भाकृअनुप
ICAR

भा.च.चा.अ.सं.
IGFRI

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ICAR-Indian Grassland and Fodder Research Institute

वार्षिक प्रतिवेदन
Annual Report
2024

An ISO 9001:2015 Certified Institution

भाकृअनुप-भारतीय चरागाह एवं चारा अनुसंधान संस्थान
झाँसी- 284 003 (उ.प्र.) भारत

ICAR-Indian Grassland and Fodder Research Institute
Jhansi-284 003 (U.P.) India

Sardar Patel Outstanding ICAR Institution Award -2015

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Contents

From the Director's Desk..

The ICAR-Indian Grassland and Fodder Research Institute (IGFRI) in Jhansi, Uttar Pradesh, is a distinguished institution in Asia, devoted to fundamental, strategic, applied, and adaptive research on both annual and perennial fodder crops and grasslands. For over six decades, ICAR-IGFRI has made notable progress in the field of forage research, extension and capacity building and has widened its visibility at national and global level. The institute has followed a multi-disciplinary and inter-divisional research approach to address national issues like fodder shortage, deficiency of good quality seeds of range grasses and legumes, restoration of degraded lands, round the year fodder availability and for the development of high yielding fodder crop varieties adaptive to climate change. The institute has also played an instrumental role in disseminating information and newly developed technologies related to fodder crops, grassland and pasture rejuvenation and development through trainings, outreach programmes and MoUs with government, non-government agencies and corporate sector. The institute currently comprises seven specialized divisions, each focusing on areas such as crop improvement, crop production, grassland and silvipasture management, farm machinery and post-harvest technology, seed technology, plant-animal relationship, and social sciences. In addition, its three arms as regional research stations located at Dharwad, Avikanagar, Srinagar, and one centre for Indian Himalayan grasslands at Palampur serve four distinct agro-climatic zones. Further AICRP (FCU) 22 centers spread in different states across nation cater forage and fodder issues locally. Institute improved and established collaboration and linkages with Ministry of Fisheries, Animal Husbandry and Dairying GOI, New Delhi, state agriculture and animal husbandry departments, National Livestock Mission, BAIF, NDDB *etc.*

During the year, a lucerne variety IGFRI-DL-5 (IGFRI-Dharwad lucerne-5) was released for cultivation in the North-West Zone. Under AICRP (FCU) 20 varieties of different forage crops were identified and 17 notified for production. To cater nation's forage crops seed demand, institute produced 121.2 tons of oat and 13.4 tons of beseem seed in *rabi* 2023-24 along with 25.72 tons of sorghum, maize, cowpea, bajra and guar seed in *kharif* 2024. For green fodder production and rejuvenation of pasture and degraded lands institute also produced 17.67 lakhs of root slips (BN hybrid, Guinea, *Brachiaria* and rhodes grass) along with 60,000 cactus cladodes. Institute sold >7.0 lakhs root slips and 151.5 tons seed of different forage crops to farmers and diverse agencies. Institute published 70 research papers in high impact factor journals of diverse publishers describe its research acumen. Seed standards for five temperate forage crops (timothy, red fescue, white clover, sain foin and persian clover) were developed.

Institute silvpasture models, climate resilient fodder production model, biochar for soil amendment, dairy based IFS models, package of practices for spineless cactus, prediction model for forage crops diseases, method for estimation of pesticides and veterinary drugs in animal feeds, defluffing machine *etc.* were certified as technologies by ICAR in field of National Resource Managemant, engineering, crop science, animal science, extension and education. During the year five varieties of fodder crops (oat, berseem and cowpea) and three machines (grass seed defluffing machine, grass seed coating machine and grass seed pelleting machine) were licensed and commercialized. Two fodder resource development plans for Odisha and Chhattisgarh were prepared. Institute got DBT Har-Gobind Khorana Innovative Young Biotechnologist Fellowship (DBTIYBF) 2023-2024 on project "Development of tailor-made amphidiploids in novel fertile BN hybrid for transfer of desirable traits from Napier to Bajra using Doubled Haploid technology" with provision of budget Rs. 70 lakhs.

To apprise institute technologies 211 training cum exposure visits to technology park, research farm and laboratories were conducted for 10900 visitors (farmers/officers/ students & teachers/forest rangers *etc.*) from villages, FPOs, KVKs, forest, horticulture, agriculture and animal husbandry departments, universities *etc.* thereby reinforcing its obligation to rural development and sustainable agricultural practices. Human Resources Development cell facilitated 05 Ph.D. and 12 M.Sc. students for dissertation. In addition to 60 in-house projects, institute is running 24 externally funded projects with budgetary out lay of Rs. 1640.73 lakhs.

Institute successfully organized national events like *Swachhta Pakhwada*, *Hindi Pakhwada*, Plantation drive (One Tree for Mother), *Tiranga Ralley*, *Van Mahotsav,* World Intellectual Property Day, *Parthenium* Awareness Week and World Soil Day.

Notably the institute conducted economic impact analysis of 13 key leading and popular varieties of forage crops namely IGFRI-727 (*Cenchrus ciliaris*), BD-2 (*Pennisetum pedicellatum*), Wardan, BL-10 and BB-2 (*Trifolium alexandrinum*), JHO-822 and UPO-212 (*Avena sativa*), African tall and J-1006 (*Zea mays*), EC-4216 (*Vigna unguiculata*), and AL-3, RL-88 and Ananad-2 (*Medicago sativa*). The economic impact of these varieties amounted Rs. 495.9 billion, with an annual impact of Rs. 18.6 billion.

Seamlessly over the year, the institute significantly strengthened its outreach initiatives to disseminate forage improvement, production and conservation technologies to farmers through key programmes such as Farmer FIRST, SCSP, TSP, and NEH. Under these activities, approximately 400 demonstrations were conducted, benefiting over 10,000 farmers across the country. Improved varieties of forage crops including oat, berseem, and sorghum, along with more than 3 lakhs root slips of perennial grasses, were distributed to selected farmers.

The year 2026 has been designated as the International Year of Rangelands and Pastoralists (IYRP), aiming to raise global awareness and mobilize stakeholders for the sustainable management of rangelands-Earth's largest terrestrial ecosystem, covering approximately 54% of the planet's land surface. In preparation for IYRP, institute organized an online brainstorming workshop on "An Initiative for IYRP 2026: Invest in Grassland Research" on August 13, 2024 wherein a panel discussion was organized to identify key research areas and focus points for planning management, conservation and restoration of grasslands and rangelands. To line up with IYRP2026 institute published "Indian Rangeland and Grassland Conservation, Restoration and Structure: A Policy Perspective" document.

We carry out the research and development activities under the aegis of Indian Council of Agricultural Research (ICAR) and the Ministry of Agriculture and Farmers Welfare, Government of India. I extend my sincere thanks to institute advisory bodies: the Research Advisory Council and the Quinquennial Review Team for their valuable inputs and proactive guidance. I also express hearty gratitude to the Hon'ble Ministers of Agriculture and Farmers Welfare, Director General, ICAR and Secretary, DARE, Deputy Director General (Crop Science) and Assistant Director General (FFC) for their unwavering support, encouragement, and constructive approach towards institute's overall progress. I appreciate the commitment and dedication of the entire institute staff: scientific, technical, administrative, supporting, and contractual for their tireless dedication to the institute's mission which led to achieving our goals and upholding the standards of this ISO 9001:2015 certified institute. I also acclaim the editorial committee for their industrious work in compiling institute's all-round achievements in this Annual Report.

(Pankaj Kaushal)

कार्यकारी सारांश

कार्यक्रम 1: चारा फसलों की गुणवत्ता, बहुकटाई, अजैविक दबाव प्रबन्धन एवं जैव-फोर्टिफिकेशन, परम्परागत, अपोमिक्सिस और नये प्रजनन उपकरणों का उपयोग करते हुए अनुवांशिक सुधार

- लूसर्न किस्म आईजीएफआरआई–डीएल–5 (आईजीएफआरआई–धारवाड़ लूसर्न–5) को कृषि फसलों की किस्मों के मानक, अधिसूचना एवं विमोचन पर केंद्र सरकार की फसल उप–समिति की 92वीं बैठक में अधिसूचित कर कर्नाटक राज्य हेतु जारी किया गया। राजपत्र अधिसूचनाः एसओ 4388 (ई) दिनांक 8 अक्टूबर, 2024।
- **संकलनः** इस वर्ष के दौरान चारा फसलों एवं घासों (सेन्क्रस, बोथ्रिओक्लोआ, हेटेरोपोगोन, डाइकैंथियम, पैनिकम, मेडिकैगो तथा मक्का, ज्वार) की 973 प्रविष्टिया तथा रेड क्लोवर, ब्रोम ग्रास, व्हाइट क्लोवर, राई ग्रास, टॉल फेस्क्यू और एलिमस प्रजातियों की 37 संकलन संकलित कर जीन पूल को समृद्ध किया गया।
- **विश्लेशण एवं मूल्यांकनः** बरसीम (222 प्रविष्टियाँ), दीनानाथ घास (146 प्रविष्टियाँ), नेपियर घास (23 प्रविष्टियाँ), लोबिया (230 प्रविष्टियाँ), मोरस (अर्ध–शुष्क परिस्थितियों में 73 तथा समशीतोष्ण परिस्थितियों में 20 एवं ऐलैंथस एक्सेल्सा 46 (प्लस ट्री) जर्मप्लाज्म का विश्लेषण एवं मूल्यांकन किया गया।
- **संरक्षणः** दीनानाथ घास (140 प्रविष्टियाँ) और बरसीम (222 प्रविष्टियाँ) के बीज को आईसीएआर–एनबीपीजीआर के राष्ट्रीय जीन बैंक में दीर्घकालिक संरक्षण एवं संग्रह हेतु भेजे गये।

