all responses were systematically compiled and entered into a structured Google-based proforma to ensure accuracy, consistency, and ease of data management. The digitized dataset was subsequently coded, and subjected to statistical analysis for examining production practices, marketing channels, price realization, and supply chain dynamics of mungbean in the selected districts. The average cost of cultivation of greengram was ₹17,317.52 per hectare, with operational costs accounting for 96.15%. Fertilizer and manure (28.03%) and human labour (25.41%) were the major cost components. With an average yield of 8.54 quintals per hectare and gross returns of ₹70,091.64, the benefit–cost ratio was 4.06, indicating high profitability (Table 18.1).

Table 18.1 Average cost of cultivation of greengram in Bihar

Particular	Operational cost (Rs.)	Percentage (%)
Human labour	4399.74	25.41
Machine labour	2311.02	13.34
Seed	1736.54	10.03
Fertilizer & manure	4854.08	28.03
Plant Protection	1457.88	8.42
Irrigation charges	1892.21	10.93
Total operational cost	16651.46	96.15
Interest on working capital	666.06	3.85
Total cost	17317.52	100.00

Marketing efficiency was higher in medium and long channels despite lower producer share. Digital platform use was very limited, with major barriers being fear of fraud, lack of awareness, and trust issues. Key challenges found were limited access to improved seeds, pest incidence, lack of technical support, poor value addition infrastructure, and limited financial access. Overall, strengthening institutional support, digital awareness, and market linkages is essential for improving greengram supply chain performance in Bihar.

Conservation of Lac insect genetic resources

Under the Network Project led by ICAR NISA, Ranchi, extensive surveys and field-level interventions were undertaken in Eastern Uttar Pradesh and Banka district of Bihar during 2024-25. A survey across 16 districts of Eastern UP covering 115 blocks revealed natural occurrence of lac insects (*Kerria lacca*) in 6 districts and 9 blocks. *Ficus religiosa*, *F. benghalensis* and *F. rumphii* were identified as major host plants. These findings provide valuable baseline information for promoting scientific lac cultivation in the region. Farmer-participatory Rangeeni lac cultivation was strengthened in Banka district (Fig.18.8). During Baisakhi crop, 150 kg broodlac was harvested from 38 palas and 5 ber trees using 76 kg inoculum. The Katki

Fig. 18.8 Inoculation of broodlac, crop growth and harvesting of lac (2024-25) in Banka district

crop expanded to four villages with inoculation of 150 kg broodlac on 200 palas trees, yielding approximately 340 kg broodlac. Subsequently, 340 kg broodlac was inoculated on 232 trees for the Baisakhi 2024-25 crop, showing satisfactory settlement and healthy crop condition. The project successfully expanded area coverage, improved broodlac production, and enhanced farmers' awareness, contributing to conservation and livelihood promotion through scientific lac cultivation.

Agri-Business Incubation

Under the ABI Project, four entrepreneurs were admitted for incubation in 2025, focusing on innovations in nursery production, organic fertilizer development, and herbal tea value addition across Jharkhand and Bihar (Tables 18.2, 18.3, 18.4 and 18.5).

Table 18.2 Incubatees admitted for incubation under ABI Project

Incubatee's name	Mobile No.	Area specification	Date of MoA
M/s Agharth Agro Pvt. Ltd.	91559 38666	Mushroom production and processing	02 July, 2025
M/s Farm Fresh 4u	72093 26385	Mushroom, production and processing	07August, 2025
M/s Akshya Mahua Agro- Business Pvt. Ltd.	70505 78623	Value addition and processing of Mahua	10 October, 2025

Table 18.3 Entrepreneurs/Incubators graduated

Area specification	Incubatee's name & mobile No.	Brief description / Status
Livestock and Poultry	M/s Aahaarsetu Technology Pvt. Ltd.,80347 90572	Engaged in livestock and poultry technologies
Nursery (Medicinal Plants) Production in Polyhouse	M/s Pararth Community Farm Livelihood Development	Engaged in nursery production of medicinal plants
Value Addition in Ayurvedic Products	M/s Albina Agri & Ayurvedic Products 90656 14332	Value addition in agriculture and herbal products
Grafted Tomato Plants	MS Murmu High-tech Nursery 99343 33551	Grafted tomato plants under the firm Murmu Hi-Tech Nursery
Amino Acid Fertilizer from Hairs	M/s Myrika Agro Pvt. Ltd. 78588 71016	Amino acid based organic fertilizer from hairs for agriculture applications

Table 18.4 Entrepreneur Development Programme (EDPs) organized

Name of programme	Date of programme	Participants (No.)	Type of participants
ABI-entrepreneurship orientation programme on mushroom production and processing	31 Jan., 2025	50	ABI Incubatee/farmers/ students
Entrepreneurship orientation programme on mushroom production and processing	11 May., 2025	25	Agripreneurs
Livelihood and entrepreneurship	03 Nov., 2025	25	Scientists, farmers & agripreneurs
Tribal agri-entrepreneurship summit-connecting farmers and agri-startups	13 Nov., 2025	50	Scientists, SMS, tribal farmers, agripreneurs

Table 18.5 New products/ technologies developed under incubation

Entrepreneur / Startup	Product / Technology developed	Key features / Description	Status / Remarks
M/s Pararth Community Farm Livelihood Development, Gumla	Medicinal Plants & Value-Added Products	High-quality medicinal plants produced in polyhouses; products include herbal extracts and formulations for health and wellness	Currently in production and market promotion, farmers trained
M/s Albina Agri and Ayurvedic Products, Ranchi	Ayurvedic Medicinal Formulations (Oil, Herbal Products)	ITK-based Ayurvedic formulations, developed from local medicinal plants; brand "Epil Ranu Sunum"	Product line established; market-ready and promoted
M/s Eco Life India, Hajipur	Herbal Tea Blend & Value-Added Products	Herbal tea blends using local organic herbs and spices; under certification (FSSAI, AYUSH, organic, trademark)	Product development ongoing; field visits and awareness conducted
M/s Netarhat Beverages Pvt. Ltd, Latehar	Strawberry Plants & Fruits	High-quality strawberry saplings; year-round production using polyhouse technology; premium strawberries for direct sale or processing	Established polyhouse nursery; demonstrated commercial production

Chapter 19

KRISHI VIGYAN KENDRAS

Photo: Women's Day celebration at KVK Ramgarh

Krishi Vigyan Kendra (KVK), Buxar and KVK, Ramgarh continue to play a vital role in bridging the gap between agricultural research and field-level application through technology assessment, refinement, demonstration, capacity building, and extension support. During 2025, both KVKs made substantial contributions toward enhancing farm productivity, promoting climate-resilient agriculture, strengthening livelihood opportunities, and improving outreach among farmers, rural youth, women, and producer groups. Their efforts were aligned with the broader mandate of the institute for farmer-centric technology dissemination and sustainable agricultural development. Given below are the performances of both KVKs in nutshell.

KVK Buxar

KVK Buxar organized 170 major activities during 2025, including 65 training programmes, 7 demonstrations, 2 CFLDs on oilseeds, and 96 awareness programmes, benefiting 28,668 farmers. Training programmes reached 2,758 participants (2,058 male and 700 female) on improved crop production, integrated nutrient and pest management, mushroom cultivation, seed production, natural farming, climate-resilient agriculture, and farm mechanization.

Technology assessment and refinement

Under OFTs, KVK Buxar evaluated rice-based IPM technologies. During Kharif 2025, Buprofezine 25 SC and Chlorantraniliprole + Fipronil/Thiamethoxam for Brown Plant Hopper management in paddy outperformed Imidacloprid spray, resulting in 13.35–13.87% higher yield.

Frontline Demonstrations (FLDs)

FLDs covered 233 farmers and included paddy varieties (Rajendra Sweta, CO-51, Swarna Samridhi), zero-tillage wheat, finger millet (RAU-8), barnyard millet, sesame [CUMS-17 (Suprava)] and oyster mushroom. Yield advantages recorded were 32.18% in Rajendra Sweta, 30.0% in barnyard millet, 25.0% in oyster mushroom, and 16.27% in sesame.

Cluster Frontline Demonstrations (CFLDs) on oilseeds

Improved mustard and linseed production technologies were demonstrated in 315 ha across 25 villages covering 693 farmers. Mustard occupied 300 ha with 625 farmers and linseed 15 ha with 68 farmers. Technologies included line sowing, seed treatment, nutrient management, and foliar application of NPK 18:18:18.

Seed production and revenue generation

The KVK produced 126.7 quintals of paddy, wheat, chickpea, and lentil seed, generating Rs. 7,44,186.

Extension activities and farmer outreach

KVK Buxar organized 520 extension activities reaching 26,326 participants through Kisan Melas, field days, Kisan Goshthis, demonstrations, advisory services, scientific visits, animal health camps, and exposure visits. Group discussions (137) reached 14,154 participants, while 105 farmers' visits involved 3,068 participants. Major events included PM-KISAN live streaming, Krishi Choupal, safe IPM awareness programmes, fisheries awareness programmes, World Soil Day celebrations, Yoga Day and Viksit Krishi Sankalp Abhiyan (Fig 19.1- 19.3). Under the campaign, 134 panchayats in 11 blocks were covered, reaching 14,832 farmers.

Other significant achievements of KVK Buxar

Major achievements included promotion of zero-tillage wheat in 45,000 ha benefiting 65,850 farmers, groundwater recharge of 6–8 feet through raised bunding in 114 ha among 65 farmers, and 14.4% higher

Fig. 19.1 Krishak Samvad cum Krishi Pradarshani

Fig. 19.2 Outreach programme on fisheries

Fig. 19.3 Yoga Sangam at KVK, Buxar

rice yield in 35 ha through alternate wetting and drying. Raised-bed pigeon pea–maize intercropping in 65 ha covering 235 farmers resulted in 16.5% higher productivity and water savings. The KVK also facilitated utilization of 69.5 tonnes of crop residue as fodder in 15 ha, provided custom hiring services to 24 farmers covering 96 ha, and extended technical support to 4 FPOs involving over 2,100 farmers and 2,500 shareholders.

KVK Ramgarh

KVK Ramgarh organized 208 programmes reaching 26,523 farmers, comprising 67 training programmes, 21 demonstrations, and 120 awareness programmes. Participants included 10,802 males and 15,721 females.

Capacity building and awareness

Training programmes (67) benefited 2,135 participants and awareness programmes (120) reached 23,400 participants on crop production, mushroom cultivation, natural farming, water conservation, integrated farming systems, livestock management, and entrepreneurship development. The KVK also provided 1,459 advisory services benefiting 8,190 farmers, organized 148 KVK visits involving 2,279 farmers, and facilitated six live telecasts reaching 1,247 participants.

Technology assessment through OFTs

OFTs covered crops, livestock, horticulture, ICT, and extension methodologies, including rubber mat flooring in dairy cows, probiotics and enzyme supplementation in poultry, biomass mulching in mango, organic input management in papaya, cauliflower extension methods, and grafted tomato for wilt management.

Frontline Demonstrations

FLDs covered 22 interventions involving wheat (DBW-222), chickpea (Birsa Chana-3), rice varieties Swarna Shreya, Swarna Samridhi and CR Dhan 320, sesame [Suprava (CUMS-17)], Niger (JNS-28), oyster mushroom, backyard poultry, quail, pig farming, vegetable crops, and finger millet (BBM-10).

CFLD on oilseeds

Under mustard CFLD, 200 ha across 14 villages covering 625 farmers were demonstrated with variety DRMR-150-35 along with seed treatment and balanced fertilization (80:40:40:20 N:P:K:S).

Seedling, sapling, and seed production

KVK Ramgarh produced 32.22 quintals of rice seed generating Rs. 1,45,000; 5,383 mango grafts generating Rs.4,84,540 and 151,667 vegetable seedlings generating Rs. 2,27,500.

Extension activities and outreach

Extension activities included Kisan Melas, field days, Krishak Choupals, Kisan Goshthis, workshops, advisory services, scientific and exposure visits, animal health camps, and live telecasts. Under the Tribal Sub-Plan, entrepreneurship development in piggery, mushroom cultivation, tailoring, and women entrepreneurship transformed Udlu village into a model village (Fig. 19.4-19.6).

Other major achievements of KVK Ramgarh

Major achievements included promotion of improved oilseed varieties in 200 ha benefiting 625 farmers, finger millet in 20 ha covering 75 farmers, climate-resilient rice in 90 ha benefiting 195 farmers, high-yielding tomato and brinjal in 60 ha, drip

irrigation with mulching in 800 ha benefiting 3,575 farmers, Integrated Farming Systems in 15 ha covering 12 farm families, and natural farming in 25 ha.

Additional initiatives included soil health management among 1,200 farmers, entrepreneurship development through piggery, mushroom and poultry enterprises, backyard poultry among 150 rural women, livestock health support, establishment of 45 vermicompost/NADEP units and 40 nutritional kitchen gardens, and support to FPOs for market linkage and price realization.

Fig 19.4 Tribal farmers meeting at KVK, Ramgarh

Fig 19.5 Janjatiya Gaurav Diwas at KVK, Ramgarh

Fig. 19.6 Farmers' Fair and Exhibition at KVK, Ramgarh

Chapter 20

Viksit Krishi Sankalp Abhiyan

Photo: VKSA team interacting with farmers at Jamuwara, Gaya Ji

Implementation of Viksit Krishi Sankalp Abhiyan (VKSA) – 2025 in Bihar and Jharkhand

2025 is one of the largest national agricultural outreach campaigns ever undertaken by the Government of India. Conceived under the vision of Viksit Bharat @2047, the campaign aimed to bridge the gap between agricultural technologies developed in research laboratories and their adoption at the grassroots, thereby accelerating agricultural transformation. Initiated by the Ministry of Agriculture and Farmers' Welfare and implemented through the Indian Council of Agricultural Research (ICAR), the campaign sought to deliver modern, climate-resilient, and resource-efficient agricultural technologies directly to rural farming communities. In Bihar and Jharkhand, the responsibility for planning, coordinating, and implementing the programme was entrusted to ICAR RCER, Patna, (Fig. 20.1) which served as the nodal agency coordinating

(a)

(b)

Fig. 20.1 (a) Hon'ble Minister of Agriculture and Farmers' Welfare Shri Shivraj Singh Chouhan reviewing the progress of Viksit Krishi Sankalp Abhiyan in Bihar (b) Inaugural session of VKSA at Patna

State Agricultural Universities, ICAR institutes, Krishi Vigyan Kendras (KVKs), State Agriculture Departments, ATMA units, and other associated agencies. Through this highly coordinated effort, the campaign covered 62 districts in Bihar and Jharkhand, reaching an unprecedented number of farmers with scientific advisories, technology demonstrations, and comprehensive agricultural solutions.