एआईसीआरपी (एक्रीप) समन्वित परीक्षणों में प्रविष्टियों का योगदान

मक्काः आईवीटी में 03 प्रविष्टियाँ (जेएचएफएम–24–1, जेएसएफएम–24–2 और जेएचएफएम–24–3), एवीटी 1 में 02 प्रविष्टियाँ (जेएसएफएम–23–2 और जेएचएफएम–23–3)।

चारा बाजराः आईवीटी में 03 प्रविष्टियाँ (जेएचएमसीबी–24–1, जेएचएमसीबी–24–2 और जेएचएमसीबी–24–3), एवीटी 1 में 02 प्रविष्टियाँ (जेएचपीएम–23–1 और जेएचपीएम–23–2), एवीटी 2 में 01 प्रविष्टी (जेएचपीएम–22–2)।

जईः कुल 6 प्रविष्टियाँ–आईवीटीओ एमसी में 01 प्रविष्टी, आईवीटीओ (द्विउद्देशीय) में 01, आईवीटीओ एससी में 01, एवीटीओ–2 एससी में 01, और एवीटीओ–1 (द्विउद्देशीय) में 01 प्रविष्ट।

बरसीमः आईवीटी में 01 प्रविष्टी (जेएचबी–24–1)।

डाइकैंथियम-बोथ्रिओक्लोआ समूहः कुल 6 प्रविष्टियाँ (जेएचडी–22–1, जेएचडी–22–2, जेएचडी–22–3, जेएचडी–22–4, जेएचडी–22–5, जेएचडी–22–6)।

लूसर्नः एवीटी–1 में 01 प्रविष्टी (एडब्ल्यूएल–6)।

उच्च जैवभार प्रविष्टियों का चयन एवं स्टेशन परीक्षण

बरसीमः 17 लाइनों का परीक्षण किया गया, जिनमें से 03 लाइनों को गुणन एवं बहुस्थान परीक्षण हेतु चयन किया गया।

जईः 03 स्टेशन परीक्षण किये गये। जिनमें एकल कटाई परीक्षण में 15 लाइनों का परीक्षण एवं 04 का चयन, बहुकटाई परीक्षण में 12 लाइनों का परीक्षण एवं 03 का चयन और द्विउद्देशी परीक्षण में 12 लाइनों का मूल्यांकन एवं 05 का चयन किया गया।

लोबियाः 19 लाइनों का परीक्षण किया गया, जिनमें से 03 लाइनों का चयन बहुस्थान परीक्षण (एक्रीप) हेतु किया गया।

संकरण एवं पीढ़ी उत्थान

बीएन हाइब्रिडः प्रजनक बीएन हाइब्रिड की एफ 4 पीढ़ी (750 पौधों) को ग्रीष्मकाल 2024 में ग्लास हाउस स्थितियों में एफ 5 एवं एफ 6 पीढ़ी तक उन्नत किया गया।

पेनिसेटम त्रि-प्रजातीय संकरः प्रजनक बीएन हाइब्रिड को पेनिसेटम स्केमुलेटम के साथ क्रॉस किया गया। इससे 39 नए पादप प्रकार प्राप्त हुए, जिनमें से 17 एपोमिक्टिक (अलैंगिक प्रजनन वाले) तथा शेष 22 लैंगिक प्रकार पाये गये।

मक्काः 55 इनब्रेड्स को एस 3 पीढ़ी तक, 68 इनब्रेड्स को एस 4 पीढ़ी तक, 139 इनब्रेड्स को एस 5 पीढ़ी तक उन्नत किया गया, 20 इनब्रेड्स को एस 7 तक स्थिर किया गया। कुल 245 इनब्रेड्स में से परफॉर्मेंस के आधार पर 23 एस 2/एस 3 इनब्रेड्स का चयन हरा चारा उपज (जीएफवाई) हेतु किया गया, इन चयनित इनब्रेड्स को रैंडम ढंग से क्रॉस कर 26 एफ 1 संयोजन विकसित किए गए, जिनमें से 8 क्रॉस उच्च हरा चारा उत्पादन (जीएफवाई) हेतु चिन्हित किये गये।

लोबियाः लोबिया की 9 विभिन्न क्रॉस की एफ 2 जनसंख्या को प्रक्षेत्र में उगाया गया। प्रत्येक एफ 2 जनसंख्या से चयनित पौधों को एफ 3 पीढ़ी तक उन्नत किया गया तथा आगे की पीढ़ी के लिए प्रजनन सामग्री का चयन किया गया।

जईः उच्च जिंक (Zn) एवं लौह (Fe) युक्त लाइनों तथा किस्मों (जेएचओ–99–2 एवं जेएचओ–15–1) से प्राप्त चार मैपिंग जनसंख्याओं को एफ 4 पीढ़ी तक उन्नत किया गया। विभिन्न कृषि–मॉर्फोलॉजिकल लक्षणों एवं ब्लॉच रोग प्रतिरोधिता हेतु चयनित 13 बेस एफ 3 जनसंख्याओं को एफ 4 पीढ़ी तक उन्नत किया गया।

चारा बाजराः ब्राउन मिडरिब मैपिंग जनसंख्याओं RIL1 (ICbmr07×ICBP19) एवं RIL2 (ICBbmr09 × ICBP01) को खरीफ एवं ग्रीष्मकाल 2024 में आगे बढ़ाया गया।

तनाव सहनशीलता एवं विशिष्ट गुणों हेतु चारा फसलों का आनुवांशिक सुधार

लोबियाः पाँच जीनोटाइप (आईजीसी 21, आईजीसी 48, आईजीसी 121, आईजीसी 202, आईजीसी 241) में उच्च पुनर्वृद्धि क्षमता (>91%) पाई गई, जबकि दो जीनोटाइप (आईजीसी–59, आईजीसी–167) में तीव्र सीधी वृद्धि प्रकृति पाई गई। तीन जीनोटाइप (आईसी 202781, आईसी 202789, ईसी 99573) में लगातार उच्च फॉस्फोरस उपयोग दक्षता देखी गई, क्योंकि कम फॉस्फोरस स्थिति में भी इनका जैवभार पर्याप्त था।

230 जर्मप्लाज्म लाइनों में से सात जीनोटाइप (आईजीसी 167, आईजीसी 193, आईजीसी 205, आईजीसी 230, आईजीसी 242, आईजीसी 245, आईजीसी 247) में उच्च हरा चारा उपज (जी एफ वाई) दर्ज की।

बीएन हाइब्रिडः सभी एफ 2 लाइनें उर्वर थी और विभिन्न बीज उत्पादन क्षमता के साथ उर्वर बीज उत्पन्न कर रही थीं, जिनमें प्रति पौधा बीज संख्या (एनएपीपी) 13 से 550 और इसका हजार बीज भार (टीएसडब्ल्यू) 0.62 से 4.77 ग्राम तक पाया गया।

चारा बाजराः बीएमआर इनब्रेड्स ICBbmr07 को उच्च जैवभार जीनोटाइप्स से क्रॉस कर बीएमआर इनब्रेड्स विकसित किए गए। इन्हें आपस में क्रॉस कर ग्रीष्म 2024 में एफ 1 लाइनें बनाई गईं। खरीफ 2024 में इन विविध एफ 1 लाइनों को दोबारा क्रॉस कर उच्च जैवभार देने वाले बीएमआर बाजरा संयोजन विकसित किए गए। 26 जीनोटाइप्स के बहु–स्थानिक परीक्षण में ICMbmr2402 और ICBbmr07 को लगभग 3% लिग्निन सामग्री वाले निम्न लिग्निन जीनोटाइप्स के रूप में चिन्हित किया गया। आईसीएफवीएम 05 में सबसे अधिक टिलर (11–18) और लंबी पत्तियाँ (74.55 से 85 सेमी) पाई गईं। आईजीबीवी 100 में सर्वाधिक पत्तीःतना अनुपात (1.8 से 2.3) देखा गया, जबकि आईसीएमएफवी 2308 और आईसीएमएफवी 2401 को देर से फूलने वाले जीनोटाइप्स के रूप में चिन्हित किया गया।

बरसीमः बरसीम और ट्राइफोलियम प्रजातियों को संक्रमित करने वाले पाउडरी मिल्ड्यू रोगजनक का रूपात्मक एवं आणविक लक्षणन किया गया, जिससे पुष्टि हुई कि यह इरिसाइफी ट्राइफोलियम नामक कवक है।

ज्वारः चारा ज्वार के बीस जीनोटाइप्स को बहुकटाई क्षमता और निम्न एचसीएन सामग्री के लिए विभिन्न जल स्थितियों में जाँचा गया। उच्च जल तनाव की स्थिति में एसएमसी–81, आईजीएस–68 और आईजीएस–डी2 जीनोटाइप्स ने बेहतर प्रदर्शन किया, जो उनके चारे की उपज, शारीरिक और रूपात्मक विशेषताओं पर आधारित था।

चारा फसलों में जैव प्रौद्योगिकी

लोबियाः इन–सिलिको विश्लेषण के माध्यम से लोबिया के जीनोम में कुल 13 फ्लावरिंग लोकस टी (एफटी) और इससे संबंधित जीनों की पहचान की गई। जीन संरचना के विश्लेषण से पता चला कि सभी जीनों में 4 एक्सॉन और 3 इंट्रॉन उपस्थित हैं।

क्लोरिस गयानाः लिपोक्सीजिनेज–5, कैल्सियम– निर्भर प्रोटीन काइनेज 7, सेलवाल–एसोसिएटेड रिसेप्टर काइनेज 3, एवं हाइड्राक्सीएसाइल–सीओए डिहाइड्रेटेज जीनों की अभिव्यक्ति सूखा एवं लवणता तनाव की स्थितियों में नियंत्रण की तुलना में काफी अधिक पाई गई। ये जीन क्लोरिस गयाना में अजैविक तनाव सहनशीलता में भूमिका निभाते हैं।

चारा बाजराः चारा बाजरा में बीएमआर लक्षण से संबंधित एक्स पीएसएम 2077 नामक मार्कर की पहचान लिंकेज ग्रुप–2 पर की गई। इस मार्कर को बीएमआर लोकस वाली विभिन्न आनुवंशिक पृष्ठ भूमियों पर सफलतापूर्वक सत्यापित किया गया। यह मार्कर बीएमआर और गैर–बीएमआर लाइनों को पृथक करने में सक्षम पाया गया।

नाभिकीय बीज उत्पादन

लोबिया : बीएल–1 (5 किग्रा.), बीएल–2 (5 किग्रा.), बीएल–4 (5 किग्रा.) बीज का उत्पादन किया गया।

जई: जेएचओ–822, जेएचओ–851, जेएचओ–99–1, जेएचओ–99–2, जेएचओ–2000–4, जेएचओ–10–1, जेएचओ–09–1, जेएचओ–12–2 और जेएचओ–15–1 किस्मों के प्रति किस्म 30 किग्रा. बीज का उत्पादन।

बरसीम: बीबी–5 (15 किग्रा.), बीबी–6 (20 किग्रा.), बीबी–7 (15 किग्रा.), बीबी–8 (03 किग्रा.) बीज का उत्पादन किया गया।

- मक्का में फाल आर्मीवर्म की उपस्थिति का वर्षा (–0. 50**) एवं प्रातः कालीन आर्द्रता (–0.42*) के साथ महत्वपूर्ण रूप से नकारात्मक सह–संबंध देखा गया। एन्टोमोपैथोजेन मेटारिजियम (नोमोरिया) रिलेई/2 ग्राम/लीटर के पश्चात नीम/5 मिली/लीटर का छिड़काव अनुक्रम, अधिक हरे चारे (जीएफवाई) और सूखे चारे (डीएफवाई) की उपज प्राप्त करने के लिए प्रभावी पाया गया।

कार्यक्रम 2 : उत्पादकता एवं आजीविका विकल्पों में सुधार हेतु चरागाह तथा अन्य संसाधनों के मूल्यांकन और कायाकल्प सहित विभिन्न भू–उपयोग प्रणाली में चारा उत्पादन का विविधीकरण और टिकाऊ सघनीकरण

- बीएन हाइब्रिड में 75% उपलब्ध मृदा आर्द्रता पर ड्रिप सिंचाई और 100% सिफारिशित उर्वरक (आरडीएफ) उपयोग करने से पारंपरिक बाढ़ सिंचाई की तुलना में हरे चारे की उपज (जीएफवाई) में 23.6% तथा जल उपयोग दक्षता में 81% की वृद्धि दर्ज की गई।
- बीएन हाइब्रिड में एसपीएडी मान (41–45) के आधार पर नाइट्रोजन देने से 8.6% अधिक हरे चारे की उपज और 19% अधिक कृषि नाइट्रोजन उपयोग दक्षता प्राप्त हुई, जो प्रत्येक कटाई के बाद 40 किग्रा. नाइट्रोजन प्रति हेक्टेयर देने से अधिक प्रभावी रही।
- विभिन्न घासों और साइलेज से लैक्टिक एसिड बैक्टीरिया (एलएबी) को अलग किया गया ताकि साइलिंग प्रक्रिया को बेहतर बनाया जा सके। लगभग 100 लैक्टीक एसिड वैक्टीरिया नमूनों में से चार कुशल लैक्टीक एसिड वैक्टीरिया स्ट्रेन की पहचान की गई, जिन्होंने बीएन हाइब्रिड और *सेंक्रस सिलियेरिस* साइलेज में लैक्टिक एसिड उत्पादन को बढ़ाया और पीएच को प्रभावी रूप से घटाया।
- जई में पीजीपीएम बीज उपचार से उपज और मृदा सूक्ष्मजीव गतिविधि में सुधार हुआ, जो कि 100% आरडीएफ के बराबर या उससे बेहतर था। एचपीएलसी विश्लेषण ने जड़ों से निकलने वाले उत्सर्जनों में वृद्धि दिखाई, जो सक्रिय पौधा–माइक्रोब अंतःक्रिया को दर्शाता है।
- चारा झाड़ी आधारित एली फसल प्रणाली में सिंचित परिस्थितियों में सहजन + बाजरा–नेपियर हाइब्रिड तथा वर्षा आधारित परिस्थितियों में सहजन + ग्रेजिंग गिनी सिग्नल घास प्रणाली ने अन्य प्रणालियों की तुलना में अधिक हरे चारे, सूखे चारे और कच्चे प्रोटीन की उपज दर्ज की।
- फसल विविधिकरण और जिंक फोर्टिफिकेशन (कश्मीर हिमालय) में गहन चारा उत्पादन से पता चला कि लोबिया में कच्चे प्रोटीन (CP) की मात्रा सबसे अधिक थी, जबकि मक्का + लोबिया प्रणाली में CP उपज सर्वाधिक पाई गई। मृदा + फोलियर जिंक छिड़काव से CP में 3.18% और CP उपज में 17.61% की वृद्धि हुई।
- प्राकृतिक खेती परियोजना में परंपरागत खेती पद्धति में चारा जई और ऑर्चर्ड घास में क्रमशः अधिकतम हरा एवं सूखा पदार्थ प्राप्त हुआ, जबकि प्राकृतिक खेती में दोनों फसलों के लिए हरा एवं सूखा पदार्थ सबसे कम रहा।
- वर्षा आधारित परिस्थितियों में प्रणाली के अंतर्गत स्वीट कॉर्न–चना प्रणाली ने सात फसल प्रणालियों में सबसे अधिक उत्पादकता, शुद्ध लाभ और अधिकतम प्रतिदिन उपज दर्ज की, जिससे यह सबसे कुशल एवं लाभकारी प्रणाली सिद्ध हुई।
- सूखा सहिष्णु पीजीपीबी के साथ ज्वार और लोबिया का टीकाकरण करने से सूखे की स्थिति में पीजीपीबी कंसोर्टिया द्वारा ज्वार और लोबिया का उपचार करने से पौधों की जल स्थिति, प्रोलिन मात्रा, चारा एवं बीज उपज में सुधार हुआ।
- पोषक तत्व उपयोग दक्षता बढ़ाने और पर्यावरणीय नुकसान को कम करने हेतु नैनो–आकार के जिओलाइट, हाइड्रॉक्सीएपाटाइट और सूक्ष्म पोषक तत्वों (कापर, लौह, जिंक) से युक्त हाइब्रिड नैनोफर्टिलाइज़र विकसित किये गये।

कार्यक्रम 3: टिकाऊ एवं जलवायु समुत्थानशील चारा उत्पादन हेतु कृषि योग्य एवं गैर कृषि योग्य भूमि के प्राकृतिक संसाधनों एवं मृदा स्वास्थ्य का प्रबन्धन

- तीन–स्तरीय सिल्विपास्चर प्रणाली में झाड़ियों और पेड़ों की छंटाई प्रबंधन में 70% तीव्रता से छंटाई करने पर 50% की तुलना में अधिक टॉप फीड और जलाऊ

लकड़ी प्राप्त हुई। झाड़ी प्रजातियों में बेर ने सर्वाधिक टॉप फीड और लकड़ी दी, इसके बाद घोट और कत्था रहे, जो हार्डविकिया बिनाटा के साथ उगाये गये थे।

- *हार्डविकिया बिनाटा* आधारित सिल्विपास्चर प्रणाली में छंटाई प्रबंधन में 60% छंटाई करने से चरागाह की उपज और टॉप फीड में महत्वपूर्ण वृद्धि हुई। घासों में धबलू घास ने सर्वाधिक चारा उपज दी, उसके बाद अंजन घास और गिनी घास का स्थान रहा।
- प्राकृतिक खेती के तहत आँवला आधारित हॉर्टी–पास्चर प्रणाली में विभिन्न डीकंपोजर के प्रयोग से फलों की उपज में महत्वपूर्ण वृद्धि दर्ज की गई। डीकंपोजर उपचारित भूखंडों में हॉर्टी–पास्चर प्रणाली की उत्पादकता भी अधिक रही।
- अमरूद आधारित हॉर्टी–पास्चर प्रणाली में बोरोन के उच्च सांद्रता के पर्णिय छिड़काव से फल गठन (64.8%) और फल धारण (66.8%) तथा कुल उपज में सर्वाधिक वृद्धि पाया गया।
- सिल्विपास्चर प्रणाली में हरे चारे की उपज गिनी घास (42.4 टन/हे.) में सर्वाधिक रही, उसके बाद धबलू घास (32.2 टन/हे.) और स्टाइलो (12.7 टन/हे.) में पाया गया। वृक्ष/झाड़ियों में सूबबूल से सर्वाधिक (15.01 टन/हे.) हरा चारा प्राप्त हुई। सूबबूल और पाकड़ आधारित सिल्विपास्चर प्रणाली में जलौनी भेड़ों को उनके शरीर के भार के 1% के अनुपात में रावत पूरक आहार देने पर प्रतिदिन 50–60 ग्राम वजन वृद्धि दर्ज की गई।
- उन्नत चारागाह प्रबंधन के अंतर्गत मिट्टी–चारागाह–पशु स्थायित्व हेतु 1 एसीयू चराई दबाव पर अधिकतम जैवभार उत्पादकता प्राप्त हुई। मिट्टी गुण विश्लेषण में 3 एसीयू दबाव पर सर्वाधिक कुल नाइट्रोजन, पौधों हेतु उपलब्ध फॉस्फोरस, और सबसे कम पोटाश तथा जैविक कार्बन (एसओसी) सामग्री दर्ज की गई।
- मिट्टी के स्वाभाविक फॉस्फोरस को घुलनशील करने हेतु प्राकृतिक सिलिकॉन स्रोतों और फॉस्फोरस घुलनशील सूक्ष्मजीवों (पीएसएम) का प्रयोग किया गया। धान के भूसे /10 टन/हे.+ बर्कहोल्डरिया स्पेशिस (पीएसएम) के प्रयोग से अधिक मात्रा में फॉस्फोरस खनिजीकृत हुआ।
- बुंदेलखंड क्षेत्र के ललितपुर, छतरपुर और हमीरपुर जिलों में जियोस्पेशियल तकनीक से चरागाह का मूल्यांकन हेतु रैंडम फॉरेस्ट मॉडल ने चारागाह उत्पादकता पूर्वानुमान में श्रेष्ठ प्रदर्शन किया (R^2=0.80, NSE = 0.74 g/m², RMSE = 15.66 g/m², RPIQ = 1.70)।
- अमृत महल की प्राकृतिक चरागाह पारिस्थितिकी तंत्र निगरानी प्रणाली में एक्स जी बुस्ट मॉडल ने चारागाह उत्पादकता और पारिस्थितिकी तंत्र सेवाओं के पूर्वानुमान में श्रेष्ठ प्रदर्शन किया।
- ड्रोन आधारित सीड पैलेट तकनीक से केन्द्रीय अनुसंधान फार्म की विकृत भूमि पर स्थापित चरागाह से गिनी घास, दीनानाथ घास और अंजन घास से क्रमशः 1.54, 1.95 और 0.68 टन/हे. हरे चारे की उपज प्राप्त किया गया।