The campaign was conducted from 29 May to 12 June 2025, during which more than 8.58 lakh farmers in Bihar and Jharkhand directly benefited through 7,201 village-level programmes. ICAR-RCER, Patna played a pivotal role not only as the coordinating institution but also in direct field-level implementation. A multi-tier coordination mechanism was established, with guidance from ICAR Headquarters and the Agricultural Technology Application Research Institute (ATARI), Patna at the national level; strategic planning with senior officials of the Agriculture Departments and State Agricultural Universities at the state level; and implementation through 162 multidisciplinary scientific teams at the district level. A digital dashboard developed by the National Informatics Centre (NIC) was used for daily monitoring of village visits, farmer participation, field observations, and photographic documentation. Dedicated WhatsApp groups and a centralized control room ensured seamless coordination throughout the 15-day campaign. Extensive pre-campaign planning clarified responsibilities, selected villages, arranged transportation, and standardized technical messages to be communicated to farmers.

The campaign primarily focused on disseminating crop-specific, climate-resilient, and regionally appropriate technologies. Farmers across both states received detailed guidance on improved varieties of rice, pulses, maize, vegetables, and millets. Considering the predominance of rice-based farming systems in eastern India, special emphasis was placed on rice cultivation. Farmers were introduced to drought-tolerant varieties such as Sahbhagi Dhan and DRR-42, flood-tolerant varieties such as Swarna Sub-1 and Samba Mahsuri Sub-1, and high-yielding varieties suitable for irrigated conditions. Improved varieties of pigeon pea, mungbean, maize, and millets were also promoted to diversify cropping systems and enhance resilience to climate risks. Integrated weed and pest management strategies, particularly for Fall Armyworm in maize, were widely disseminated. Alongside crop production technologies, significant emphasis was placed on natural resource management and soil health. Farmers were encouraged to utilize Soil Health Cards and adopt balanced fertilizer application based on soil test recommendations. The

campaign promoted green manuring using dhaincha and sunhemp to restore soil organic matter and reduce dependence on chemical fertilizers. Water management interventions such as micro-irrigation, solar pumps, farm ponds, and rainwater harvesting structures were recommended, especially for water-scarce and rainfed areas. Resource conservation technologies including zero tillage, mulching, and crop residue management were promoted as key components of sustainable and climate-smart agriculture.

Fig. 20.2 Glimpses of ICAR RCER team interacting with farmers in Viksit Krishi Sankalp Abhiyan

Another important aspect of the campaign was the dissemination of technologies related to livestock, poultry, and fisheries, which are integral to rural livelihoods. Farmers were sensitized about vaccination against diseases such as Foot and Mouth Disease (FMD) and Peste des Petits Ruminants (PPR), deworming, and scientific breeding management. The campaign also emphasized fodder production, establishment of fodder banks, silage preparation, and cultivation of high-yielding fodder varieties such as Hybrid Napier. In Jharkhand, where integrated farming systems are widely practiced, information on crop–livestock–fishery–horticulture integration generated considerable interest among farmers. In horticulture, technical guidance was provided on pit preparation, nursery management, grafting, and pest and disease management in mango, litchi, guava, and banana. Demonstrations of drone technology for nutrient application and pesticide spraying attracted significant attention and introduced farmers to emerging precision agriculture technologies.

The campaign also served as an effective platform for enhancing awareness about various government schemes. It was observed that many farmers were still unaware of programmes such as PM-KISAN, Pradhan Mantri Fasal Bima Yojana (PMFBY), Kisan Credit Card (KCC), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), micro-irrigation subsidy schemes, and the initiative for formation of 10,000 Farmer Producer Organizations (FPOs). During the campaign, these schemes, their benefits, eligibility criteria, and application procedures were explained in simple language. Distribution of extension literature, field demonstrations, and interactive question-and-answer sessions further enhanced farmers' understanding.

In Bihar, the campaign reached 5.68 lakh farmers across 5,991 villages. ICAR RCER, Patna deployed 15 scientific teams that actively worked in Patna, Gaya, Buxar, Bhojpur, Nawada, Jehanabad, and Arwal districts. The highest farmer participation was recorded in Sitamarhi, Saharsa, and Nawada districts. Farmer interactions highlighted several major agricultural challenges, including low productivity of cereals and pulses, fragmented landholdings, groundwater depletion in South Bihar, recurring floods in North Bihar, inadequate storage and processing infrastructure, and limited mechanization. Farmers also emphasized issues such as poor availability of quality seed, crop damage by wild animals including nilgai and wild boar, and delays in fertilizer supply. These discussions identified several future research priorities, including climate-resilient rice varieties, yellow mosaic virus-resistant mungbean

and vegetable varieties, quality planting material production technologies, and shelf-life enhancement technologies for fruits such as litchi and jackfruit. The campaign also documented valuable indigenous innovations, including seed treatment using cow urine, jaggery, and vermicompost in Nawada, traditional rice storage practices in East Champaran, and indigenous fruit fly management techniques in mango orchards in Patna.

In Jharkhand, where the campaign was led by the Farming System Research Centre for Hill and Plateau Region, Ranchi, approximately 2.9 lakh farmers participated through programmes conducted in 3,820 villages. Women constituted 53% of the total participants, with substantial representation from tribal and Scheduled Caste communities. Considering the state's unique agricultural challenges—including undulating terrain, poor soil fertility, limited irrigation, and dependence on rainfall—the campaign emphasized millet cultivation, poultry and piggery-based income generation, fisheries-based livelihoods, and water conservation structures. Special efforts were also made to strengthen women farmer groups and Farmer Producer Organizations (FPOs).

Overall, the Viksit Krishi Sankalp Abhiyan in Bihar and Jharkhand emerged as a landmark initiative due to both its unprecedented scale and significant impact. By integrating scientific knowledge, local experience, modern technologies, and real-time farmer feedback, the campaign established an effective agricultural extension model. Importantly, it generated valuable field-level insights to guide future agricultural research, extension strategies, and policy formulation. The coordinated efforts of ICAR, State Governments, Krishi Vigyan Kendras, and partner institutions transformed the campaign into an exemplary model of participatory, technology-driven rural development. By empowering farmers with knowledge, strengthening institutional convergence, and promoting sustainable agricultural practices, the Viksit Krishi Sankalp Abhiyan has laid a strong foundation for building a resilient, productive, and prosperous agricultural sector in line with the vision of Viksit Bharat@2047.

Chapter 21

KSKS, PRAYAS & NEH INITIATIVES

Photo: PRAYAS activity at Malda, West Bengal

Technology dissemination is a cornerstone of agricultural research, ensuring that scientific innovations reach farmers and other stakeholders in a timely and effective manner. Through targeted outreach, capacity building, skill development, and participatory interventions, research outcomes are translated into practical technologies that enhance productivity, profitability, sustainability, and livelihood security. In this direction, ICAR RCER has adopted a multi-pronged approach to strengthen technology transfer across diverse agro-ecological regions and farming communities. The institute implements Kaushal se Kishan Samriddhi (KSKS) to promote skill-oriented technology dissemination, while PRAYAS serves as a unified platform integrating the Scheduled Caste Sub-Plan (SCSP) and Tribal Sub-Plan (TSP) programmes to ensure inclusive and equitable access to agricultural technologies among socially disadvantaged communities. In addition, the institute undertakes dedicated interventions under the North Eastern Hills (NEH) Initiative to address the region-specific needs of the North Eastern Hill states through location-specific technologies and capacity-building programmes. Together, these initiatives reflect ICAR RCER's commitment to accelerating the adoption of improved agricultural technologies, strengthening farmers' capacities, and fostering inclusive, sustainable agricultural development. The major technology dissemination initiatives implemented by the institute during the reporting period are presented in the following sections:

- **Kaushal se Kishan Samriddhi (KSKS)**
- **PRAYAS**
- **NEH Initiative**

Kaushal Se Kisan Samriddhi: A flagship programme under SCSP and TSP for rural youth and women

"Kaushal Se Kisan Samriddhi" has been conceptualized as a flagship initiative under the Scheduled Caste Sub Plan (SCSP) and Tribal Sub Plan (TSP). The programme aims to bridge the skill gap, enhance employability, and promote entrepreneurship in agriculture and allied sectors through a structured, inclusive, and demand-driven capacity-building approach.

Systematic Participatory Approach

The programme adopts a systematic participatory approach, ensuring that training interventions are demand-driven, locally relevant, and outcome oriented. The framework is built on five key pillars: Targeted Outreach, Participatory Need Assessment, Modular Training Design, Hands-on and Practical Exposure, Post-training Linkages, and Implementation Strategy as shown in Fig. 21.1

The trainings conducted under SCSP and TSP are

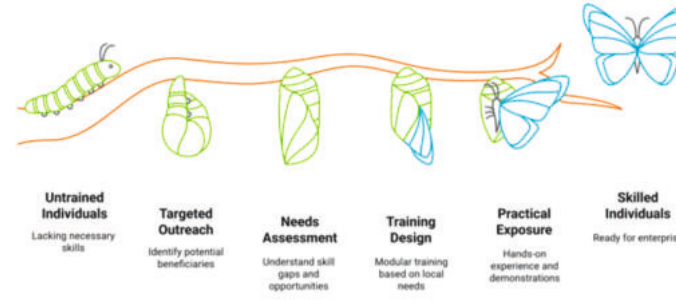


Fig. 21.1 Steps followed in skilling rural youth

given in Table 21.1 and Table 21.2, respectively. The training targeted skilling the youth, knowing the technology, imparting knowledge, understanding the challenges, supporting them in terms of marginal inputs, and providing them sustenance by running the business. The farmers were provided with skills in tailoring (Fig. 21.2), and they were provided with basic knowledge on digital agriculture through the use of

Fig. 21.2 Basic tailoring skill training to SC women farmers

computer operations (Fig. 21.3). In addition, the farmers were also given practical training on direct-seeded rice production (Fig. 21.4).

Participatory Research Application for Year-round Income and Agricultural Sustainability (PRAYAS)

Under the PRAYAS (Participatory Research Application for Year-Round Income and Agricultural

Table 21.1 Trainings conducted under SCSP fund

S. No.	Title of training/exposure visit/awareness program	Duration	No. of participants M- male; F- female			Institute involved	Venue of training
			M	F	Total		
1	Basic Tailoring Skill Training Brings New Livelihood Opportunities for SC Women Farmers	15-19 Sep., 2025	0	10	10	ICAR RCER Patna and KVK Malda, WB	KVK Malda
2	Empowering Farmers through Digital Agriculture	1-5 Dec., 2025	14	0	14	ICAR RCER	ICAR RCER, Patna
3	Income generation Through Mushroom Production	14-16 Nov., 2025	17	3	20	KVK, Buxar	KVK Buxar
4	Income generation Through Mushroom Production	10-12 Nov., 2025	0	20	20	KVK, Buxar	KVK Buxar
5	Power tiller driving and preventive maintenance	4-6 Aug., 2025	5	0	5	KVK Ramgarh	KVK Ramgarh
6	Training cum exposure visit on "Direct Seeded Rice Production System"	25 Sep., 2025	30	16	46	ICAR RCER Patna	ICAR RCER Patna
7	Improvement of livelihood of fish farmers through integrated wetland management	21 Nov., 2025	40	10	50	ICAR RCER Patna	Kanwar Lake, Ekamba Panchayat, Begusarai, Bihar
8	ग्रामीण युवा एवं महिलाओं के लिये बकरी पालन आधारित उद्यमशीलता हेतु कौशल प्रशिक्षण	10 - 12 Jul., 2025	8	22	30	ICAR RCER Patna	Village - Balua Fatehpur, Block - Narpatganj, Distt- Araria, Bihar
9	ग्रामीण युवा एवं महिलाओं के सशक्तीकरण हेतु सतत बकरी पालन एवं कौशल विकास	17-19 Nov., 2025	6	24	30	ICAR RCER Patna	Village - Khairimal, Block - Chakia, Distt East Champaran, Bihar
10	पोषण एवं नारी सम्मान समारोह (Poshan and Women Recognition Celebration)	21 Nov., 2025	0	150	150	ICAR RCER Patna	ICAR RCER Patna

Sustainability) initiative, a multi-state intervention strategy was implemented to enhance farmers' income, livelihood diversification, and nutritional security through location-specific, integrated farming approaches. The results indicate substantial improvements in average net income across all participating states between 2023 (pre-intervention) and 2025 (post-intervention) (Fig.21.5).

Jharkhand recorded one of the highest gains, with average annual family income increasing from Rs. 85,900 to Rs. 1,19,000 (38.53%). This growth is attributed to the convergence of traditional knowledge with improved technologies such as TND piggery, improved vegetable and drought-tolerant paddy varieties, poultry, duck rearing, and scientific livestock health management. Similarly, Bihar demonstrated a 36.84% rise in income (Rs. 76,000 to Rs. 1,04,000), driven by backyard farming, nutri-garden promotion,

Table 21.2 Trainings conducted under TSP fund

S. No.	Title of training/exposure visit/awareness program	Duration	No of participants			Institute involved	Venue of training
			M	F	Total		
1	Brainstorming Workshop program on Rice Fallow Management through Conservation Agriculture Technology	04 Dec., 2025	50	0	50	FSRCHPR, Ranchi (ICAR RCER), College of Agriculture and Research Centre, Jashpur (IGKV) & KVK Jashpur	College of Agriculture and Research Centre, Kunkuri, Jashpur, Chattisgarh
2	Grafting techniques in Solanaceous and Cucurbitaceous Vegetable Crops	8-12 Dec., 2025	8	17	25	FSRCHPR, Ranchi ICAR RCER	FSRCHPR, Ranchi ICAR RCER
3	Castration and Vaccination in Livestock and Poultry (Practical Training for Skill Development and Rural Livelihood Generation)	15-19 Dec., 2025	10	0	10	FSRCHPR, Ranchi ICAR RCER	FSRCHPR, Ranchi ICAR RCER

*M- male; F- female

Fig. 21.3 Empowering farmers through digital agriculture at ICAR RCER, Patna

Fig. 21.4 Training on "Direct seeded rice production system" at ICAR RCER, Patna

rice-fallow intensification, mushroom cultivation, and farm mechanization support. Odisha achieved a 27.92% increase (Rs. 46,200 to Rs. 59,100) through poultry-based interventions, improved vegetable seeds, mini rice mills, and mineral supplementation. Eastern Uttar Pradesh recorded a 21.11% rise (Rs. 78,850 to Rs. 95,495) through vegetable-based productivity enhancement and improved crop varieties. Assam and Chhattisgarh reported income increases of 18.68% and 19.58%, respectively, reflecting the positive impact of horticulture-based systems, water facility development, goat-based interventions, and rice-fallow management. West Bengal showed moderate yet stable growth of 14.67% (Rs.1,52,000 to

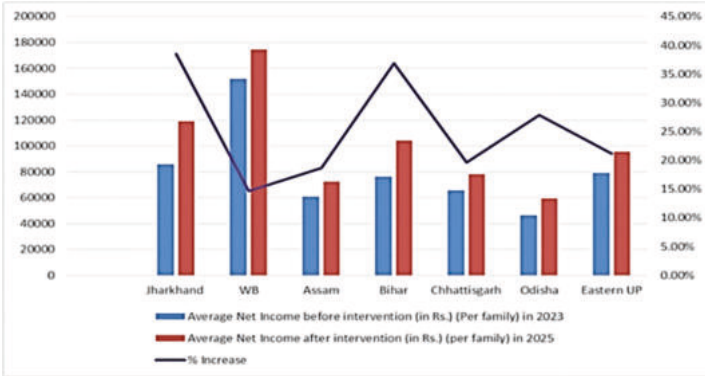


Fig. 21.5 Economic impact of PRAYAS interventions

Rs.1,74,300), supported by mushroom cultivation, goat rearing, nutrigardens, poultry, hybrid crops, and fishery integration. The PRAYAS demonstrates that diversified, context-specific, and participatory agricultural interventions can significantly enhance farm income, strengthen livelihood resilience, and promote sustainable intensification across eastern and northeastern India.

The NEH Initiatives

ICAR RCER, Patna, pursued a distinctive and forward-looking approach for the North Eastern Hill (NEH) region during January to December 2025 through a novel four-pillar strategy that moved beyond conventional technology transfer and placed equal emphasis on institutional partnership, mutual learning, farmer capacity enhancement, and field-level validation of technologies (Fig. 21.6). The strategy was conceived in recognition of the fact that the NEH region, with its diverse agro-ecologies, small and fragmented holdings, fragile landscapes, high rainfall, and difficult market access, requires context-specific, participatory and partnership-based interventions rather than a one-way extension approach. Drawing upon more than two decades of research experience in the Eastern region, ICAR RCER aligned its strengths in climate-resilient agriculture, integrated farming systems, horticulture, livestock, fisheries, land and water management, and socio-economic innovation with the emerging priorities of NEH agriculture.

The first pillar of this strategy focused on institutional engagement through stakeholder consultation and needs assessment. The second pillar promoted two-way knowledge and experience sharing by bringing NEH stakeholders to ICAR RCER platforms and by linking the scientists of the Institute with field realities in the hill region. The third pillar centered on farmer capacity building under the broad spirit of Kaushal se Kisan Samriddhi. The fourth pillar emphasized on-

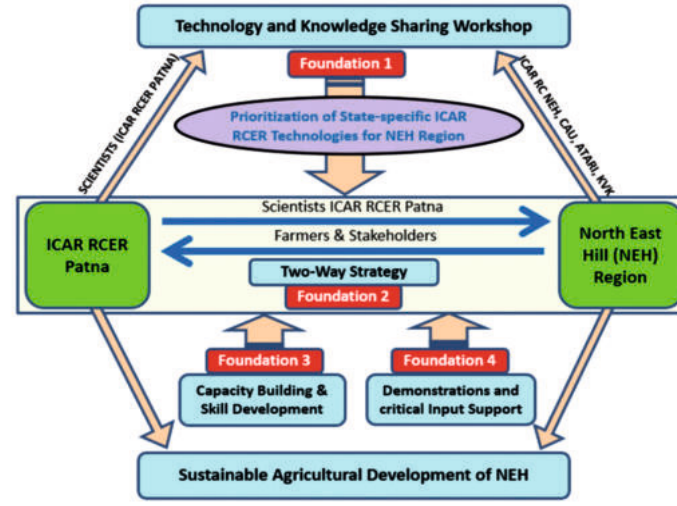


Fig.21.6 Process model for implementation of NEH component by ICAR RCER

ground demonstrations and critical input support so that improved technologies could be translated rapidly into field practice through location-specific models, quality seed and planting materials, livestock and fishery inputs, tools, micronutrients, and other essential supports.

Within this strategic framework, ICAR RCER undertook a series of major initiatives across the NEH region during 2025, covering workshops, collaborative programmes, training, demonstrations, exhibitions, and farmer-oriented input support. A major institutional milestone during the year was the Technology and Knowledge Sharing Workshop organized at ICAR RCER, Patna on 22-23 September 2025, and the details of which have been given under Chapter 26 (Major Events Chapter). This was followed by a team of farmers who visited ICAR RCER, Patna for an exposure visit to understand the latest technologies in integrated farming system (Fig. 21.7).

Under second major thrust, the institute organized the five-day programme on "Recent Advances in Horticulture for Farmers' Prosperity" for farmers from Tripura from 4-8 November 2025, with 23 participants, at FSRCHPR, Ranchi (Fig. 21.8). The programme addressed the need to strengthen horticulture-based livelihoods in the NEH region through scientific production, protected cultivation, integrated farming, value addition, and entrepreneurship. The curriculum included techniques on grafted vegetables, nursery management, integrated pest management, multi-tier systems, vermicomposting, horticultural business development, and field visits, thereby helping farmers understand not only production technologies but also

Fig. 21.7 Farmers' team during exposure visit from NEH region to ICAR RCER, Patna

enterprise opportunities. Quality seeds, planting materials, and improved inputs were also distributed so

Fig. 21.8 Field exposure to NEH farmers at FSRCHPR, Ranchi

that trainees could initiate field-level demonstrations after returning to their locations (Fig. 21.9).

Another important collaborative intervention in 2025 was the National Workshop on strengthening FPOs for agri-enterprise development and sustainable livelihoods in rural border communities, held at Tawang, Arunachal Pradesh on 12-13 September 2025 (Fig. 21.10). This initiative, organized with CAU Imphal and associated institutions, brought together about 200 participants, while critical agricultural inputs were provided to 150 farmers and FPO representatives.

The institute enhanced its outreach in the NEH region through participation in the CAU Regional Agri Fair 2025–26 at Kyrdemkulai, Meghalaya (17-19 November 2025). The event directly reached around 300 farmers and stakeholders, showcasing ICAR RCER technologies on climate-resilient agriculture, integrated farming systems, natural resource management, horticulture, livestock, water management, and sustainable hill agriculture.

Fig. 21.9 NEH farmers during training on advance Horticulture at FSRCHPR, Ranchi

Several field-based demonstration and training initiatives undertaken during 2025 reflected the fourth pillar of the institute's strategy most vividly. This included demonstration of integrated farming system models in Ri-Bhoi district of Meghalaya benefiting 97 stakeholders, land shaping models for enhancing agriculture-horticulture-livestock-fisheries productivity in Imphal West district of Manipur, customized integrated farming demonstrations in Tripura, Nagaland and Mizoram. These demonstration units collectively showed that Institute's interventions were not limited to awareness generation, but extended to real-time establishment of replicable farming models tailored to varied agro-ecologies of the NEH region.

Taken together, the NEH initiatives implemented by ICAR RCER during January to December 2025 revealed a systematic progression from strategy to partnership, from knowledge exchange to farmer training, and from demonstration to field-level adoption support.

Fig.21.10 Director, ICAR RCER with FPO farmer-members in Tawang, Arunachal Pradesh for NEH programme

Chapter 22

WOMEN IN AGRICULTURE

Photo: Rice transplantation at Sabajpura farm

Empowering Women in Agriculture: ICAR RCER's Initiatives for Inclusive Research, Livelihoods and Nutritional Security

Women farmers are the backbone of the agricultural sector, serving as its most vital and steadfast contributors whose efforts often go under-recognized. They play a multifaceted role in ensuring household food security, nutritional well-being, and income generation through their active involvement in both on-farm and off-farm activities. In this context, ICAR RCER has made significant progress in promoting gender inclusion through both scientific research and field-level interventions. The institute has actively integrated gender components across its research, extension, and capacity-building activities. About 2% of research projects and 25% of research activities include gender integration, such as the "Round the Year Demonstration of Vegetable Production Module" and "Swarna e-Vatika" Nutri-Garden, alongside initiatives enhancing nutritional security through homestead and peri-urban farming models.

The institute has developed 14 women-centric technologies promoting nutrition, income, livelihood diversification, and drudgery reduction, widely adopted by women farmers. Four dissemination programmes reached 600 women beneficiaries, while over 50 women farmers were recognized for their contributions. A women led FPO has been established in Nawada, and a dedicated bulletin on women empowerment was published during this year. Women constitute 35% of participants in trainings, technology adoption, and leadership programmes, reflecting their active involvement. Two Gender Cells have been established at Patna and Ranchi, with structured gender-focused interventions underway, including Gender Action Plan initiatives, maternity/childcare support, and encouragement for women scientists. The institute also collaborates with state agencies like BAMETI, Patna, and other organizations for women centric training and innovation programmes.

"Naari Poshan evam samman"–programme organized by ICAR RCER

To support and empower women in agriculture, the institute has organized dedicated programmes aimed at creating awareness on nutrition, health, and overall well-being. Despite the pivotal role played by women, they often face nutritional deficiencies due to limited access to balanced diets, healthcare, and nutrition awareness. Ensuring the nutritional well-being of women is essential not only for their own health and productivity but also for improving family nutrition, child development, and sustainable agricultural livelihoods. Recognizing this vital linkage between women's nutrition and agricultural development, ICAR RCER organized the Naari Poshan and Samman programme on November 21, 2025 to promote nutrition awareness, encourage the adoption of nutrient-rich foods and healthy dietary practices, and honour the invaluable contributions of farm women to agriculture and rural development.

The chief guest, Dr Arti Kumari, HOD department of biotechnology, Patna women's college, highlighted the importance of women's empowerment by emphasizing the pivotal role of women in agriculture, family nutrition, and household decision-making. She underscored the significance of a balanced diet and advocated the concept of "Rango Se Bhara Thaali – Sampurn Aahaar", which encourages the inclusion of diverse, colourful foods to ensure complete nutrition. She also promoted the regular consumption of millets owing to their superior nutritional value, climate resilience, and suitability for smallholder farming systems. Her address motivated participants to adopt healthy dietary practices while exploring entrepreneurship opportunities in agriculture and allied sectors.

Dr. Anup Das, Director, ICAR RCER, Patna, emphasized the importance of self-reliance and encouraged participants to build practical knowledge and confidence through experiential learning in agriculture and allied sectors. He highlighted the need to adopt scientific and field-based farming practices while effectively utilizing various government support schemes. Appreciating the active participation of women, he urged them to strengthen their capacities in agriculture, nutrition, and entrepreneurship. He also emphasized the importance of providing girls with equal opportunities in education, nutrition, skill development, and employment, stating that gender-equitable parenting is fundamental to building a balanced, inclusive, and progressive society.

Fig. 22.1 Glimpses of women centric programmes organized by ICAR RCER Patna

Dr. Shivani emphasized the importance of women's empowerment at both household and community levels, highlighting that empowered women play a pivotal role in improving family well-being, child development, and economic stability. She stressed the importance of consuming a balanced diet comprising cereals, pulses, vegetables, fruits, and other locally available nutritious foods. She also encouraged women to take responsibility for their health, actively participate in household and community decision-making, and benefit from government initiatives promoting women's education, nutrition, and entrepreneurship.

Dr. Kumari Shubha delivered an informative session on the Indian Council of Medical Research (ICMR)-recommended dietary allowances of essential vitamins and minerals for women across different age groups. She highlighted the importance of adequate intake of iron, calcium, folic acid, and vitamin A, the consumption of diversified foods for balanced nutrition, and healthy cooking practices to preserve nutrient content. She encouraged participants to incorporate millets, green leafy vegetables, pulses, and seasonal fruits into their daily diets to achieve nutritional security.

The women scientists of Krishi Vigyan Kendras (KVKs) delivered technical sessions on sustainable agricultural practices, including the use of biofertilizers to reduce dependence on chemical fertilizers, organic farming suitable for smallholder farmers, and the cultivation and consumption of nutri-cereals (millets) as climate-resilient and nutritionally rich crops. They encouraged women farmers to adopt improved technologies for enhancing farm productivity while conserving soil health.

The interactive session featured inspiring experiences shared by women farmers engaged in goat farming, fish farming, beekeeping, lac cultivation, mushroom production, vegetable cultivation, the use of Ayurvedic herbal preparations, seed treatment, tailoring, and homestead gardening. Their success stories demonstrated the potential of diversified farming and allied enterprises in improving household nutrition, enhancing income, and strengthening rural livelihoods.

A series of publications on agriculture, nutrition, women's entrepreneurship, and livelihood enhancement was formally released during the programme. These publications are intended to provide farmers with practical knowledge and scientific guidance for adopting improved technologies and sustainable farming practices.

The programme served as an effective platform for knowledge exchange among scientists, subject matter specialists, and women farmers. Deliberations on nutrition, health, women's empowerment, and sustainable agriculture equipped the participants with valuable scientific insights and practical skills. The event concluded with a vote of thanks, reaffirming the commitment of ICAR RCER to promoting a healthier, nutritionally secure, empowered, and self-reliant farming community.

Gender-responsive research and technology development

The institute has mainstreamed gender considerations across its research and extension programmes. About 2% of research projects and 25% of research activities incorporate gender integration through initiatives such as the Round the Year Demonstration of Vegetable Production Module and Swarna e-Vatika Nutri-Garden, which promote nutritional security

through homestead and peri-urban farming models. ICAR-RCER has also developed 14 women-centric technologies focusing on nutrition, livelihood diversification, income generation and drudgery reduction, which have been widely adopted by rural women. To institutionalize gender-responsive interventions, two Gender Cells have been established at Patna and Ranchi to implement Gender Action Plan initiatives and promote gender-inclusive research and extension activities.

Capacity building and livelihood enhancement

Capacity building remains a major pillar of the institute's women empowerment initiatives. During the year, four dissemination programmes directly benefited nearly 600 women farmers, while more than 50 women farmers were recognized for their outstanding contributions to agriculture. Women constituted nearly 35% of participants in training programmes, technology demonstrations and leadership development initiatives. A women-led Farmer Producer Organization (FPO) was established in Nawada, and a dedicated bulletin on women empowerment was published during the year. In collaboration with BAMETI, Patna and other state agencies, ICAR RCER organized women-centric training programmes and promoted agricultural innovations among rural women.