कार्यक्रम 4: गुणवत्तायुक्त बीज उत्पादन बढ़ाने हेतु बीज विज्ञान एवं तकनीकी को बढ़ावा देना तथा राष्ट्रीय चारा बीज नेटवर्क को मजबूत करना

- *लैसियुरस सिन्डिकस, क्लाइटोरिया टरनेटिया, डिसमेन्थेस विरगेटस, स्टाइलोसेंथिस हमाटा, टाल फेस्क्यू,* आरचर्ड घास, ब्रोम घास, राई घास और रेड क्लोवर के लिए बीज मानक विकसित किये गये।
- पोटैशियम नाइट्रेट एवं पूर्व शीतन उपचार से पाँच समशीतोष्ण चारे वाली प्रजातियों में बीज निष्क्रियता तोड़ने की विधियाँ मानकीकृत की गईं।
- बरसीम की लगभग 1400 उत्परिवर्तित पंक्तियाँ (EMS से उपचारित) जिसमें बीबी 6 किस्म की एम4–एम5 पीढ़ी) ग्लाइफोसेट किग्रा. सक्रिय तत्व/हे. की स्क्रीनिंग खुराक पर जाँची गईं, जिनमें से पाँच उत्परिवर्तित पंक्तियों को चिन्हित की गईं।
- एक स्मोक वॉटर मशीन विकसित की गई, जिससे धुएं को पानी के साथ प्रभावी ढंग से मिलाया जा सके। धुएं वाले पानी के 1% घोल ने दीनानाथ घास (प्रजाति बीडी–2) और लम्पा घास (प्रजाति बीएल–1) के अंकुरण को नियंत्रण की तुलना में सार्थक रूप से बढ़ाया।
- गहरे रंग की आवरण वाली बीज प्रजातियों में टैनिन, फिनोलिक, फ्लावोनॉइड्स और विद्युत चालकता अधिक पाई गई, जबकि एंटीऑक्सीडेंट की मात्रा कम थी, जिससे यह संकेत मिलता है कि बीज आवरण का रंग और उम्र बढ़ने से बीज का अंकुरण और जीवन क्षमता कम करती है।

- दोनों प्रक्षेत्र परीक्षण (खरीफ 2023 और ग्रीष्म 2024) और रेत संवर्धन प्रयोग में तीन उच्च फॉस्फोरस उपयोग दक्षता वाली जर्मप्लाज्म पंक्तियाँ (आईसी 202781, आईसी 202789, और ईसी 99573) चिन्हित की गईं, जिनमें कम फॉस्फोरस उपलब्धता जैवभार में न्यूनतम गिरावट देखी गई।
- सिरात्रों और ब्रेकिएरिया के बीज गुणवत्ता परीक्षण के लिए प्रोटोकॉल विकसित किये गये।
- लम्पा और सेहिमा प्रजातियों के अंकुरण के लिए टॉप ऑफ पेपर (टीपी) माध्यम और 250 सेल्सियस तापमान अंधकार स्थिति में अधिक उपयुक्त पाये गये।

कार्यक्रम 5: चारा संसाधनों का पोषण मूल्यांकन एवं फसल–पशुधन उत्पादन प्रणाली सुधार

- ब्रेसिका प्रजातियों से निकाले गए ईसेन्सियल तेल ने एस्परजिलस पैरासिटिकस और एस्परजिलस फ्लेवस की वृद्धि को 40 $\mu L L^{-1}$ या उससे अधिक मात्रा में रोका, जबकि कुरकुमा और साइट्रस तेल व नीम बीज गिरी अर्क के लिए 250 $\mu L L^{-1}$ प्रभावी सांद्रता रही।
- मिलेट उपोत्पादों और बरसीम हे का उपयोग करके एक टीएमआर (टोटल मिक्स्ड रेशन) तैयार किया गया, जो वाणिज्यिक बकरी पालन के लिए अनाज आधारित टीएमआर से 12% सस्ता पाया गया।
- गिनी घास और सान्द्र मिश्रण से बनी टीएमआर साइलेज खिलाये गये जानवरों में औसतन 84.7 ग्राम प्रतिदिन वजन वृद्धि दर्ज की।
- चराई के दौरान चाहे सुबह हो, दोपहर या शाम, भेड़ों ने चराई में घासों को प्रमुखता दी, गर्मियों में चरागाह समय और चरागाह सेवन पर्यावरण तापमान से नकारात्मक रूप से संबंधित पाये गये।
- बुन्देलखण्डी बकरी के लिए झाँसी जिले की 5 और दतिया जिले की 2 गाँवों को जोड़ा गया। कुल 2387 बकरियाँ पंजीकृत की गयी जो पिछले वर्ष से 26% अधिक थीं। बकरियों की विस्तृत शारीरिक विशेषताएं और बायोमेट्रिक माप लिए गये। बेहतर नर बकरों का प्रदर्शन (15), टीकाकरण, स्वास्थ्य शिविर, चारा प्रचार और किसानों का प्रशिक्षण आयोजित किया गया।
- शुद्ध नस्ल की भदावरी भैंसों के झुंड का रख–रखाव किया गया, जिसमें दुग्ध उत्पादन और दुग्ध संघटन में महत्वपूर्ण आँकड़े दर्ज किए गये। 3 प्रजनक सांड बेचे गए, 9200 वीर्य डोज फ्रीज़, 2571 कृत्रिम गर्भाधान, और 1060 वीर्य डोज बेचे गये। बछड़ों की मृत्यु दर 2.38%, औसत एलएमवाई – 1657.4 किग्रा., 305 दिन का एलएमवाई – 1496.9 किग्रा., डब्ल्यूए– 4.55 किग्रा., एचए–2.92 किग्रा., एएफसी– 45.6 माह, और सीआर– 62.2% दर्ज किया गया।
- सेब का खोइंरा की मिलावट से तैयार घास/दलहनी–सेब पत्तियों वाले चारे की पोषण गुणवत्ता और साइलेंज गुणवत्ता पर प्रभाव देखा गया। साइलेज में सीपी, एनडीएफ, एडीएफ सेल्यूलोज और लिग्निनकी मात्रा क्रमशः 9.63–13.78%, 41.12–51.51%, 22.07–30.39%, 17.50–22.01% और 4.45–8.16% पाई गई। टीडीएन, डीई और एमई क्रमशः 65.40–76.24%, 2.88–3.36 किलो कैलोरी/ग्राम और 2.37–2.76 किलो कैलोरी/ग्राम के बीच थे। पीएच मान सभी साइलेज में मानक सीमा (3.74–4.10) में रहा।
- विकसित चारा बीज लेप मशीन की लेपन क्षमता बरसीम के लिए 6.0 कुन्तल प्रति घंटे और लोबिया के लिए 6.5 कुन्तल प्रति घंटे पाई गई, जो 90% श्रम की बचत करती है। इस मशीन को एमएस न्यू अशोक वर्मा इंडस्ट्रीज, झाँसी को मार्च 2024 से 3 वर्षों के लिए लाइसेंस किया गया।
- सौर ऊर्जा चालित स्वचालित बहुउद्देशीय मशीन विकसित की गई, जिसमें रोटरी टिलिंग यूनिट और स्प्रेइंग यूनिट शामिल हैं। स्प्रेइंग के लिए मशीन की कार्य क्षमता 0.75 हेक्टेयर/घंटा और कार्य कुशलता 93% पाई गई, जबकि टिलिंग के लिए 0.09 हेक्टेयर/घंटा और 90% कार्य कुशलता रही।
- दो पहियों वाली पशु चालित शेड स्क्रैपर मशीन का प्रोटोटाइप तैयार किया गया, जो पशु शेड की सतह को साफ करने और श्रम को कम करने में सक्षम है। इसकी कार्य क्षमता 0.08 हेक्टेयर/घंटा और कार्य कुशलता 89% रही।
- पशुओं के लिए टीएमआर (टोटल मिक्स्ड रेशन) बनाने की मशीन विकसित की गई, जिसकी क्षमता 4 कुन्तल प्रति घंटा है। यह मशीन प्रति घंटे 26 बैग पैक कर सकती है, जिनमें से प्रत्येक बैग का वजन 15 किलोग्राम होता है।

कार्यक्रम 6: सामाजिक, आर्थिक नीतिगत हस्तान्तरीय अनुसंधान एवं क्षमतर निर्माण

- पशुधन आधारित एकीकृत खेती प्रणाली ने उत्पादकता को 3.3 से 4.5 गुना तक बढ़ाया, जिससे 11.0 लाख रुपये/हेक्टेयर वार्षिक सकल और 4.6 लाख रुपये/

हेक्टेयर शुद्ध आय प्राप्त हुई, जोकि पारंपरिक मूंगफली– गेहूं फसल प्रणाली की तुलना में कहीं अधिक है। मृदा उर्वरता में 11–16% की वृद्धि और 3–5 वर्षों में 22% चारे का आवश्यकता में कमी दर्ज की गई।

- आदर्श चारा ग्राम योजना के तहत, चारा ग्रामों में डेयरी किसानों की आवासीय सुरक्षा में 14–19%, आर्थिक सुरक्षा में 19–21% और खाद्य सुरक्षा में 13–16% तक अधिक सुधार की संभावना पाई गई।
- देश में 13 प्रमुख चारा फसल किस्मों के आर्थिक प्रभाव का अनुमानित लाभ 495.9 अरब रुपये रहा। केवल अफ्रीकन टाल मक्का किस्म ने ही 338.1 अरब रुपये का आर्थिक अधिशेष उत्पन्न किया। अध्ययन से ज्ञात हुआ कि उपभोक्ता अधिशेष 60% और उत्पादक अधिशेष 40% था, जो बेहतर चारा प्रौद्योगिकियों के व्यापक लाभ पर जोर देते है।
- फार्मर फर्स्ट कार्यक्रम के तहत डीबीडब्ल्यू–187 (गेहूं), डीएचबीएम 93–1 (बाजरा) जैसे अधिक उपज देने वाली, रोगरोधी फसलें और जई की उन्नत किस्म जेएचओ–822 को बढ़ावा दिया गया। साथ ही मृदा स्वास्थ्य, वर्मी कंपोस्टिंग और खरपतवार नियंत्रण पर प्रशिक्षण तथा 254 चारा एवं पशुपालन प्रदर्शन किए गए। इसके परिणाम स्वरूप मूंगफली में 26%, मूंग में 23% और गेहूं में 13% उत्पादन वृद्धि हुई, जिससे 381 किसानों को 20% तक लाभ प्राप्त हुआ।
- एससीएसपी परियोजना के अंतर्गत संस्थान ने कृषि विज्ञान केन्द्रों के सहयोग से छह राज्यों में 1,000 किसानों को प्रशिक्षण दिया, जिसमें 245 चारा उत्पादन और 525 पशुपालन प्रदर्शन शामिल थे। अनुसूचित जाति के किसानों को पशुधन सहायता, प्रशिक्षण और उपकरण प्रदान किए गए। टीएसपी परियोजना के तहत राजस्थान में 668, जम्मू–कश्मीर में 442, मध्य प्रदेश में 110, महाराष्ट्र में 60, और हिमाचल प्रदेश में 64 आदिवासी किसानों को चारा और औषधियों की सहायता प्रदान की गई।
- आम बागानों में चारा फसलों के समावेशन से हरा और सूखा चारे की कमी को क्रमशः 59.17% से 16.30% और 48% से 31.67% तक कम किया गया। चारा हस्तक्षेपों के कारण शुद्ध लाभ में वृद्धि, 2691 रुपये से बढ़कर 4649 रुपये तक हुई।

Executive Summary

Programme 1: Genetic enhancement of forage crops with emphasis on quality, multicut, stress tolerance & bio-fortification utilizing conventional, apomixes and new breeding tools

- Lucerne variety IGFR-DL-5 (IGFRI-Dharwad Lucerne-5) - Released and notified for Karnataka state by 92[nd] meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops. Gazette Notification; SO 4388 (E) dt 8[th] Oct. 2024.
- **Collection:** Forage gene pool was enriched by 973 accessions of forage crops and grasses (*Cenchrus, Bothriochloa, Heteropogon, Dichanthium, Panicum, Medicago*, maize and sorghum); 37 collections of red clover, brome grass, white clover, rye grass, tall fescue, and *Elymus* spp.
- **Characterization and evaluation:** Berseem (222 accessions), Dinanath grass (146 accessions) napier grass (23 accessions), cowpea (230 accessions); Morus germplasm (73 in semi-arid conditions and 20 in temperate condition); *Ailanthus excelsa* plus trees germplasm *(*46).
- Seeds of 140 Dinanath grass and 220 berseem accessions were submitted to ICAR-NBPGR for long term conservation.

Entries contribution in AICRP (FCU) trials

Maize: IVT 03 (JHFM-24-1, JSFM-24-2 and JHFM-24-3), AVT1 02 entries (JSFM-23-2 and JHFM-23-3).

Fodder pearl millet: IVT 03 (JHMCB-24-1, JHMCB-24-2 and JHMCB-24-3) , AVT1 02 (JHPM 23-1 and JHPM 23-2) and AVT2 01 (JHPM-22-2) entries.

Oat: Six entries IVTO MC 01, IVTO (Dual) 01, IVTO SC 01, AVTO-2 SC 01 and one in AVTO-1 (dual).

Berseem: IVT 01 (JHB-24-1).

Dichanthium-Bothriochloa **complex:** Six entries (JHD-22-1, JHD-22-2, JHD-22-3, JHD-22-4, JHD-22-5 and JHD-22-6).

Lucerne: AVT-1 (AWL-6)

Multiplication of high biomass entries and station trials

Berseem: 17 lines tested, 03 lines selected for multiplication and multilocation testing.

Oat: 03 station trials were conducted. In single cut trial, 15 lines tested and 04 lines selected. In multi cut trial, 12 lines tested, 03 lines were selected. In dual purpose trial, 12 lines were evaluated, 05 lines selected.

Cowpea: 19 lines tested, 03 lines were selected for multi-location trials under AICRP.

Hybridization and generation advancement

BN hybrid: F_4 population of fertile BN hybrid (750 individuals) were advanced to F_5 and F_6 generation.

Pennisetum tri species hybrid: Fertile BN hybrids were crossed with *Pennisetum squamulatum* (PS) and 39 new plant-types were obtained (17 apomictic and rest 22 sexual).

Maize: Fifty-five inbreds were advanced to S3, 68 inbreds to S_4, and 139 inbreds to S_5 generation. Twenty inbreds were stabilized to S_7 generation.

About 23 out of 245 S2/S3 inbreds were selected based on the green fodder yield and were crossed in random fashion to generate 26 F_1 combinations. Eight crosses were identified with high GFY.

Cowpea: The F_2 populations of nine different crosses of cowpea were grown in field. The selected plants in each F_2 population were advanced to F_3 generation and subsequent progenies were selected for next generation.

Oat: Four mapping populations derived from high Zn and high Fe lines with oat varieties (JHO-99-2 and JHO-15-1) and 13 base F_3 populations segregating for various agro-morphological and blotch disease resistance trait were advanced to F_4 generation.

Forage pearl millet: Developed BMR mapping populations RIL1 (ICbmr07 × ICBP19) and RIL2 (ICBbmr09 × ICBP01) were advanced during *kharif* and summer 2024.

Genetic improvement of forage crops for stress tolerance and other specific traits

Cowpea: Five cowpea genotypes (IGC21, IGC48, IGC121, IGC202 and IGC241) were identified with high regrowth (>91%), while two genotypes (IGC-59 and IGC-167) were identified with acute erect growth habit.

Three genotypes (IC 202781, IC 202789 and EC 99573) consistently exhibited high phosphorus use efficiency, as evidenced by least reduction in biomass under low-P condition compared to sufficient-P condition.

Out of 230 germplasm lines evaluated, seven genotypes *viz.*, IGC167, IGC193, IGC205, IGC230, IGC242, IGC245 and IGC247 recorded high GFY.

BN hybrid: All the F_2 lines were fertile and produced viable seeds in differential pattern with NSPP varied from 13 to 550 with TSW ranged from 0.62-4.77 g.

Pearl millet: bmr inbreds were developed by crossing ICBbmr07 with high biomass genotypes. They were then crossed with each other to generate F_1 lines during summer 2024. During *kharif* 2024, F_1 lines were again crossed to develop high-biomass yielding bmr pearl millet composites.

The multi-location trial conducted with these 26 genotypes, ICMbmr2402 and ICBbmr07 were identified as low lignin genotypes (~3.0%). ICFPM 05 exhibited a higher number of tillers (11–18) with longer leaf length (74.5 to 85.0 cm). IGBV 100 had highest leaf-to-stem ratio (1.8 to 2.3), while ICMFV 2308 and ICMFV 2401 were identified as late-flowering genotypes.

Berseem: Morphological and molecular characterization of powdery mildew pathogen infecting berseem and *Trifolium* spp. confirmed the pathogen as *Erysiphe trifoliorum.*

Sorghum: Twenty fodder sorghum genotypes were screened for multicut, and low HCN contents under water regimes. Based on the fodder biomass, physiological and morphological attributes the sorghum genotypes SMC-81, IGS-68 and IGS-D2 performed better under high water stress treatment.

Biotechnology in forage crops

Cowpea: *In-silico* analysis led to identification of 13 flowering locus T (FT) and its related genes across cowpea genome. Gene structure analysis revealed presence of 4 exons and 3 introns in all the genes.

Chloris gayana: Expression levels of lipoxygenase-5, calcium-dependent protein kinase 7, cell wall-associated receptor kinase 3, and hydroxyacyl-CoA dehydratase were significantly higher in both drought and salinity stress conditions compared to the control. These genes play important role in abiotic stress tolerance in *Chloris gayana*.

Pearl millet: Marker *XPSPM2077* located on linkage group 2 in pearl millet found associated with bmr trait. This marker was successfully validated on different genetic backgrounds carrying bmr loci. The marker clearly differentiated bmr and non bmr lines in segregating generation.

Nucleus seed production

Cowpea: BL-1, BL-2 and BL-4 (5 kg each).

Oat: JHO-822, JHO-851, JHO-99-1, JHO-99-2, JHO-2000-4, JHO- 10-1, JHO-09-1, JHO-12-2 and JHO-15-1 (30 kg each).

Berseem: BB-5 (15 kg), BB-6 (20 kg), BB-7 (15 kg), BB-8 (03 kg).

- Significant negative correlations with the rainfall (-0.50) and morning humidity (0.42) was observed with fall armyworm in maize. Entomopathogen *Metarhizium (Nomoraea) rileyi* @ 2 g l^{-1} followed by neem @ 5 ml l^{-1} proved better sequence of sprays with higher GFY and DFY.