Institutional support for women scientists

ICAR RCER has created an enabling institutional environment to promote gender equity in agricultural research. Of the 87 research projects currently being implemented, 22 projects (25.3%) are led by women scientists, demonstrating their growing leadership in research. A dedicated Mini Institutional Research Committee (IRC) has been constituted to ensure continuity and periodic evaluation of research during maternity and childcare leave, thereby addressing work-life balance challenges. Competitive research grants under the Institute Corpus Fund are specifically extended to women scientists to encourage innovation and high-quality research. The scientific contributions of women researchers have also received international recognition, including appreciation from Springer Nature for their significant research achievements.

Through these integrated research, extension, capacity-building and institutional initiatives, ICAR RCER continues to promote gender-responsive agricultural development by empowering both women farmers and women scientists. These efforts have strengthened livelihoods, enhanced nutritional security, promoted women's leadership and entrepreneurship, and contributed significantly towards building an inclusive, resilient and sustainable agricultural system in eastern India.

Chapter 23

HUMAN RESOURCE DEVELOPMENT & TRAINING INITIATIVES

Photo: Training on digital agriculture

Human capital development and capacity building are integral components of ICAR RCER's mandate to enhance the knowledge, skills, and competencies of farmers, rural youth, extension personnel, entrepreneurs, and other stakeholders. During the year, the institute organized more than 200 capacity-building initiatives encompassing training programmes, awareness campaigns, animal health camps, field days, exposure visits, farmers' fairs, and farmers–scientists interactions. These programmes were implemented under various national and regional initiatives supported by SCSP, TSP, NEH, AICRP, NPBI, DST, BAMETI, NASF, AnGR, and other institutions/ projects. Through these interventions, the institute facilitated the dissemination of improved technologies, promoted skill enhancement, strengthened stakeholder engagement, and contributed to sustainable agricultural and livelihood development across the region. Given below are few significant initiatives undertaken under the capacity building programme.

Animal health camp, awareness programmes etc. organised

S. No.	Programmes	No.	Participants
1.	Animal health camp	9	438
2.	Awareness programme	7	440
3.	Mushroom Diwas	1	50
4.	Mahila Kisaan Gosthi	1	83
5.	Hands on workshop	1	11
6.	Farmers scientists interaction	1	37

Training programmes organized

S. No.	Training	Date	Participants	Funding source
1.	Training cum demonstration programme on "Scientific cultivation of important rabi crops"	16 Oct.	160	TSP
2.	Recent advances in integrated fish farming	06-10 Jan.	30	Govt. of Bihar
3.	Integrated farming system for livelihood security of farmers	09-11 Jan.	25	RKVY
4.	Integrated farming system for livelihood security	13-15 Jan.	25	RKVY
5.	Integrated farming system for livelihood security	16-18 Jan.	25	RKVY
6.	Production and marketing techniques of rabi crops	17 Jan.	50	DST, New Delhi
7.	Integrated farming system for livelihood security	20-22 Jan.	25	RKVY
8.	Gramin Ajivika sudhar Hetu Samekit mastya palan ki Taknikiyan	20-24 Jan.	22	Govt. of Bihar
9.	Livelihood security of farmers through integrated farming system	21-23 Jan.	25	RKVY
10.	Livelihood security of farmers through integrated farming system	23-25 Jan.	25	RKVY
11.	Horticulture-based IFS	27-31 Jan.	25	ATMA Banka
12.	Integrated farming system for livelihood security	28-30 Jan.	25	RKVY
13.	Field day on multitier cropping system	30 Jan.	32	AICRP On Fruits (TSP)
14.	Animal genetic resources for sustainable farm productivity	04-06 Feb.	6	AnGR
15.	Scientific cultivation of grafted solanaceous and cucurbitaceous crops	10-12 Feb.	25	RKVY
16.	Scientific cultivation of grafted solanaceous and cucurbitaceous crops	13-15 Feb.	25	RKVY
17.	Jharkhand me Vagyanik Vidhi se laghu kaddu vargiyey sabjiyon evam sahjan ki kehti ka utpadan evam prasanskaran	17-19 Feb.	25	RKVY
18.	Tailoring as a tool for social upliftment	01-07 Mar.	10	SCSP
19.	Upliftment of rural livelihood through livestock-fish integrated farming	03-07 Mar.	30	Govt. of Bihar
20.	Mushroom cultivation and their value addition	04 Mar.	50	AICRP Mushroom

21.	Demonstration of multitier farming systems	05 Mar.	34	AICRP On Fruits (TSP)
22.	Cultivation of important minor leguminous crops	10-12 Mar.	25	RKVY
23.	Demonstration of multitier farming systems	12 Mar.	33	AICRP On Fruits (TSP)
24.	Greening rice fallow areas through conservation agricultural practices	17-19 Mar.	28	ICAR RCER
25.	Crop diversification	18-19 Mar.	30	KVK, Piprakothi
26.	Gramin Ajivika sudhar Hetu Samekit mastya palan ki Taknikiyan	18-22 Mar.	30	Govt. of Bihar
27.	Crop diversification	19-20 Mar.	25	KVK, Piprakothi
28.	Cultivation of important minor leguminous crops	19-21 Mar.	25	RKVY
29.	Integrated farming system for rainfed ecosystem	20-22 Mar.	25	SCSP
30.	Improved mushroom production technique	21-22 Mar.	100	AICRP-Mushroom
31.	One day training cum field day on litchi production systems	23 Mar.	20	AICRP On Fruits (TSP)
32.	One day exposure visit of farmers from Lawalong, Chatra	24 Mar.	50	AICRP On Fruits (TSP)
33.	Technology led livelihood improvement of SC farmers	24-26 Mar.	30	SCSP
34.	Role of indigenous of livestock species for enhancing agricultural productivity	25 Mar.	50	TSP
35.	Training cum field day on multitier systems	25 Mar.	28	AICRP On Fruits (TSP)
36.	Round the year vegetable production with resource conservation technology	27-29 Mar.	25	RKVY Project
37.	Role of indigenous of livestock species for enhancing agricultural productivity	29 Mar.	90	NPBI
38.	Exposure visit & training of farmers on multitier systems	09 May.	21	AICRP On Fruits (TSP)
39.	Scientific cultivation of Kharif crops	11 Jun.	55	Farmer FIRST Programme
40.	Exposure visit cum training of farmers on multitier systems	26 Jun.	21	AICRP On Fruits (TSP)
41.	ग्रामीण युवा एवं महिलाओं के लिये बकरी पालन आधारित उद्यमशीलता हेतु कौशल प्रशिक्षण	10-12 Jul.	30	AICRP on Goat
42.	Effective weed management in direct seeded rice production system	16-18 Jul	20	ICAR RCER

43.	Millet production and processing under climate change scenarios	02-04 Sep.	30	ICAR RCER
44.	Upscaling the production technology through integrated farming system	9–13 Sep.	15	TSP
45.	Small scale commercial goat farming	08-10 Oct.	32	AnGR
46.	Integrated farming system for livelihood security	09-11 Oct.	25	TSP
47.	Education and skill development (Mushrooms for nutrition of tribal people: Hands on training) under Janjatiya Gaurav Varsh Pakhwara	02 Nov.	10	TSP
48.	"Livelihood and entrepreneurship- SHGs, startups, tribal product branding" under Janjatiya Gaurav Varsh Pakhwara	03 Nov.	25	TSP
49.	Culture & heritage: digital tribal (Organization and digital documentation of tribal culture and showcasing)" under Janjatiya Gaurav Varsh Pakhwara	05 Nov.	36	TSP
50.	Infrastructure development (Vermibed, polyhouse, fencing etc.) under Janjatiya Gaurav Varsh Pakhwara	07 Nov.	22	TSP
51.	Tribal agri-entrepreneurship summits connecting farmers and agri-start-ups" under Janjatiya Gaurav Varsh Pakhwara	13 Nov.	34	TSP
52.	Establish Tribal farmers' markets for direct sale of produce under Janjatiya Gaurav Varsh Pakhwara	14 Nov.	25	TSP
53.	ग्रामीण युवा एवं महिलाओं के सशक्तीकरण हेतु सतत बकरी पालन एवं कौशल विकास	17-19	30	AICRP on Goat
54.	Income enhancement of farmers through integrated advanced horticultural practices in KVK Dhalai, Tripura	19 Nov.	100	NEH
55.	Soil and water conservation for sustainable agriculture development	20-22 Nov.	35	ATMA, Banka
56.	Harnessing remote sensing, GIS, and machine learning for advanced land and water management	25 Nov.	24	BAMETI
57.	Empowering farmers through digital agriculture	01-05 Dec.	14	Institute SCSP
58.	Scientific cultivation of grafted solanaceous and cucurbitaceous crops	08-12 Dec.	25	RKVY
59.	Integrated farming system: need of the hour	09-12 Dec.	20	BAMETI
60.	Capacity building of scheduled caste farmers on scientific cultivation of important crops	12 Dec.	188	SCSP
61.	Millets farming under climate change scenario	15-19 Dec.	13	ICAR RCER
62.	Castration and vaccination in livestock and poultry	15-19 Dec.	10	TSP

Chapter 24

IARI PATNA HUB

Photo: Secretary, DARE & DG, ICAR interacting with students

Academic status & student activities report - 2025

At present there are 38 UG and 06 Ph.D. students enrolled in IARI Patna Hub. Students are actively engaged in academic, cultural, sports, and wellness activities. These programmes have enhanced their knowledge, fostered team spirit, encouraged cultural participation, and promoted holistic development. Details of activities involving students are given in Table 24.1 - 24.5

Table 24.1 Details of academic programmes - present status

Sl. No	Discipline	Admission year	No. of students	Present status	No. of credit hours for offered courses
1	B.Sc. (Hons.) Agriculture	2023-24	21	Currently in 3rd year (Semester-I)	46
		2024-25	17	Currently in 2nd year (Semester-I)	42
2	M.Tech. (SWCE)	2023-24	2	Passed out	
3	Ph.D.	2023-24	1(SWCE)	Currently in 3rd year (Semester-I)	40 credits
		2024-25	5 Agronomy (3) SWCE (2)	Currently in 2nd year (Semester-I)	25 24

Table 24.2 Details of academic programmes - present status

S. No.	Date	Category	Event / activity
1	03 Jan., 2025	Academic	National workshop on strategies & approaches for greening rice-fallow areas
2	16 Jan., 2025	Institutional	National Youth Day celebration
3	16 Jan., 2025	Cultural	UG fresher's programme
4	26 Jan., 2025	National celebration	Republic Day celebration
5	31 Jan., 2025	Academic interaction	Interaction with dignitaries & IAS trainees
6	02 Feb., 2025	Cultural	Saraswati Puja celebration
7	22 Feb., 2025	Institutional	Participation in ICAR-RCER Silver jubilee Foundation Day & National seminar, PAVER 2025
8	13 Mar., 2025	Cultural	Holi celebration
9	05 Jun, 2025	Environmental	World Environment Day observance
10	21 Jun., 2025	Health & Wellness	International Yoga Day
11	17-18 Jul., 2025	Academic interaction	Interaction with Secretary, DARE & Director General, ICAR
12	15 Aug., 2025	National / Sports	Independence Day celebration & Sports events
13	22 Sep., 2025	Innovation & Outreach	Waste-to-Wealth student presentation
14	14-29 Sep., 2025	Cultural	Hindi fortnight celebration
15	02-31 Oct., 2025	Cleanliness drive	Special Swachhata campaign 5.0
16	31 Oct., 2025	National Unity	Run for Unity Programme & Art/Drawing competition
17	07 Nov., 2025	Cultural	Vande Mataram citation
18	26 Nov., 2025	Constitutional Awareness	Constitution Day celebration & quiz
19	23-24 Dec., 2025	Extension & Outreach	National Farmers' Day & Farmers' Fair

Table 24.3 Student-led cultural & outreach initiative

Sl. No.	Initiative	Description
1	Food & cultural stall	UG students organised a traditional food stall titled "Apna Gaon & Padharo Saa" during institutional programmes

Table 24.4 Details of degree completion - postgraduate programme

S. No.	Name of Student	Programme	Discipline	Year of Completion
1	Mr. Sujit Kumar	M.Tech.	SWCE	2025
2	Mrs. Poonam Sahu	M.Tech.	SWCE	2025

Table 24.5 Competitive examination achievements

S. No.	Name of student	Examination qualified
1	Mr. Sujit Kumar	ARS Prelims
2	Mr. Vishal Gupta	ARS Prelims
3	Mr. Sujit Kumar	ICAR AIEEA (PG/PhD) conducted by NTA
4	Mrs. Poonam Sahu	ICAR AIEEA (PG/PhD) conducted by NTA
5	Mr. Vishal Gupta	NET; ICAR AIEEA (PG/PhD) conducted by NTA
6	Mr. Arijit Garai	NET; ICAR AIEEA (PG/PhD) conducted by NTA

Nomination for Inter-University debate competition

Ashutosh Kumar, III year UG student from IARI Patna Hub, out of four candidates nominated from the entire IARI, has been selected to represent IARI University at "YUVA'26 – 21st National Youth Awakening Festival UDBHAV (19th National Inter-University Debate Competition)".

Chapter 25

SWACHHATA ABHIYAN

Photo: Swachhata Hi Seva 2025: Oath ceremony at ICAR RCER, Patna

Implementation of Swachhata Initiatives under Swachh Bharat Mission, 2025

The institute implemented a series of structured and coordinated initiatives during 2025 to promote cleanliness, sanitation, and administrative efficiency in alignment with national priorities. The activities were conducted at main campus ICAR RCER, Patna, FSRCHPR, Ranchi, and its KVKs located in Buxar and Ramgarh as well as at Sabajpura farm of ICAR RCER, Patna. These included the Swachhata Hi Seva Campaign (17 September - 2 October 2025), the Government of India's Special Campaign 5.0 on Swachhata and pendency reduction (3 - 31 October 2025), and Swachhata *Pakhwada* (16 - 31 December 2025).

The Swachhata Hi Seva Campaign 2025 was implemented with the objective of fostering cleanliness awareness and encouraging community participation. The campaign commenced with the display of banners at strategic locations and administration of the Swachhata pledge to staff and stakeholders. A series of thematic activities were conducted throughout the campaign period, including transformation of Cleanliness Target Units (CTUs), organization of Swachhata Samvad programmes, and outreach initiatives involving school children to promote awareness at the grassroots level. Community engagement was strengthened through activities such as Safai Mitra Suraksha Shivirs, human chain formations, and Clean Green Utsav. Cleanliness drives were also extended to nearby public places, including tourist and religious sites, while nationwide initiatives such as "Ek Din, Ek Ghanta, Ek Saath" facilitated mass participation through collective shramdaan. Innovative activities, including waste-to-art initiatives and cultural programmes under the Swachh Bharat Mission, added further value to the campaign.