Programme 2: Diversification and sustainable intensification of fodder production in different land use systems including assessment and rejuvenation of grasslands and other resources for improving productivity and livelihood options

- Drip irrigation at 75% available soil moisture in BN hybrid with 100% RDF recorded 23.6% higher GFY and 81% higher water use efficiency compared to the farmer's practice of flood irrigation.
- Nitrogen application based on SPAD values (41–45) in BN hybrid resulted in 8.6% higher GFY and 19% higher agronomic nitrogen use efficiency compared to blanket application of 40 kg N ha^{-1} after each cut.
- Lactic acid bacteria (LAB) were isolated from various grasses and silages to enhance the

ensiling process by improving lactic acid production and lowering silage pH. Out of ~100 isolates, four efficient LAB strains were identified which significantly improved fermentation quality, lactic acid content, and pH reduction in BN hybrid and *Cenchrus ciliaris* silages.

- PGPM seed inoculation in oats improved yield and soil microbial activity, matching or exceeding 100% RDF in poor soils. HPLC showed enhanced root exudates, indicating active plant-microbe interactions.
- Among the fodder shrub based alley cropping systems, moringa with BN hybrid under irrigated and moringa with grazing guinea signal grass under rainfed conditions recorded higher green fodder, dry fodder and crude protein yield as compared to other systems.
- Intensive fodder production through crop diversification and zinc fortification in Kashmir Himalaya revealed that cowpea recorded highest CP content; however, maize + cowpea recorded highest CP yield. Soil + foliar application of zinc increased CP content by 3.18% and CP yield by 17.61% over control.
- Fodder oat and orchard grass recorded highest green and dry matter yield, respectively, under conventional/ modern farming, while natural farming recorded lowest green and dry matter yield for both the crops.
- Under rainfed conditions, sweet corn– chickpea system showed highest productivity. It also had highest per-day yield, making it the most efficient and profitable among seven cropping systems evaluated.
- Inoculation of sorghum and cowpea with drought-tolerant PGPB consortia improved plant water status, proline content, fodder, and seed yields under drought stress.
- Hybrid nanofertilizers were developed using nano-sized zeolite, hydroxyapatite, and micronutrients (Cu, Fe, Zn) to enhance nutrient use efficiency and minimize environmental losses.

Programme 3: Management of natural resources and soil health of arable and non arable lands for climate resilient sustainable fodder production

- Under lopping management in three tier silvipasture system, lopping of shrubs and trees at 70% intensity gave higher top feed and fire wood as compared to 50% lopping. Among shrub species *Ziziphus mauritiana* recorded maximum top feed and fire wood followed by *Z. xylopyrus and Acacia catechu* in association with *Hardwickia binata*.
- Under pruning management in *H. binata* based silvipasture systems, 60% pruning resulted significantly higher pasture yield and top feed. Among grasses, *Chrysopogon fulvus* recorded maximum pasture yield followed by *Cenchrus ciliaris* and *Megathyrsus maximus* in association with *H. binata*.
- Under the natural farming in aonla-based horti-pasture system with different decomposers recorded significantly higher fruit yield. The system productivity was also significantly higher in decomposer treated plots.
- In guava based hortipasture system, foliar application of higher concentration of boron recorded highest fruit set and retention (64.8 & 66.8%) and fruit yield.
- In silvipasture systems, GFY was maximum in *Megathyrsus maximus* (42.4 Mg ha^{-1}) followed by *Chrysopogon fulvus* (32.2 Mg ha^{-1}) and *Stylosanthes seabrana* (12.7 Mg ha^{-1}). Among tree/ shrubs maximum GFY was obtained from *Leucaena leucocephala* (15.01 t ha^{-1}). Jalauni sheep grazing on *L. leucocephala* and *F. infectoria* based silvipasture system with supplementation of concentrate @ 1% body weight could support a daily body weight gain of 50-60 g in the systems.
- In improved pasture management for sustaining soil-pasture-animal, the highest biomass productivity was under 1 ACU grazing pressure. The soil property analysis revealed that 3 ACU grazing pressure had the highest total N, plant available P, and lowest plant available K and SOC content.

- Under solubilisation of native soil phosphorus using natural sources of silicon and P solubilising microbes (PSM), application of rice starw at 10 Mg ha^{-1} + PSMs (*Burkholderia cepacia*) mineralize greater P.
- In grassland assessment using geospatial technology in Lalitpur, Chhatarpur and Hamirpur district of Bundelkhand region, random forest model (R^2 = 0.80, NSE = 0.74 g m^{-2}, RMSE = 15.66 g m^{-2}, RPIQ= 1.70) performed superior for predicting pasture productivity.
- For natural grassland ecosystem monitoring system of Amrit Mahal, XGboost model performed superior for predicting pasture productivity and ecosystem services.
- Grassland was established on the degraded land patch of the central research farm using a drone with seed pellet technology. *Megathyrus maximus, Pennisetum pedicellatum and Cenchrus ciliaris* attained the green fodder yield of 1.54, 1.95 and 0.68 Mg ha^{-1}, respectively.

Programme 4: Accelerating seed biology research and technology development for enhanced quality forage seed production and strengthening national forage seed network

- Seed standards were developed for *Lasiurus scindicus*, *Clitoria ternatea*, *Desmanthus virgatus*, *Stylosanthes hamata,* tall fescue, orchard grass, brome grass, rye grass and red clover.
- Seed dormancy-breaking protocols were standardized in five temperate forages using KNO_3 and pre-chill treatment.
- About 1400 mutant lines of berseem (EMS-treated BB6 variety of berseem at M4-M5 generation) were screened against glyphosate (0.8 kg a.i. ha^{-1}) and five mutant lines were identified.
- A smoke water machine was developed to efficiently blend smoke with water. About 1% concentration of smoke water significantly improved germination of *Pennisetum pedicellatum var.* BD-2 and *Heteropogon contortus var.* BL-1 over control.
- Seeds with darker coats exhibited elevated tannins, phenolics, flavonoids and electrical conductivity coupled with low antioxidants suggested that changes in seed coat colour and ageing were associated with low seed germination and viability.
- Across both field trials (*kharif*-2023 and *summer*-2024) and sand culture experiment, three P efficient genotypes (IC 202781, IC 202789, and EC 99573) were identified with least reduction in biomass under low P regimes.
- Protocols were developed for seed quality testing of *Siratro* and *Brachiaria*.
- Top of paper (TP) medium and 25°C temperature in dark were found more suitable for germination evaluation of *Heteropogon* and *Sehima* species.

Programme 5: Nutritional evaluation and post harvest management of forage resources for sustainable and improved crop-livestock production systems

- Essential oil extracted from *Brassica* sp. inhibited *Aspergillus parasiticus* and *Aspergillus flavus* growth @ 40 µl l^{-1} and more, whereas, 250 µl l^{-1} was the effective concentration for *Curcuma* and *Citrus* essential oil & neem seed kernel extract.
- Utilizing millet by-products and berseem hay, a total mixed ration (TMR) was developed for commercial goat production costing 12% less than spent grain-based TMR.
- TMR silage using guinea grass and concentrate mixture improved daily body weight gain (~84.7 g) in silage-fed animals.
- During grazing sheep favored grasses majorly, including the morning, afternoon, and evening. Grazing time and grazing intake were negatively correlated with the ambient temperature during summer season.
- Under Bundelkhandi goat improvement programme, 05 villages of Jhansi and 02 villages of Datia were added. Total registered goats were 2387, 26% more than previous year. Demonstration of improved bucks-15 vaccination, health camps, fodder promotion, training of farmers were conducted.

- Under Bhadawari buffalo improvement programme, a herd of pure-breed Bhadawari buffaloes was maintained, The 3 Breeding bulls were sold, 9200 semen doses frozen, 2571 AI done, 1060 semen doses were sold. Calf mortality was 2.38 %. Av LMY, 305 days LMY, WA and HA were recorded as 1657.4 kg, 1496.9 kg, 4.55 kg and 2.92 kg, respectively. AFC -45.6 months, CR -62.2 %.
- Effect of apple pomace (AP) supplementation on nutritive value and silage quality of grass/legume- apple leaf based diets revealed that silage CP, NDF, ADF, cellulose and lignin ranged between 9.63-13.78, 41.12-1.51, 22.07-30.39, 17.50-22.01 and 4.45-8.16%, respectively. The TDN, DE and ME contents of silage diets were in range of 65.40-76.24%, 2.88-3.36 k cal/g & 2.37-2.76 k cal/g, respectively. Silage prepared from different diets had pH between standard values 3.74-4.10.
- The coating capacity of the developed forage seed coating machine was 60 and 65 kg for berseem and cowpea seeds, respectively and it saved 90% of the labor involved in manual coating. The machine was licensed to M/S New Ashok Verma Industries, Jhansi for 3 years.
- The solar-powered self-propelled multipurpose machine was developed with a rotary tilling unit and spraying unit. The field capacity and field efficiency of the machine were 0.75 ha h^{-1} and 93% for spraying and 0.09 ha h^{-1} and 90% for tilling operations.
- A prototype of a two-wheeled animal-drawn shed scraper was fabricated for cleaning the animal shed's floor surface and reducing drudgery. Its field capacity and field efficiency were 0.08 ha h^{-1} and 89%, respectively.
- An animal TMR-making machine was developed with capacity of 400 kg. The machine can pack 26 bags of 15 kg capacity per hour.