Particular emphasis was laid on the welfare and safety of sanitation workers. Personal Protective Equipment (PPE) kits were distributed, access to health services was facilitated, and awareness programmes on social welfare schemes, including financial inclusion, were conducted. The campaign also included stakeholder engagement through media interactions, farmer outreach programmes, and public awareness initiatives. The observance culminated with Swachh Bharat Diwas, during which Safai Mitras were felicitated in recognition of their contributions. All activities were systematically documented through reports and photographic records to ensure transparency and effective monitoring.

Subsequently, the institute actively participated in the Special Campaign 5.0 on Swachhata and pendency reduction from 3 to 31 October 2025. It was initiated with a briefing session to sensitize staff regarding its objectives and implementation strategy. This was followed by sustained cleanliness drives across the institute's campus and its constituent units, including KVKs and research farms. Regular cleaning of office premises, laboratories, common areas, and surrounding environments was undertaken with the active involvement of scientific, technical, and administrative staff. In addition to physical cleanliness, focused efforts were made towards systematic record management, organization of office spaces, and reduction of pendency in administrative processes. Emphasis on proper waste disposal and workplace organization contributed to improved efficiency and a more conducive working environment. The campaign was closely monitored through daily progress reports and photographic documentation. Overall, the initiative resulted in enhanced sanitation standards, improved workplace discipline, and strengthened institutional practices.

Fig. 25.1 Cleanliness activity at ICAR RCER, Patna

Further, the institute also organized Swachhata *Pakhwada* from 16 to 31 December 2025 with active participation of scientists, staff, and students. The fortnight-long programme encompassed campus

cleanliness drives, plantation activities, community outreach, and awareness campaigns promoting hygiene and environmental sustainability. A seminar on "Clean Environment, Healthy Living" was also organized to highlight the importance of sanitation in ensuring public health.

Information, Education, and Communication (IEC) materials, including banners and posters, were displayed across the campus to reinforce awareness messages. Saplings were distributed to encourage environmental responsibility among participants and the wider community. The programme was implemented with adequate logistical support, ensuring the smooth conduct of all activities. The *Pakhwada* concluded with a valedictory session, during which participants and media personnel were acknowledged for their contributions.

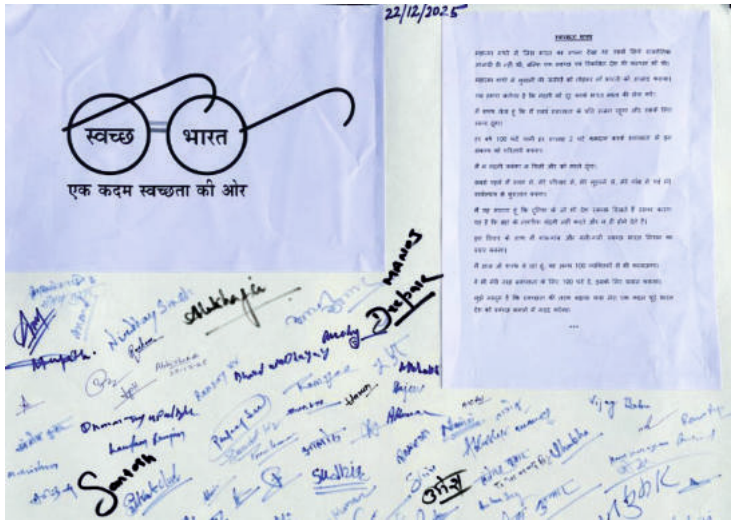


Fig. 25.2 Swachhata Hi Seva 2025: Collective pledge signing ceremony at ICAR RCER, Patna

Fig. 25.3 Swachh Bharat Abhiyan 2025: Community outreach and cleanliness drive organized at public places

Fig. 25.4 IARI Patna hub students participating in Swachhata Hi Seva during 2025

Fig. 25.5 Swachhata Hi Seva during 2025 at KVK Buxer

Chapter 26

MAJOR EVENTS

Photo: Inauguration of micro & nano homestead farming models by Padma Bhushan Dr R S Paroda, Former Secretary, DARE & DG, ICAR

ICAR RCER, Patna celebrated its Silver Jubilee Foundation Day

ICAR RCER, Patna celebrated its Silver Jubilee Foundation Day from 20–22 February 2025 under the theme "Progressive Agriculture – Viksit Bharat: Preparedness for Eastern India (PAVER 2025)" (Fig. 26.1 and Fig. 26.2). The three-day event comprised a

Fig. 26.1 Address by Dr Himanshu Pathak during RCER foundation day

Fig. 26.2 Foundation day celebration at ICAR RCER, Patna

National Seminar, Kisan Mela, Foundation Day celebrations, exhibitions, and stakeholder interactions focusing on sustainable agricultural development in Eastern India.

Padma Bhushan Dr. R.S. Paroda, Chairman, TAAS and former Secretary (DARE) & DG, ICAR, the chief guest of the inaugural function of the national seminar emphasized the need for eco-region-specific and interdisciplinary research to drive the Second Green Revolution in Eastern India and advocated a transition towards integrated farming systems for sustainable agriculture. Dr. Himanshu Pathak, Secretary (DARE) and DG, ICAR, highlighted the immense agricultural potential of Eastern India and stressed the adoption of climate-resilient and biofortified crop varieties, eco-friendly farming practices, and stronger linkages between research and farmers. Dr. B. Rajender, IAS, Additional Chief Secretary, Government of Bihar, emphasized close collaboration between policymakers and scientists and the wider dissemination of agricultural technologies.

Dr. Anup Das, Director, ICAR RCER, highlighted the Institute's major achievements, including the development of climate-resilient crop varieties, integrated farming and land-use models, technologies for sustainable agricultural intensification, and innovations in livestock, fisheries, water management, and agrivoltaic systems aligned with the vision of Viksit Bharat 2047. The Silver Jubilee celebration attracted over 2,000 farmers and stakeholders and featured 50 exhibition stalls showcasing agricultural technologies, innovations, and entrepreneurship opportunities. Progressive farmers, media personnel, and Institute employees were also honoured for their outstanding contributions. The chief guest of the valedictory function, Dr Sanjay Kumar, Chairman, Agricultural Scientists Recruitment Board, emphasized the transformative role of mechanization and innovative engineering in shaping the future of agriculture.

Shri Shivraj Singh Chouhan, Hon'ble Union Agriculture Minister visited ICAR RCER, Patna

Hon'ble Union Minister of Agriculture and Farmers' Welfare, Shri Shivraj Singh Chouhan, visited the ICAR RCER, Patna, and reviewed the Institute's research and development initiatives aimed at accelerating agricultural transformation in Eastern India. The Hon'ble Minister was accompanied by Shri Vijay Kumar Sinha, Hon'ble Deputy Chief Minister-cum-Agriculture Minister, Government of Bihar, along with senior officials from the Government of India and the State Government (Fig. 26.3).

The Director, ICAR RCER, Patna highlighted the Institute's achievements and ongoing research programmes in climate-resilient agriculture, water productivity enhancement, integrated land and water

Fig. 26.3 Review meeting by Hon'ble Union Minister of Agriculture and Farmers' Welfare, Shri Shivraj Singh Chouhan

Fig. 26.4 Release of PRAYAS Book by Hon'ble Secretary (DARE) & DG, ICAR

management, and farmer-centric technological interventions for small and marginal farmers.

Reviewing the Institute's research portfolio and infrastructure, Shri Chouhan appreciated the scientific efforts being undertaken for improving farmers' livelihoods and urged scientists to align their research outcomes with the national vision of Viksit Bharat @2047. Emphasizing the importance of translational research, he stressed that technologies developed in laboratories should effectively reach farmers' fields.

ICAR RCER research activities reviewed by Dr. M.L. Jat, Hon'ble Secretary, DARE & DG, ICAR

Dr. M.L. Jat, Hon'ble Secretary, DARE and DG, ICAR, visited ICAR RCER, Patna during 17–18 July 2025 and reviewed the Institute's research, education and extension programmes. Dr. Jat visited experimental fields, laboratories, livestock and fisheries units, and appreciated the Institute's efforts towards developing resource-efficient and diversified farming systems for small and marginal farmers of Eastern India. During the interaction session, he emphasized that agricultural research must be demand-driven, outcome-oriented and responsive to farmers' needs. He highlighted priority areas including rice-fallow intensification, natural farming, climate-resilient agriculture and strengthening of Integrated Farming Systems through a "One Team–One Task" approach.

The program also featured the release of "PRAYAS", a publication showcasing institute efforts covering marginalized farmers of seven states of Eastern India (Fig. 26.4), and the launching of *"Kaushal-Se-Kisan Samriddhi"*, a flagship initiative aimed at empowering marginalized farmers through skill development. This occasion also witnessed an Memorandum of Understanding (MoU) with a women-led Farmer Producer Organization (FPO) and institute for tomato grafting.

Secretary (DARE) and DG, ICAR, Dr M L Jat visited ICAR RCER, FSRCHPR, Plandu, Ranchi

Dr. M. L. Jat, Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR, New Delhi, visited the ICAR RCER Farming Systems Research Centre for Hill and Plateau Region (FSRCHPR), Plandu, Ranchi, on 10 September 2025 to review research activities and assess the Centre's contribution to sustainable agricultural development in the eastern plateau and hill regions (Fig. 26.5). He was accompanied by Dr. D. K. Yadav, DDG(CS), ICAR New Delhi.

Addressing the scientists, Dr. Jat emphasized the "One Team, One Task" approach and highlighted the need for state-wise collaborative scientific teams in the Eastern region to ensure participatory research and effective delivery of institutional mandates. He also stressed strengthening collaboration with nearby ICAR institutes in priority areas of research and education.

The dignitaries visited an exhibition of innovative technologies developed by the Centre and witnessed the signing of an MoU with an ABI incubatee for

Fig. 26.5 Visit of Hon'ble Secretary (DARE) & DG ICAR to Ranchi Centre

commercial production of the vegetable soybean variety "Swarn Vasundhara". Earlier Dr. Anup Das briefed the dignitaries on the Centre's activities and achievements, and Dr. Awani Kumar Singh proposed the vote of thanks.

Deputy Director General (NRM) appraised research activities at ICAR RCER, FSRCHPR, Plandu, Ranchi

Dr. A. K. Nayak, Deputy Director General (NRM), ICAR, New Delhi, along with Dr. B.P. Bhatt, Officer on Special Duty to DG, ICAR, visited the ICAR RCER, FSRCHPR, Plandu, Ranchi, on 10 October 2025. The visit aimed to appraise ongoing research programmes, assess infrastructure and field-level interventions, and provide strategic guidance for strengthening the centre's role in addressing regional agricultural challenges

The delegation toured major facilities including the Churu Research Farm, livestock production unit, Farm-I and Farm-II, Integrated Farming System (IFS) models and horticultural plantations (Fig. 26.6).

In his address, Dr. Nayak emphasized the need to design future-ready agricultural research aligned with population growth and climate change challenges. He stressed effective dissemination of technologies in simple, farmer-friendly language and strengthening engagement with farmers and agri-entrepreneurs. He also highlighted the importance of optimal utilization of Farm-II by prioritizing externally funded projects, along with strengthening infrastructure through

Fig. 26.6 Dr A.K. Nayak, DDG (NRM) visited field trials at ICAR RCER, FSRCHPR, Ranchi

micro-irrigation, bio-fencing, improved road connectivity, and enhanced farm mechanization.

On this occasion, a Memorandum of Understanding (MoU) was signed with ABI incubatee, Akshay Mahua Agro Business Pvt. Ltd., Ramgarh, for the commercial production of value-added mahua products. Earlier, Dr. Anup Das, Director, ICAR RCER, welcomed the dignitaries and made a detailed presentation on the research activities ICAR RCER FSRCHPR, Ranchi.

21st Research Advisory Committee meeting held at ICAR Research Complex, Patna

The 21st Research Advisory Committee (RAC) meeting of the ICAR ICAR RCER, Patna, conducted during July 02-04, 2025, under the chairmanship of Dr. K.D. Kokate, former DDG (Agricultural Extension), ICAR,

New Delhi (Fig. 26.7). The three-day meeting was attended by distinguished members including Dr. Masood Ali, former Director, IIPR, Kanpur; Dr. S.D. Singh, former Assistant Director General (Fisheries), ICAR; Dr. K.N. Tiwari, former Professor, IIT Kharagpur; and Dr. S. Kumar, former Head, ICAR RCER Research Centre, Ranchi. Dr. A. Velmurugan, ADG (NRM), ICAR, New Delhi, participated virtually.

The Research Advisory Committee reviewed the institute's major research achievements, management initiatives, and ongoing scientific activities and appreciated its significant contributions towards agricultural development in Eastern India. The institute's efforts in promoting smart, climate-resilient, and sustainable agricultural systems through the integration of advanced technologies were highly commended. The committee also appreciated the quality of research trials, laboratory facilities, extension activities, and collaborative initiatives undertaken by the institute. While acknowledging these achievements, the committee emphasized the need for more farmer-centric research that provides practical, scalable, and economically viable solutions. Members recommended greater focus on climate resilience, resource-use efficiency, waste-to-wealth approaches, value-chain development, integrated farming systems, and post-harvest management. The importance of improving soil and water resource management, enhancing productivity in rice-fallow ecosystems, and leveraging emerging technologies for agricultural decision-making was also highlighted. The committee expressed confidence that the Institute's research and extension efforts would continue to contribute significantly to sustainable agricultural growth and farmers' welfare in the region.

Fig. 26.7 Research Advisory Committee meeting at ICAR RCER Patna

Institute Research Council meeting conducted at ICAR Research Complex, Patna

A three-day Institute Research Council (IRC) meeting was successfully organized at ICAR RCER, Patna, from July 21–23, 2025, under the chairmanship of Dr. Anup Das, Director of the Institute. Scientists from the Institute headquarters, the Research Centre for Hill and Plateau Region, Ranchi, KVK Buxar, and KVK Ramgarh participated in the meeting (Fig. 26.8).

The Research Council reviewed the progress of ongoing research activities across crop production, natural resource management, livestock and fisheries, socio-economic and extension studies, and the research activities in Farming System Research Centre for Hill and Plateau Region, Ranchi. The institute's efforts in addressing emerging challenges through need-based and farmer-centric research were highly appreciated. Emphasis was placed on aligning research activities with strategic themes such as climate-smart agriculture, digital agriculture, agri-food systems, genetic improvement, and sustainable resource management.

Fig. 26.8 Institute Research Council meeting at ICAR RCER, Patna

Addressing the meeting, Dr. A. Velmurugan, ADG, ICAR, stressed the importance of aligning research with national and regional priorities and focusing on challenges such as climate change, degraded land rehabilitation, and issues affecting small and marginal farmers. New research proposals covering natural farming, post-harvest technology, high-tech horticulture, value chains, and smallholder farming systems were discussed and refined.