Programme 6: Social, economic, policy and translational research and capacity building

- Livestock-based Integrated Farming System (LIFS) boosted productivity by 3.3-4.5 times, generating Rs. 11.0 and 4.6 lakhs ha^{-1} annual gross and net returns over the traditional groundnut-wheat cropping system, respectively. Soil fertility improved by 11-16%, and fodder deficit decreased by 22% over 3-5 years.
- Under the Adarsh Chara Gram, dairy farmers in fodder villages had a 14-19% higher likelihood of improving habitat security, a 19-21% improvement in economic security, and a 13-16% better food security.
- The economic impact of 13 key forage crop varieties resulted an estimated economic surplus of Rs. 495.9 billion. The African tall maize variety alone generated Rs. 338.1 billion. The study revealed that consumer surplus accounted for 60% and producer surplus for 40%, emphasizing the substantial benefits of improved forage technologies.
- The Farmer FIRST Programme (FFP) promoted high-yielding, disease-resistant crops like DBW-187 (wheat) and DHBM93-1 (Banyard millet), along with improved fodder varieties of oat (JHO-822). It conducted training on soil health, vermicomposting, and weed management, and 254 demonstrations on forage and livestock management. This led to a 26% increase in groundnut yields, 23% in green gram, and 13% in wheat, boosting productivity by 20%, benefiting 381 farmers.
- Under the SCSP project, institute in collaboration with KVKs, trained 1,000 farmers across six states, with 245 fodder and 525 livestock demonstrations. SC farmers received livestock support, training, and equipment. The TSP project supported tribal farmers (668 in Rajasthan, 442 in Jammu & Kashmir, 110 in Madhya Pradesh, 60 farmers in Maharashtra and 64 in Himachal Pradesh) with fodder inputs and medicines.
- Introducing fodder crops into mango orchards significantly reduced green and dry fodder shortages, from 59.2 to 16.3% and 48.0 to 31.7%, respectively. Fodder interventions resulted in an increase in net returns from Rs. 2691 to Rs. 4649.

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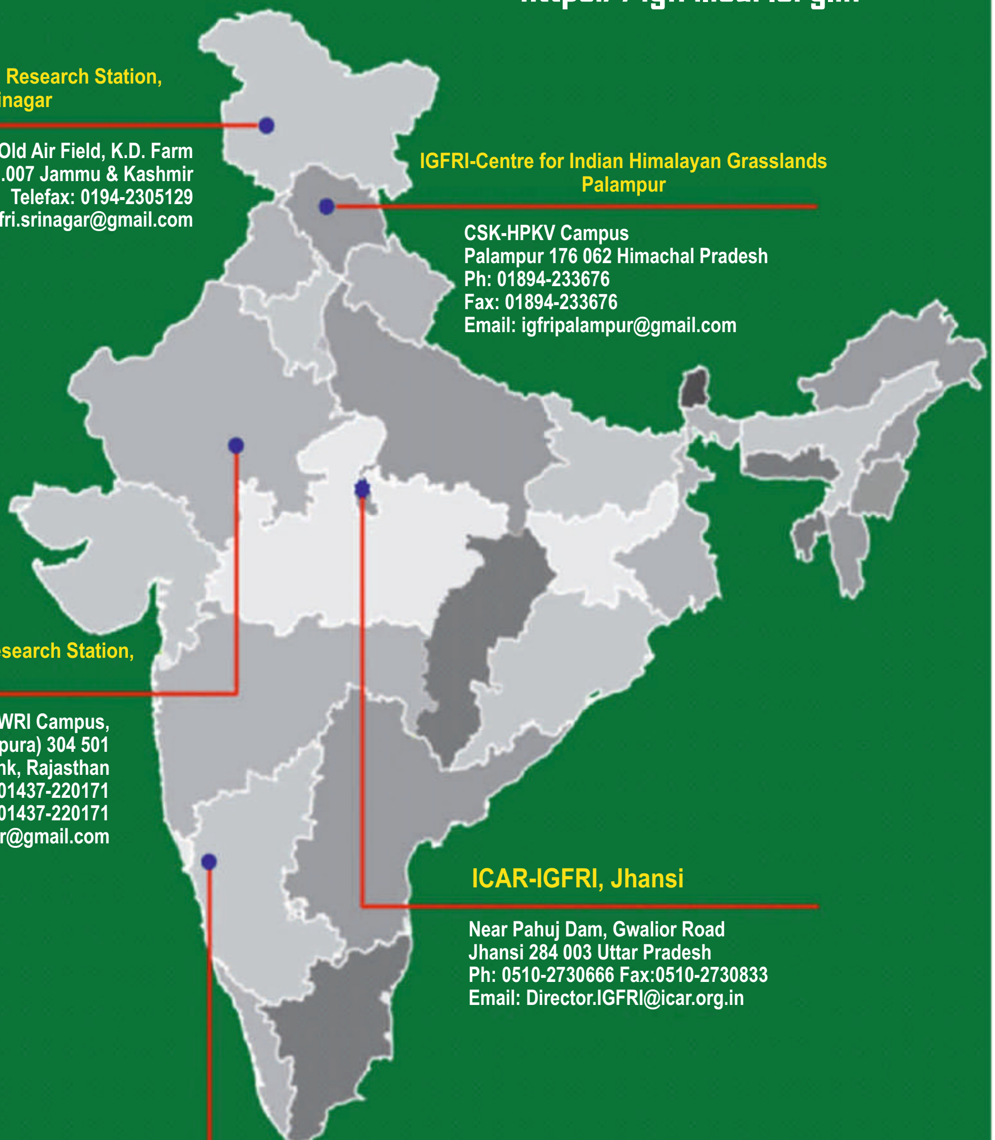

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Chapter 1

ICAR-IGFRI : An Introduction

To address fodder and forage requirements of a nation endowed with largest livestock population (536 million) globally through systematic scientific research on forage crops improvement, grasslands and pasture development, fodder production and their utilization, the Government of India established the prestigious 'Indian Grassland and Fodder Research Institute' (IGFRI) on 1st November, 1962, in Jhansi, Uttar Pradesh, a biodiversity hotspot for grasses. On 1st April, 1966, the institute became part of Indian Council of Agricultural Research (ICAR). The Council initiated All India Coordinated Research Project on Forage Crops and Utilization in 1972 at IGFRI as its headquarters. Presently, this project facilitates multi-location testing of forage varieties and technologies across different agro-climatic zones through 22 coordinating centres in 21 states located mostly at State Agricultural Universities under the National Agricultural Research System. IGFRI an institute under Crop Science division of the Council comprises seven multi-disciplinary divisions: crop improvement, crop production, farm machinery and post-harvest technology, seed technology, social science, grassland and silvipasture management, and plant-animal relationship, with the latter two being particularly unique. Institute has well functional PME, HRD, ATIC, ITMU, AKMU, and ABIC units and other facilities such as a library, central research farm, dairy, central instrumentation lab, MTS and museum to show case its history and chronological achievements. The institute is spread out in a total area of 373 ha at Jhansi and also operates three regional stations in Dharwad (Karnataka), Avikanagar (Rajasthan), and Srinagar (Jammu & Kashmir) to conduct targeted forage research in humid tropic, semi-arid to arid, and temperate climatic conditions, respectively, along with centre for Indian Himalayan grasslands, Palampur (Himachal Pradesh). ICAR-IGFRI has successfully served the nation for more than six decades, running seventh decade with numerous achievements in developing need-based, tailor-made technologies aimed at promoting green and sustainable production processes for the farming community. The institute has made significant strides in forage research, grassland development, extension, capacity building, and infrastructure development. IGFRI, an ISO 9001:2015 certified institute, is actively involved in conducting, collating, and coordinating organized forage research, transferring new technologies, and offering training to government and non-government organizations, trainers, farmers, forest officers, and other stakeholders. The institute is engaged in both basic and applied research on various aspects of cultivated and range species, including fodder crop improvement, intensive fodder production systems, alternative fodder sources, grasslands, silvi- and horti-pasture systems, seed production technology, farm mechanization, post-harvest conservation and utilization, and livestock nutrition. IGFRI is taking lead in getting externally funded research projects from national and international agencies and establishing linkages and collaborations with central and state government departments along with corporate sector to address the persistent issues of both fodder quantity and quality. Additionally, the institute's outreach programmes are multifaceted, including Model Fodder Villages, *Mera Gaon Mera Gaurav*, National Initiative for Fodder Technologies Adoption, Soil Health Cards, *Pradhan Mantri Adarsh Gram Yojana, Sansad Adarsh Gram Yojana*, Farmer FIRST, KISAN MITRA, Doubling Farmers' Income, Tribal Sub Plan, Scheduled Caste Sub Plan, and NEH. These initiatives aim to demonstrate developed technologies to farmers and other stakeholders, along with showcasing them at national events and platforms.

Institute with AICRP (FCU) has identified and notified 434 varieties of diverse forage crops (cereals, legumes and grasses) in 22 crops since its establishment. Institute has made a breakthrough in forage research by developing seed producing BN hybrid (world's first); developed resource specific livestock based IFS models. Seed standards were developed in four tropical grasses

(*Lasiurus scindicus, Clitoria ternatea, Desmanthus virgatus,* and *Stylosanthes hamata*) and five temperate forages (tall fescue, orchard grass, brome grass, rye grass and red clover); developed silvipasture and hortipasture models for rainfed agro-ecosystems; development and evaluation of nutrigel from rice straw for improving water and nutrient use efficiency in degraded lands of Bundelkhand; and machine developed (Forage seed coating machine, berseem chicory seed separator, tractor-operated grass seed harvester, defluffing machine).

Institute has developed Fodder Resources Development Plans for 29 states. Realising the importance, many states such as Uttar Pradesh, Assam, Tripura, Goa and Rajasthan have already adopted and implemented, while many other states are in process of implementation. Two patents (A soil core sampler assembly and tractor operated grass seed harvesting apparatus) have been granted in institute name and many are in advanced stages of approval and grant. To commemorate the International Year of Rangeland and Pastoralists (IYRP) 2026, the institute prepared a policy document on "Rangeland and grassland conservation, restoration: Policy document". The vitals of the institute include:

Vision

To evolve technologies for maximizing productivity of forages and feeds for livestock in an eco-friendly manner.

Mission

To generate and disseminate technologies for enhanced productivity and quality of forages and livestock in socio-economic and environmental perspectives.