Workshop on "Technology and Knowledge Sharing under NEH Component" held at ICAR RCER, Patna

A two-day workshop on "Technology and Knowledge Sharing Workshop under the NEH Component" was held at ICAR RCER, Patna on September 22, 2025, jointly organized by ICAR RCER and ICAR-MGIFRI, Motihari. The programme was honored by the esteemed presence of the Chief Guest, Dr. Anupam Mishra, Honourable Vice Chancellor, CAU Imphal, while Dr. Rakesh Kumar, ADG (AAF & CC), NRM, ICAR, New Delhi, joined the session virtually. The event was also attended by Dr. Anjani Kumar, Director, ICAR-ATARI, Patna; Dr. Bikash Das, Director, ICAR-NRC on Litchi; Dr. S.K. Purbey, Director, ICAR-MGIFRI; Dr. H. Kalita, HoRC, ICAR RC for NEHR, Nagaland Centre; Dr. L.M. Garnayak, Director of Research, CAU Imphal; and other dignitaries (Fig. 26.9). Scientists and Heads from various ICAR institutes across the NEH region also participated actively.

Fig. 26.9 Technology and knowledge sharing workshop inaugurated by Dr A Mishra, VC, CAU, Imphal

Hon'ble Vice Chancellor, CAU, Imphal during the event, underscored the vital role of system knowledge sharing and cross-learning in strengthening agriculture, while calling for urgent adoption of resource conservation technologies and ensure efficient drainage management to tackle challenges of waterlogged areas. He emphasized on inclusion of makhana and water chestnut in wetland ecosystem of NEH region.

Welcoming the participants, Dr. Anup Das, Director, ICAR-RCER, Patna, stated that the NEH region is rich in unique germplasm and home to an extensive range of biodiversity, which holds immense potential for agricultural advancement. He emphasized that this workshop will strengthen knowledge exchange, collaborative research, and technology adaptation to benefit not only the NEH but also the entire Eastern region and beyond.

Workshop on "Strategies and Approaches for Greening Rice Fallow Area" held in Patna

The National workshop on "Strategies and approaches for Greening Rice Fallow Areas" was organized at ICAR RCER, Patna during 3-4 January 2025 to formulate strategies for sustainable intensification of rice fallow ecosystems (Fig. 26.10).

Fig. 26.10 National workshop on greening rice fallow area.

The workshop was inaugurated by Dr. S.K. Chaudhari, DDG (NRM), ICAR, who emphasized integrated and multidisciplinary approaches, resource-conservation technologies, and efficient utilization of groundwater resources. Leading experts from across the country deliberated on technological, policy, and research interventions for enhancing the productivity of rice fallow areas. Dr. Anup Das, Director, ICAR RCER, highlighted the successful greening of more than 1,000 ha of rice fallows through participatory interventions implemented by KVKs. The workshop recommended the promotion of short-duration climate-resilient crops, efficient utilization of residual soil moisture, and integrated water and nutrient management practices.

ICAR RCER, Patna inaugurated 'Water Smart Farming Model' to enhance agricultural productivity

ICAR RCER, Patna inaugurated the 'Water Smart Farming Model' at Sabajpura farm to demonstrate

efficient and sustainable water management practices for enhancing agricultural productivity in eastern India. The model was inaugurated by Dr. S.K. Chaudhari, DDG (NRM), ICAR, who underscored the importance of integrated water-resource management in addressing the challenges of climate change and increasing resource scarcity (Fig. 26.11).

The event was attended by several eminent scientists

Fig. 26.11 Water smart farming system model inauguration

and experts from across the country. Dr. Anup Das, Director, ICAR RCER, highlighted the model's integration of innovative practices such as mulching, agri-horti systems, composting, and renewable energy technologies to improve resource-use efficiency and farm sustainability.

Review meeting on progress of foreign-aided projects under NRM division held.

The review meeting on the progress of foreign-aided projects under the NRM Division of ICAR was held at ICAR RCER, Patna on 4 January 2025 under the chairmanship of Dr. S.K. Chaudhari, DDG (NRM), ICAR, New Delhi (Fig. 26.12).

The meeting reviewed more than 20 projects being implemented in collaboration with international organizations such as IRRI, CIMMYT, and IWMI, and was attended by over 120 delegates from more than 10 ICAR institutes. During the meeting, Dr. Chaudhari emphasized to focus on challenges, scalability, and future strategies in international collaborations to advance in sustainable agriculture, resource conservation, and natural resource management. Dr. Anup Das, Director, ICAR RCER, highlighted the need to strengthen global partnerships for fostering

Fig. 26.12 Review meeting on foreign aided projects

innovation, enhancing research outcomes, and accelerating the adoption of sustainable technologies.

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

The interaction meeting with scientists of ICAR RCER, Patna was held on 22 January 2025 under the chairmanship of Dr. U.S. Gautam, DDG (Agricultural Extension), ICAR, New Delhi. The event was attended by distinguished dignitaries including the Directors from different ATARIs (Fig. 26.13)

Fig. 26.13 Visit of DDG Extension Dr U. S. Gautam

Dr. Gautam interacted with scientists and appreciated the institute's contributions, recalling his association with ICAR RCER and the inspirational visit of Dr. A.P.J. Abdul Kalam. In his address, he emphasized on teamwork, scientific excellence, and the need to focus on emerging areas such as water footprint, ecosystem services. Dr. Anup Das, Director, ICAR RCER, in his

address, highlighted the institute's achievements while Dr. Abhay Kumar outlined Dr. Gautam's contributions to extension. Dr. Dhiraj Kumar Singh presented progress on the "zero hunger and zero technology gap village" project.

Hon'ble Union Minister Shri Giriraj Singh addressed during PM-Kisan Samman Nidhi Yojana

The 21st instalment of the PM-Kisan Samman Nidhi Yojana was released by Hon'ble Prime Minister Shri Narendra Modi on 19 November 2025, and a live webcast was organized at ICAR RCER, Patna with participation of more than 300 farmers, scientists, and staff. The chief guest, Hon'ble Union Minister Shri Giriraj Singh, addressed the gathering and emphasized crop diversification beyond the traditional paddy–wheat system, encouraging the cultivation of pulses, oilseeds, millets, and horticultural crops (Fig. 26.14). He also highlighted the importance of integrated farming systems, including livestock rearing, goat farming, and mushroom cultivation.

Fig. 26.14 Visit of Hon'ble Union Minister Shri Giriraj Singh

The Director, ICAR RCER Patna, welcomed the Minister and briefed him on the institute's achievements and ongoing research activities. An agricultural exhibition and field visit showcased advanced technologies, improved seeds, and models for farmers.

Hon'ble Agriculture Minister of Bihar inaugurated farmers' fair during National Farmers' Day

National Farmers' Day, a two-day Kisan Mela–2025 on the theme "Flight to Self-Reliance through Research - Prosperous Agriculture, Empowered Farmers" was organized on 23 December 2025 at ICAR RCER, Patna to promote advanced agricultural technologies and awareness about government schemes (Fig. 26.15). The inaugural session was addressed virtually by Union Agriculture Minister Shri Shivraj Singh Chouhan, who emphasized adoption of modern, research-based technologies, while Chief Guest Bihar Agriculture Minister Shri Ram Kripal Yadav inaugurated the event and appreciated ICAR RCER's research achievements.

Fig. 26.15 Celebration of National Farmers' Day

Director Dr. Anup Das highlighted the mela as a bridge between research and farmers' fields and reiterated the institute's commitment to sustainable and climate-resilient agriculture. Eminent dignitaries including Dr. K. M. Bujarbaruah, Dr. Raghavendra Bhatta, Dr. Niranjan Kalita, Dr. D. J. Rajkhowa, Dr. Anjani Kumar Singh, and Shri D. P. Tripathi shared their insights on agricultural growth, technology dissemination, and farmer welfare. The mela witnessed participation of over 1,185 attendees, including more than 815 farmers, and featured 26 exhibition stalls showcasing improved varieties, modern technologies, and innovations in agriculture and allied sectors.

Workshop on 'Harnessing Remote Sensing, GIS & Machine Learning for Advanced Land and Water Management'

A one-day Training–cum–Workshop on "Harnessing Remote Sensing, GIS, and Machine Learning for Advanced Land and Water Management," was organized by ICAR RCER, Patna on 25 November 2025

with participation of 24 officials from various wings of the Bihar Government (Fig. 26.16).

Fig. 26.16 Remote Sensing, GIS & Machine Learning workshop

The experts emphasized the role of AI-driven analytics in developing precision-oriented and sustainable agricultural systems.

Hindi Fortnight-2025

The Hindi Fortnight–2025 was organized at the ICAR–Research Complex for Eastern Region, Patna, from 14 to 29 September 2025 with great enthusiasm and fervour. The programme was not merely an initiative to promote the Official Language Hindi but also served as a vibrant platform to foster a sense of commitment, responsibility, and affinity towards Hindi among scientists, staff members, and students. The series of competitions commenced on 15 September 2025 with an Essay Writing Competition, in which employees of the institute participated enthusiastically. Addressing the participants, Dr. Ashutosh Upadhyaya, Acting Director informed them that Hindi Fortnight–2025 had been formally inaugurated by the Hon'ble Union Home Minister, Sh. Amit Shah, at Gandhinagar (Gujarat). He emphasized that Hindi is not only a language of administration but also a powerful medium of cultural integration and effective communication. During the fortnight, several competitions, including Extempore Speech, Poetry Recitation, Grammar, Vocabulary, Antakshari, Unicode Typing, and Quiz were organized. Employees and students from the IARI Patna Hub participated enthusiastically.

A three-day workshop was also organized as part of the Hindi Fortnight–2025 celebrations. On the first day, a workshop on "Official Language Implementation and e-HRMS" was conducted, focusing on the effective implementation of the Official Language Policy and the use of Hindi in the e-HRMS platform. On the second day, a scientific workshop on "Contribution of Advanced Technologies towards Prosperous Agriculture" was organized, highlighting the role of emerging agricultural technologies in enhancing productivity and sustainability. On the third day, Shri Virendra Kumar Yadav, Hon'ble Member, Hindi Advisory Committee, Government of India, graced the programme as the Chief Guest. He elaborated on the constitutional provisions relating to Hindi under Articles 343 to 351 of the Constitution of India and emphasized the significance of the Official Languages Act in promoting the use of Hindi in official work.

The Hindi Fortnight–2025 concluded with a grand Valedictory Function held on 29th September 2025. Employees and students of the IARI Patna Hub attended the programme in large numbers. The winners of various competitions were awarded with cash prize and certificates of appreciation in recognition of their outstanding performance. The successful organization of Hindi Fortnight–2025 was coordinated by Dr. Shivani, Principal Scientist and Mr. Umesh Kumar Mishra, Hindi Translator with the active support of the members of the Institute Official Language Implementation Committee.

Fig. 26.17 Shri Virendra Kumar Yadav, Hon'ble Member, Hindi Advisory Committee, Government of India during Hindi Fortnight Celebration

Fig. 26.18 Glimpses of Hindi Fortnight-2025 activities at ICAR RCER, Patna

Chapter 27

AWARDS & RECOGNITIONS

1. KVK Buxar received the prestigious **"NAAS Dhanuka Award for Best KVK Zonal Award 2025"** for Excellence in Agricultural Extension, with a cash award of Rs. 25,000.

2. Dr. Ashutosh Upadhyaya received the **"Sustainability Excellence Award"** from the Sustainable Development Forum, The Institution of Engineers (India), during the 1st National Sustainability Convention 2025 held at Patna during December 13-14, 2025.

3. Dr. Arti Kumari received the **"SCSI Mrs. Mohini Kumari Gupta Memorial Award-2024"** from the Soil Conservation Society of India, New Delhi, on December 8, 2025.

4. Dr. Indra Jeet received the **"Best KVK Scientist Award"** during the International Conference on "Sustainable Innovation in Agriculture, Veterinary and Allied Sciences," jointly organized by the UAS, Karnataka, and the NADC Ltd., J&K, held during December 29-31, 2025.

5. Dr. Indra Jeet received the **"Best Ph.D. Thesis Award"** during the International Conference on "Sustainable Innovation in Agriculture, Veterinary and Allied Sciences jointly organized by the UAS, Karnataka, and NADC Ltd., J&K, held during December 29-31, 2025.

6. Dr. Rachana Dubey received the **"Best Women Scientist Award 2024"** of the institute during the Silver Jubilee Foundation Day celebration of ICAR RCER, Patna, held on February 22, 2025.

7. Dr. Rakesh Kumar received the **"Dr. RCGY Agronomist-2024"** Award from IARI in 2025 for his outstanding contribution in the field of Agronomy.

8. Dr. Rakesh Kumar was conferred with the **"ISA Fellowship-2024"** by the Indian Society of Agronomy, New Delhi, in 2025.

9. Dr. Santosh Kumar received the **"Best Scientist Award 2024"** during the Silver Jubilee Foundation Day celebration of ICAR RCER, Patna, held on February 22, 2025.

10. Dr. Santosh S. Mali was inducted as **"Adjunct Senior Research Scientist"** at the School of Agriculture and Environmental Science, Institute for Resilient Regions, University of Southern Queensland, Toowoomba, Australia.

11. Scientists of ICAR RCER were honoured by Shri Shivraj Singh Chouhan, Hon'ble Union Minister for Agriculture & Farmers' Welfare, and Dr M.L. Jat, Secretary, DARE & Director General, ICAR, for registering "**Medini cattle, Palamu goat, Mala chicken and Kodo duck"**, the first registered livestock and poultry breeds from Jharkhand.

12 Dr. Shankar Dayal received the award of **"Associate Fellow"** of the National Academy of Veterinary Sciences.

Fig. 27.1 'Breed Registration Certificate' received from Shri Shivraj Singh Chouhan, Hon'ble Union Minister for Agriculture & Farmers' Welfare, and Dr M.L. Jat, Secretary, DARE & Director General, ICAR

Fig. 27.2 Dr. Ashutosh Upadhyaya receiving Sustainability Excellence Award 2025

* Besides, several scientists of ICAR RCER were honoured with many prestigious awards from recognized scientific societies.

Chapter 28
INTELLECTUAL PROPERTY

ICAR certified technology (3)

- Improved agro-techniques for enhancing productivity of millets in eastern India (ICAR-NRM-RCER-Technology-2025-041)
- Climate resilient agriculture practice in rice-fallow ecosystems of East India Plateau (ICAR-NRM-RCER-Technology-2025-042)
- Modified drip fertigated mulched planting system for commercial cultivation of vegetable in East India Plateau (ICAR-NRM-RCER-Technology-2025-043)

Varieties registered with PPV& FRA (8)

Registration No.	Name of innovation/ Technology/ Product/ Plant variety	Date of filed/ Submitted	Application granted/ Registered (Annual fees submitted on)
REG/2014/1475	Swarna Anmol (Tomato)	23 Jul, 2014	10 Nov, 2025
REG/2016/941	Swarna Kanchan (Tomato)	18 Jul, 2016	03 Dec, 2025
REG/2019/131	Swarna Ratan (Tomato)	18 Oct, 2019	10 Nov, 2025
Submission of annual fees			
REG- 2012/383	Swarna Baibhav (Tomato)	26 Feb, 2016	28 Mar, 2025
REG-2019/135	Swarna Sawani (Ridge gourd)	05 Jun, 2021	22 Sep, 2025
REG-2018/597	Swarna Safal (Faba bean)	04 Aug, 2020	25 Nov, 2025
REG-2019/134	Swarna Sneha (Bottle gourd)	02 Aug, 2022	25 Nov, 2025
REG-2019/130	Swarna Yamini (Bitter gourd)	02 Aug, 2022	25 Nov, 2025

Animal breed registered (4)

Accession No.	Name of breed	Registration of breeds
INDIA CHICKEN 2500 MALA 12021	Mala Chicken	12 Nov, 2025
INDIA CATTLE 2500 MEDINI 03054	Medini Cattle	12 Nov, 2025
INDIA GOAT 2500 PALAMU 06042	Palamu Goat	12 Nov, 2025
INDIA Duck 2500 KODO 11005	Kodo Duck	12 Nov, 2025

Patent granted (2)

- Mr. Thingujam, V. (2025) was granted a patent for "Real-Time Soil Quality Monitor," Design No. 454772-001, by the Indian Patent Office, Government of India, registered on 09 April 2025, as co-applicant.
- Dr. Anirban Mukherjee was granted a patent for "AI based agriculture market analysis computing device", Design No. 475543-001, by Indian Patent Office, Government of India, registered on 01 October 2025, as co-applicant.

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Autonomous Drone Assisted Crop Health Monitoring System (Registration Number: LD-20260180285 on 05.01.2026.

MoU & MoAs (16)

For promotion of research, technology commercialization and collaboration, the institute signed 16 MoUs/MoAs with Universities, FPOs and incubatees during the period under report.

NCBI accession number received (62)

Pv733671, PV760164, PV760167, PV731525, PV760947, PV743567, PV743566, PV743058, PV742882, Pv742695, PV759348, PV759328, PV755120, PV759328, Pv764552, PV739495, PV746262, PV749897, PV755406, Pv760226, PV746213, PV746249, PV749023, PV765523, PV770048, PV770047, PV796780, PV796781, PV796782, PV796779, PV794635, PV800148, PV796778, PV800147, PV820514, PV820513, PV809668, PV780542, PV820516, PV809336, PV780540, PV780539, PV780538, PV820517, PV820515, PV785308, PV741485, PV741269, PV740625, PV741068, PV739645, PV739561, PV780541, PV770107, PV802684, PV760619, PV760228, PV731526, PV755388, PV731526, PV755117 and Pv738150

Details of the technologies commercialized by the institute

Name of Technology/ Know-How	Name of contracting party	Date of signing MoU	Technology license fee (in Rs.)
Large scale seed production of the open pollinated varieties of French bean (Swarna Priya), Brinjal (Swarna Shyamali), Pea (Swarna Mukti), Snow Pea (Swarna Tripti) and Tomato (Swarna Lalima).	Sattva Agricultural and technological solutions OPCPvt. Ltd., Ranchi	19 Mar, 2025	35,000/-
Large scale seed production of the OP varieties of Chilli- Swarna Arohi and Tomato- Swarna Prakash.	Rajdhani Horticulture & seeds Pvt. Ltd., Bhubaneswar	19 Mar, 2025	20,000/-
Large scale seed production of the open pollinated varieties of Lobia (Swarna Harita), Amaranthus (Swarna Raktim), French bean (HAFB4), Brinjal (HABR21), Tomato (Swarna Prakash), Chilli (Swarna Praphulya), Bottle Gourd (Swarna Sneha) and Bitter Gourd (Swarna Yamini)	Ambra Agritech Pvt. Ltd., Delhi	19 Mar, 2025	80,000/-
Large scale production of the grafted tomato plant on bacterial wilt resistant root stock of brinjal.	Ambra Agritech Pvt. Ltd., Delhi	19 Mar, 2025	10,000/-
Tephrosia biomass mulching technology for improving soil health and productivity of fruit.	Semina Agro Pvt. Ltd., Ranchi	19 Mar,2025	20,000/-
Large scale seed production of the OP varieties: Vegetable Soyabean (Swarna Vasundhara) and (Swarna Sugandha).	Kapil Pradeep Inani (individual)	19 Mar, 2025	20,000/-
Large scale seed production of the OP varieties of Tomato (Swarna Lalima), Chilli (Swarna Praphulya) and Cowpea (Swarna Harita)	Dominance Agrotech Pvt. Ltd., Ranchi	10 May, 2025	30,000/-
Large scale production of planting material of pointed gourd varieties viz., Swarna Rekha, Swarna Alaukik, Swarna Suruchi	Pravin Kumar (individual) Hazaribagh	10 May, 2025	10,000/-
Large scale seed production of the OP varieties of Chilli- Swarna Apurva	Rajdhani Horticulture & seeds Pvt. Ltd., Bhubaneswar	12 Jun, 2025	10,000/-
Large scale production of the grafted tomato plant on bacterial wilt resistant root stock of brinjal	Gumla Mahila Kisan Swavlamban Trust, Gumla	18 Jul, 2025	25,000/-
Large scale seed production of the OP varieties: Vegetable soyabean Swarna Vasundhara)	Sri Prabhakar (Individual) Jamshedpur	10 Sep,2025	10,000/-

Chapter 29
PUBLICATIONS

Research Papers

1. Abshiba, K., Chaudhary, M., Sinha, N.K., Singh, T., Rosin, K.G., Naik, S.K., Singh, P., Barnwal, P.P., Deepasree, A. and Kumar, S. (2025). Soil quality in diversified agricultural systems of eastern plateau India. *Environ. Earth Sci.*, 84(20): 566.

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3. Anand, S., Ghosh, S., Mukherjee, A. and Roy, A. (2025). How sustainable are the farmer producer companies (FPCs) in India?—Unravelling the determinants of farmers' perceptions through multivariate analyses. *Ann. Public Coop. Econ. 97(2)* DOI:10.1111/apce.70017

4. Anjali, Punetha, M., Kumar, A., Tripathi, M.K., Kishor Kumar, D.G., Khanna, S., Nanda, R., Yadav, P., Sharma, S., Maurya, V.P. and Singh, G. (2025). Application of CRISPR/Cas9 for GDF9 Gene Editing in Caprine Granulosa Cells: Effects on Receptor Signalling and FGF2 Response. *Reprod. Domest. Anim.* 60 (10): 70128.

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8. Bhardwaj, A., Prasanna, R., Katral, A., Nivedha, R.M., Varsha, D., Gaur Rudra, S., Singh, A.K., Sagar, S. and Shivay, Y.S. (2025). Cyanobacteria as a nutri-fertigation option for stimulating fruit quality and yield in Capsicum annuum. *Acta Physiol. Plant.*, 47(6): 61.

9. Bharti, N., Choudhary, J.S. and Yadav, U. (2025). Field efficacy of newer insecticides against litchi seed borer, Conopomorpha sinensis. *J. Sci. Res. Rep.*, 31(4): 404–409.

10. Bharti, N., Choudhary, J.S. and Yadav, U. (2025). Impact of weather parameters on population dynamics of litchi leaf roller, Dudua aprobola in Eastern Plateau and Hill region of India. *Int. J. Plant Soil Sci.*, 37(4): 143–148.

11. Bharti, V., Kumar, T., Sarma, K., Singh, J., Ahirwal, S.K., Saurabh, K., Kumari S., and Kumar, A. (2025). Multivariate analysis of ichthyofaunal diversity in the Kasaraiya Dhar Wetland, Bihar, India. *Indian J. Fish.*, 72 (2): 19-26.

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Besides, scientists of the institute have published 16 extension folders, 29 popular articles, training manuals, e-publications, souvenir articles in addition to one patent filed. Scientists have also presented their works in the national and international scientific platforms winning many awards.

Chapter 30
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Senior Scientist
(Plant Breeding)
Dr Jaipal Singh Chaudhary
Senior Scientist (Entomology)
Dr Reshma Shinde
Senior Scientist (Soil Science)
Dr Madhumita Dasgupta
Senior Scientist (H & PB)
Dr Reena Kumari Kamal
Senior Scientist (LPM)
Dr Prerna Nath
Senior Scientist (Food Technology)
Dr Mahesh Kumar Dhakar
Senior Scientist (Fruit Science)
Dr Meenu Kumari
Senior Scientist (Hort-Veg Sci)
Mr. Victor Thingujam
Scientist (Agroforestry)

Technical ICAR-RCER, Patna

Shri Abhishek Kumar
ACTO (Field/Farm)
Shri Anil Kumar
ACTO (Computer)
Shri PK Singh
ACTO (Field/Farm)
Shri Sarfaraj Ahmad
ACTO (Computer)
Shri A.S. Mahapatra
STO (Field /Farm)
Shri Prem Pal Kumar
STO (Field /Farm)
Shri. Sanjay Rajput
TO (Photography)
Shri Akhila Nand Ray
TO (Driver, Workshop)
Shri Ramesh Kumar
TO (Driver Workshop)
Shri Amrendra Kumar
TO (Filed/Farm)
Shri Murari Maharaj
TO (Driver, Workshop)
Shri Manoj Kumar Sinha
STA (Field /Farm)
Shri Satish Kumar
STA (Library)
Shri Suresh Chandra
STA (Field /Farm)
Smt. Noopur Kumari
STA (Lab)
Shri Umesh Kumar Mishra
STA (HT)

Shri Sanjay Kumar
Technical Assistant (Library)

Shri Kalyan Kumar
Technical Assistant
(Field / Farm)

Shri Bipin Mishra
Senior Technician
(Field /Farm)
Shri Manoj Kr Singh
Senior Technician
(Field /Farm)
Shri Sunil Kumar
Senior Technician
(Field /Farm)
Shri Surendra Kumar Yadav
Senior Technician
(Field /Farm)
Shri Anand Ranu
Technician
(Field /Farm)
Smt. Usha Kiran
Technician
(Field /Farm)
Shri Ravi Ranjan Singh
Senior Technician
(Field /Farm)
Shri Tarun Kumar Rao
(Technician)
Shri Vijay Babu Ram
(Technician)
Shri Rajeev Ranjan Kumar
(Technician)
Shri Ramesh Meena
(Technician)
Shri Gautam Ranjan
(Technician)
Shri Ravi Kumar Meena
(Technician)

Administrative Staff ICAR RCER, Patna

Shri Pushpanayak
Chief Administrative Officer (SG)

Shri Vipul Raj
Administrative Officer

Shri Rajat Kumar Das
(Finance and Accounts Officer)
Shri KK Lal
(Assistant Finance and Accounts Officer
Smt. Prabha Kumari
(Assistant Administrative Officer)
Shri Dayanand Prasad
(Assistant Administrative Officer)
Shri Md. Sajid Mustaque
(Assistant Administrative Officer)
Shri Ravi Shankar
(Assistant Administrative Officer)
Shri Akash Patel
(Personal Assistant)
Shri Madan Paswan
Assistant
Shri Nagendra Kumar
Assistant
Mrs. Divyadarshini (Assistant)
Shri Markanday Mishra
Assistant
Shri Rashmi Kant
Assistant
Shri Anil Kumar
Assistant
Shri Lakshmi Prasad
Assistant
Shri Arun Kumar Shukla
Assistant
Shri Himanshu Kumar
Assistant
Shri Francis Murmu
(Upper Division Clerk)
Shri Anikesh Kumar
(Upper Division Clerk)
Shri Hari Narayan Prasad
(Upper Division Clerk)
Shri Jyoti Kumar Mani
(Lower Division Clerk)
Shri Md. Hashim Ansari
(Lower Division Clerk)

Skilled Supporting Staff ICAR - RCER, Patna

Amitesh Kumar
Skilled Supporting Staff
Anil Kumar
Skilled Supporting Staff

Technical Ranchi

Shri Suresh Kumar
ACTO (Field/Farm)
Smt. Anima Prabha
ACTO (Hindi Translator/Press & Editing Staff)
Shri Krishna Bara
TO (Workshop)
Shri Vijay Kumar Singh
TO (Lab.)
Shri Shashi Kumar Azad
TO (Field/Farm)
Shri Nagendra Kumar
(Technician)
Shri Rohit Kumar Rajak
(Technician)
Shri Subham Kumar
(Technician)
Shri Kamlesh Kumar
Technical Trainee (Technician)
Arun Kumar Yadav
(Technician)

ICAR KVK Ramgarh

Dr Sudhanshu Sekhar, Senior Scientist-cum-Head, KVK, Ramgarh
Dr Indra Jeet, Assistant Chief Technical Officer (Agri. Extension)
Dr Dharamjit Kherwar, Assistant Chief Technical Officer (Horticulture)
Sh. Sunny Kumar, Technical Officer, Farm Manager (T-5)
Sh. Gaurav Kumar, Assistant
Sh. Roshan Kumar, LDC

Administrative Staff Ranchi

Shri Bharat Ram
Assistant
Shri Keshav Kumar
Assistant
Ms. Shubhra Ratnam
Assistant
Smt. Ritu Rani
UDC
Shri Rajendra Prasad Gupta
LDC

Skilled Supporting Staff Ranchi

Shri Budhwa Lakra
Skilled Supporting Staff, (Mali)
Smt. Kathrina Lakra
Skilled Supporting Staff
Shri Ram Horo
Skilled Supporting Staff
Shri Binod Lakra
Skilled Supporting Staff
Smt. Shanti Munda
Skilled Supporting Staff
Smt. Bahalen Ekka
Skilled Supporting Staff
Shri Doman Tirkey
Skilled Supporting Staff
Smt. Munni Kesariar
Skilled Supporting Staff
Shri Rama Kachhap
Skilled Supporting Staff
Smt. Mangri Ekka
Skilled Supporting Staff
Ms. Kiran Lakra
Skilled Supporting Staff
Shri Umesh Kumar Nayak
Multi-Tasking Staff/ Skilled Supporting Staff

ICAR KVK Buxar

Dr Deo Karan
Senior Scientist *cum* Head (SS&WM)
Shri Hari Govind
SMS, ACTO (Agri. Botany)
Shri Ramkewal
SMS, ACTO (Plant Protection)
Shri Arif Parwez
STO Farm Manager
Shri Rakesh Mani
Assistant
Shri Ravi Chatterjee
Personal Assistant
Shri Rajesh Kumar Rai
Senior Technical Assistant (Driver)
Sarfaraj Ahmad Khan
Senior Technical Assistant (Driver)

New Joining of staff during 2025

Sl. No.	Place of posting	Name	Joined as	Discipline	Division	Date of joining
1.	ICAR RCER HQ	Dr. Ghous Ali	Scientist	Agronomy	DCR	13/01/2025
2.	ICAR RCER HQ	Shri Ravi Kumar Meena	Technician	--	DCR	03/03/2025
3.	FSRCHPR, Ranchi	Shri Kamlesh Kumar	Technician	--	FSRCHPR, Ranchi	05/03/2025
4.	ICAR RCER HQ	Dr. Biswajit Debnath	Senior Scientist	ABM	DSEE	15/05/2025
5.	FSRCHPR, Ranchi	Dr. Awani Kumar Singh	Head	Vegetable Science	Head, FSRCHPR, Ranchi	17/06/2025

6.	FSRCHPR, Ranchi	Dr. Madhumita Dasgupta	Senior Scientist	Genetics and Plant Breeding	FSRCHPR, Ranchi	16/06/2025
7.	ICAR RCER HQ	Dr. Neeti Lakhani	Scientist	Animal Nutrition	DLFM	05/08/2025

Promotion/MACP during 2025

Sl. No.	Name	Place of posting	Scientific/ Technical/ Administrative	From	Promoted to	Promotion date/joining date of Promotion
1.	Dr. P. K. Ray	ICAR-RCER Patna-HQ	Scientific	Senior Scientist (L-12)	Senior Scientist (L-13A)	07/01/2021
2.	Dr. M. K. Tripathi	ICAR-RCER Patna-HQ	Scientific	Scientist (L-11)	Senior Scientist (L-12)	04/04/2024
3.	Dr. Ved Prakash	ICAR-RCER Patna-HQ	Scientific	Scientist (L-11)	Senior Scientist (L-12)	01/01/2024
4.	Dr. Shinde Reshma Bhausaheb	ICAR-RCER Patna-HQ	Scientific	Scientist (L-11)	Senior Scientist (L-12)	15/09/2021
5.	Dr. Mali Santosh Sambhaji	ICAR-RCER Patna-HQ	Scientific	Senior Scientist (L-13A)	Principal Scientist (L-14)	12/06/2023
6.	Dr. Akram Ahmad	FSRCHPR, Ranchi	Scientific	Scientist (L-11)	Senior Scientist (L-12)	01/01/2023
7.	Dr. Anirban Mukherjee	ICAR-RCER Patna-HQ	Scientific	Scientist (L-11)	Senior Scientist (L-12)	01/07/2023
8.	Dr. Sonaka Ghosh	ICAR-RCER Patna-HQ	Scientific	Scientist (L-10)	Scientist (L-11)	05/10/2024
9.	Dr. Vishvendu Dwivedi	ICAR-RCER Patna-HQ	Scientific	Senior Scientist (L-12)	Senior Scientist (L-13A)	11/05/2015
10.	Dr. Rachana Dubey	ICAR-RCER Patna-HQ	Scientific	Scientist (L-11)	Senior Scientist (L-12)	01/01/2024

11.	Shri Hari Narayan Prasad	ICAR-RCER Patna-HQ	Administrative	LDC	UDC	28/11/2025
12.	Smt. Anima Prabha	ICAR-RCER Patna-HQ	Technical	STO	ACTO	06/09/2022
13.	Shri Sarfaraj Ahmad	ICAR-RCER Patna-HQ	Technical	STO	ACTO	09/09/2025
14.	Shri Murari Maharaj	ICAR-RCER Patna-HQ	Technical	STA	TO	01/01/2021
15.	Shri Rajesh Kr. Rai	KVKs Buxar	Technical	TA	STA	12/08/2025
16.	Shri Sarfaraj Ahmad Khan	KVKs Buxar	Technical	TA	STA	16/08/2025
17.	Shri Umesh Kumar Mishra	ICAR-RCER Patna-HQ	Technical	TA	STA	06/08/2025
18.	Shri Ramesh Kumar	ICAR-RCER Patna-HQ	Technical	TO	TO (Advance Increment)	28/08/2023
19.	Shri Akhilanand Ray	ICAR-RCER Patna-HQ	Technical	TO	TO (Advance Increment)	01/01/2025
20.	Shri Paul Sanjay Sircar	FSRCHPR, Ranchi	Technical	ACTO	CTO	10/09/2022
21.	Shri Guna Munda	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
22.	Shri Rajesh Karkusa	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
23.	Smt. Deoki Hans	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
24.	Smt. Kathrina Lakra	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
25.	Shri Ram Horo	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
26.	Smt. Shanti Munda	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
27.	Smt. Bahalen Tirkey	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
28.	Shri Tirathnath Mahato	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
29.	Shri Binod Lakra	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
30.	Smt. Munni Kesriyar	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024

31.	Smt. Birsi Karkuswa	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
32.	Shri Ram Kachhap	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
33.	Smt. Meera Kachhap	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
34.	Smt. Gangiya Lakra	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
35.	Smt. Mangi Ekka	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
36.	Smt. Subhash Devi	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
37.	Shri Dhura Oraon	FSRCHPR, Ranchi	SSS	2nd MACP	3rd MACP	30/03/2024
38.	Shri Jyoti Kumar Mani	ICAR-RCER Patna-HQ	LDC	2nd MACP	3rd MACP	25/04/2024
39.	Shri Amitesh Kumar	ICAR-RCER Patna-HQ	MTS/SSS	1st MACP	2nd MACP	12/01/2025
40.	Shri Ravi Chatterjee	ICAR-RCER Patna-HQ	PA	4th MACP	5th MACP	25/11/2023
41.	Shri Bharat Ram	ICAR-RCER Patna-HQ	Assistant	6th MACP	7th MACP	22/06/2025
42.	Shri Madan Paswan	ICAR-RCER Patna-HQ	Assistant	6th MACP	7th MACP	21/08/2025

Transfer during 2025

Sl. No.	Place (ICAR-RCER Patna-HQ/FSRCHPR, Ranchi/KVKs)	Name & Designation	Scientific/ Technical/ Administrative Category	From	Transfer to	Relieving date
1.	ICAR-RCER Patna-HQ	Dr. Mridusmita Debnath	Scientific	ICAR-RCER, Patna	ICAR-NISA, Ranchi	28/01/2025
2.	ICAR-RCER Patna-HQ	Dr. Ved Prakash	Scientific	ICAR-RCER, Patna	ICAR-IIFSR, Modipuram	26/02/2025
3.	ICAR-RCER Patna-HQ	Dr. Akram Ahmad	Scientific	ICAR-RCER, Patna	ICAR-IISWC, RS, Vasad, Gujarat	20/06/2025

Resignation for joining the new assignment during 2025

Sl. No.	Place (ICAR-RCER Patna-HQ/FSRCHPR, Ranchi/KVKs)	Name & Designation	Category (Scientific/ Technical/ Administrative)	Post (new assignment) and Place of Joining	Relieving date
1.	ICAR-RCER Patna-HQ	Shri Ravi Kumar Meena	Technical	Joined Indian Railways	30/06/2025
2.	FSRCHPR, Ranchi	Shri Arun Kumar Yadav	Technical	Joined Govt. of Jharkhand	31/12/2025

Retirement/Death during 2025

Sl. No.	Place (ICAR-RCER Patna-HQ/FSRCHPR, Ranchi/KVKs)	Name & Designation	Category (Scientific/ Technical/ Administrative)	Date of Retirement
1.	FSRCHPR, Ranchi	Shri Dhura Oraon	SSS	31/01/2025
2.	FSRCHPR, Ranchi	Smt. Deoki Hans	SSS	28/02/2025
3.	FSRCHPR, Ranchi	Shri Rajesh Karkusa	SSS	31/03/2025
4.	FSRCHPR, Ranchi	Smt. Gangiya Lakra	SSS	31/03/2025
5.	FSRCHPR, Ranchi	Shri Tirathnath Mahato	SSS	31/05/2025
6.	FSRCHPR, Ranchi	Smt. Alice Lakra	SSS	30/06/2025
7.	FSRCHPR, Ranchi	Smt. Birsi Karkuswa	SSS	31/08/2025
8.	FSRCHPR, Ranchi	Shri Paul Sanjay Sircar	ACTO	31/10/2025
9.	FSRCHPR, Ranchi	Smt. Meera Kachhap	SSS	31/10/2025
10.	FSRCHPR, Ranchi	Smt. Subhash Devi	SSS	30/11/2025
11.	FSRCHPR, Ranchi	Shri Sagu Kachhap	T2	30/11/2025
12.	FSRCHPR, Ranchi	Shri Balbir Ram	SSS	29/07/2025 (died)
13.	FSRCHPR, Ranchi	Shri Guna Munda	SSS	07/12/2025 (died)

Chapter 31

ONGOING RESEARCH PROJECTS

ICAR-RCER, Patna has undertaken several research projects across major domains of agriculture and allied sciences focusing on key subject-matter themes of Natural Resource Management (NRM). These research projects include both externally funded and institute-funded projects.

Externally funded projects

a. The details of projects supported by ICAR are enlisted below:

S. No.	Project Title	Funding Agency
1	Evaluation of Conservation Agriculture (CA) Practices under the Rice-Fallow System of the Eastern Region	Consortium Research Platform on CA, ICAR
2	Creation of seed hubs for increasing indigenous production of pulses in India	ICAR
3	Development of zero hunger and zero technology gap village through innovative interventions	ICAR-ATARI, Patna
4	Integrated farming system for achieving food and nutritional security and climate resilience in the Eastern Region of India.	AICRP on IFS
5	Enhancing Food, Nutritional and Livelihood Security of Marginal and Tenant Farmers in Jharkhand through Need-Based Agricultural Technologies	Farmer FIRST Project
6	Bio-Nano Sulphur Formulation of Methanotrophs for Decarbonization, Disease Resistance and Sustaining Productivity in the Rice-Oilseed Cropping System	NASF
7	Building a Resilience Model for Vulnerability Hotspots to Climate Change in Smallholder Dairy Production Systems of the Indo-Gangetic Plains Region of India Using GIS and Fuzzy Cognitive Mapping	NASF
8	Developing a Simulation Model of Technology Diffusion (TechSIM), Adoption and Impact Forecasting Using Techno-Socio-Psycho-Economic-Ecological Factors	NASF
9	Agri-Business Incubation Project	NAIF
10	ITMU Project under NAIF Component I	NAIF
11	Network Project on Conservation of Lac Insect Genetic Resources (NPCLIGR)	AINP on CLIGR
12	All India Coordinated Research Project on Goat Improvement	ICAR CIRG
13	Network Project on Buffalo Improvement	ICAR CIRB
14	Network Project on Animal Genetic Resources (AnGR)	ICAR NBAGR

b. The details of projects supported by various external funding agencies are enlisted below:

S. No.	Project Title	Funding Agency
1	IRRI NARES Breeding Network (Plant Direct) Project (Erstwhile Accelerated Breeding: Meeting Farmers Needs with Nutritious, Climate-Resilient Crops)	IRRI, Philippines
2	Cereal Systems Initiative for South Asia (CSISA) Phase IV	CIMMYT
3	Pilot Project for Crop Diversification	DA&FW, MoA, GoI
4	Building Lentil-Growing Community Resilience through the Development of Climate-Smart Lentil Varieties Using Farmers' Participatory Interventions	DA&FW, MoA, GoI
5	Supply Chain of Pulses in Major Pulse-Producing States of India with a Focus on Eastern States	Ministry of Consumer Affairs, Food and Public Distribution, GoI
6	Sustainable Improvement in the Livelihood of the SC Community in Meskaur and Sirdala Blocks of Nawada District, Bihar	DST, Govt. of India
7	Study on Biodiversity of Duck Germplasms in Bihar Using Machine Learning Models for Sustainable Conservation and Enhancing Productivity	Bihar State Biodiversity Board, Govt. of Bihar
8	Climate Resilient Agriculture Programme (Phase-II)	Govt. of Bihar
9	Strengthening of Farming System Models for Livelihood Security of Farmers and Their Promotion through Farmer Producer Organizations (FPOs) in Jharkhand	RKVY, Jharkhand
10	Demonstration and Conservation of Minor Gourds and Drumstick in Jharkhand	RKVY, Jharkhand
11	Processing and Value Addition of Jackfruit for Entrepreneurship Development in Jharkhand	RKVY, Jharkhand
12	Demonstration of a Fruit-Based Multi-Tier Organic Production System for Small and Marginal Farmers in Jharkhand	RKVY, Jharkhand
13	Popularization of Potential Underexploited Leguminous Vegetable Crops for Livelihood, Income and Nutritional Security of Farmers in Jharkhand	RKVY, Jharkhand
14	Setting up of a Referral Laboratory for Honey Testing in Jharkhand	RKVY, Jharkhand
15	Round-the-Year Demonstration of a Vegetable Production Module with Precision-cum-Resource Conservation Technology for Doubling the Income of Farmers in the Eastern Hill and Plateau Region	RKVY, Jharkhand

16	Standardization and Demonstration of Interspecific Grafting in Solanaceous and Cucurbitaceous Vegetables for the Management of Soil-Borne Diseases in Jharkhand	RKVY, Jharkhand
17	Supply Chain of Pulses in Major Pulse Producing States of India with Focus on Eastern States	RKVY, Jharkhand
18	Round-the-Year Demonstration of a Vegetable Production Module with Precision-cum-Resource Conservation Technology for Doubling the Income of Farmers in the Eastern Hill and Plateau Region	RKVY, Jharkhand
19	Strengthening the Farmer Producer Organization Model for Economic Security of Marginal and Small Farmers in Jharkhand	RKVY, Jharkhand

Institute funded research projects

The Institute undertakes its research programmes under five distinct mega-project themes, which are closely aligned with the core mandates and research priorities of ICAR RCER. These five major thematic areas are enlisted below:

S. No.	Mega-project themes
1.	Regenerative and Integrated Farming Systems for Climate Resilient Agriculture
2.	Genetic Resource Management and Improved Production Technologies
3.	Natural Resource Management for Enhancing Land & Water Productivity
4.	Sustainable Livestock & Fisheries Production System
5.	Socio-Economics, Extension and Policy Research

Notes

Notes

भाकृअनुप
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हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

ICAR RESEARCH COMPLEX FOR EASTERN REGION, PATNA

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ANNUAL REPORT 2025

25 YEARS

OF EXCELLENCE IN AGRICULTURAL RESEARCH AND INNOVATION