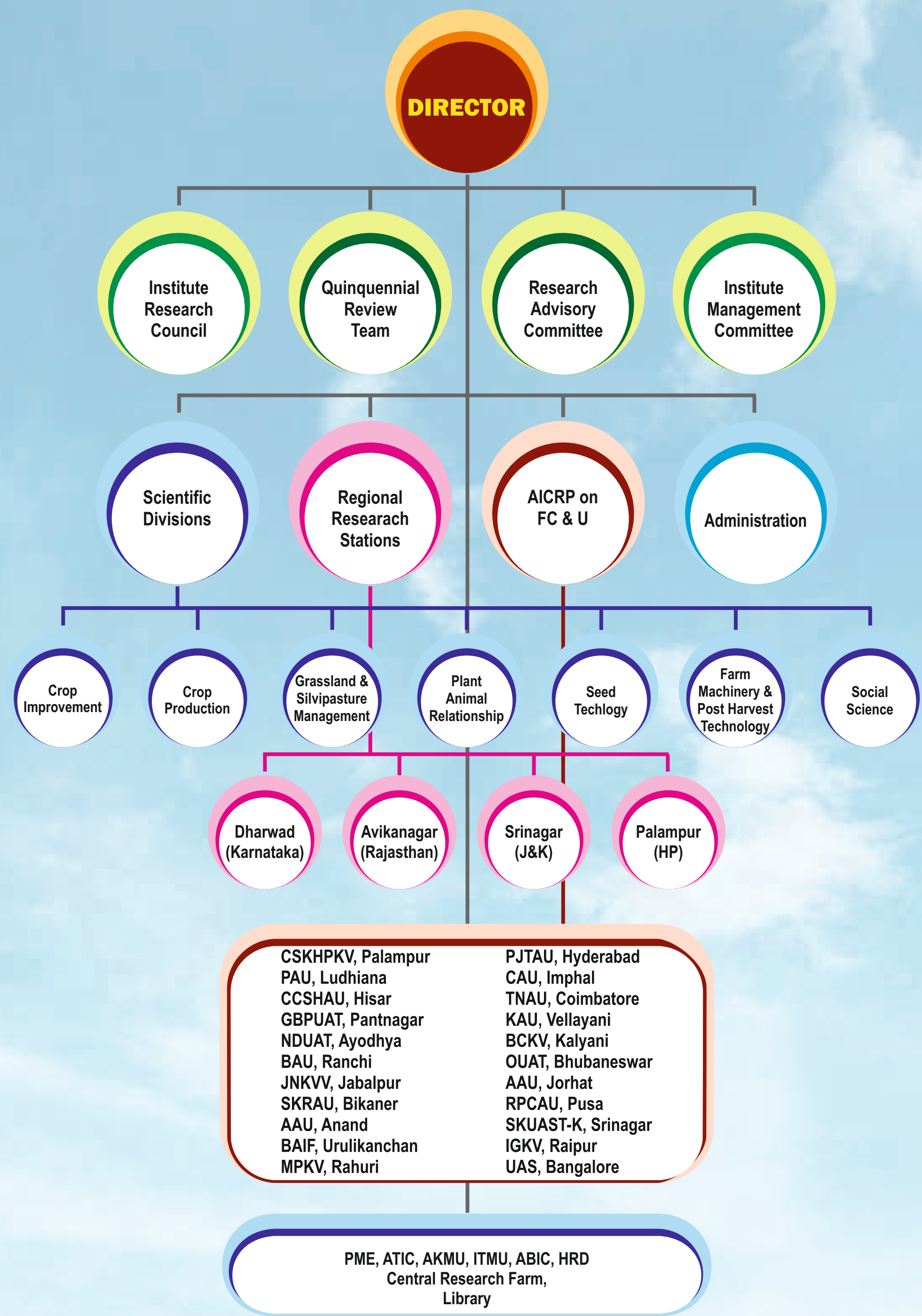
Mandate

1. Basic, strategic and adaptive research on improvement, production and utilization of fodder crops and grasslands.
2. Coordination of research on forages and grasslands for enhancing productivity and quality for enhancing livestock productivity.
3. Technology dissemination and human resource development.

The institute has restructured and prioritised its mandate in view of government agenda (organic and natural farming, waste to wealth, vocal for local), climate change (biotic and abiotic stress, NUE and WUE, more grain per drop) and commercial venture (licensing and commercialization, industrial use). The institute is currently focussing research under following six programmes.

1. Genetic enhancement of forage crops with emphasis on quality, multicut, stress tolerance & bio-fortification utilizing conventional, apomixis and new breeding tools.
2. Diversification and sustainable intensification of fodder production in different land use systems including assessment and rejuvenation of grasslands and other resources for improving productivity and livelihood options.
3. Management of natural resources and soil health of arable and non-arable lands for climate-resilient sustainable fodder production.
4. Accelerating seed biology research and technology development for enhanced quality forage seed production and strengthening the national forage seed network.
5. Nutritional evaluation and post-harvest management of forage resources for sustainable and improved crop-livestock production systems.
6. Social, economic, policy and translational research and capacity building.

Organogram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Chapter 2

Weather and Crops

India's 2024 monsoon season was marked by early onset with southwest monsoon set in over Kerala on May 30, two days before the normal date. Annual rainfall over the country as a whole was 104% of its Long Period Average (LPA) value for the period 1971-2020. The SW monsoon (June– September) recorded 934.8 mm rainfall which was 108% of the 50-year LPA rainfall of 868.6 mm, the highest since 2020. Monsoon withdrawal delayed until mid-October against the normal date of 17th September. The regional distribution of rainfall indicated receipt of 628.6 mm in NW India, 1168.5 mm in Central India, 1178.7 mm in East & NE India and 815.4 mm in South India. Country witnessed four cyclonic storms formed over the North Indian Ocean. Of these, two were severe cyclonic storms (REMAL and DANA), and two (ASNA and FENGEL) were cyclonic storms. While the abundant rainfall in 2024 bolstered the *kharif* crop yields, replenished water reservoirs and benefited winter crop sowing, it also disrupted summer crop harvests.

Weather at Jhansi

2.1 Rainfall pattern

In Jhansi, total rainfall of 945.3 mm was recorded during 2024 (January-December) in 43 rainy days. The rainfall was found to be surplus by 4.0% from its LPA of 908.8 mm. The seasonal rainfall during *rabi* (1-22 SMW) and *kharif* (26-52 SMW) are illustrated in Fig. 2.1. In *rabi*, 55.9 mm of rainfall occurred in 5 rainy days and it was higher by 14.0% from its LPA (48.1 mm). Rainfall during *kharif* was 814.8 mm, which was deficient by 5.5% from its LPA (860.0 mm). The monthly rainfall pattern (Fig. 2.2), indicated that the June (23-26 SMW) received a total of 74.6 mm rainfall which was 14.5 mm lesser than the normal rainfall of the same period. Similarly, July (27-30 SMW), with 207.2 mm rainfall, recorded deficit of 42.4 mm; August (31-34 SMW), with 260.8 mm rainfall, recorded deficit of 14.9 mm; however, September (35-39 SMW) with 299.8 mm rainfall, recorded surplus of 158.0 mm.

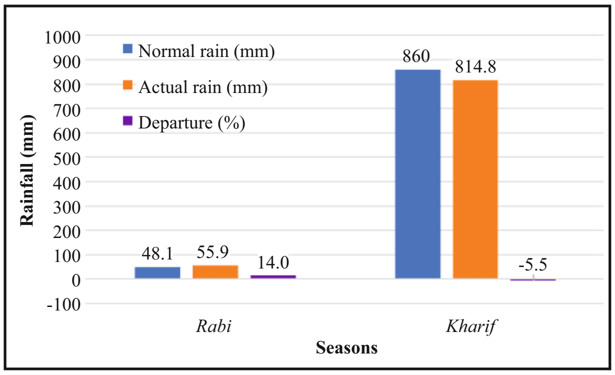

Fig. 2.1 Seasonal rainfall along with its departure from normal at Jhansi

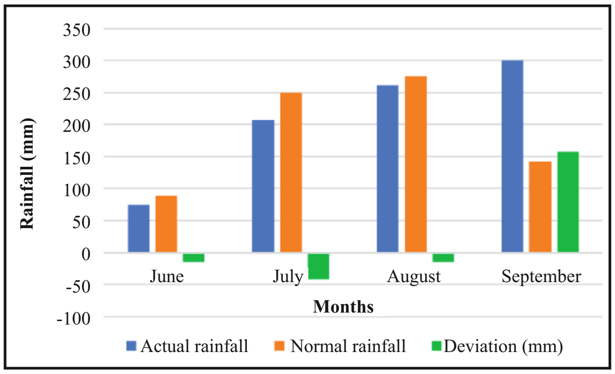

Fig. 2.2 Monthly rainfall and its deviation from normal at Jhansi

2.2 Temperature

Mean T_{Max} and T_{Min} during 1-22 SMW were lower by 0.8 and 0.5°C, respectively from their corresponding normal values (T_{Max}=33.3°C and T_{Min}=16.6°C). Weekly anomaly for the period 1-22 SMW of T_{Max} and T_{Min} is presented in fig. 2.3. In *rabi* crop growing season (1 to 5th SMW), T_{Max} were lower in first four weeks from their normal temperature in the range of 1.2 (in 2nd SMW) to 5.5 °C (in 3rd SMW). However, 5th SMW recorded 1.4°C higher average temperature than the normal. Further, in subsequent weeks (6-12 SMW, except 8th SMW) the T_{max} was lower than their normal values in the range of 0.5 to 3.8°C. The T_{Max} anomaly in 8th SMW recorded with 0.7°C higher temperature than the normal. The T_{max} anomaly during these weeks (1-10th SMW) fluctuated in the range of -2.3 (in 3rd SMW) to 3.1°C (in 1st SMW). Similarly, during 11-22 SMW, the T_{min} anomaly varied in the range of -4.6 (in 17th SMW) to 2.4°C (in 13th SMW).

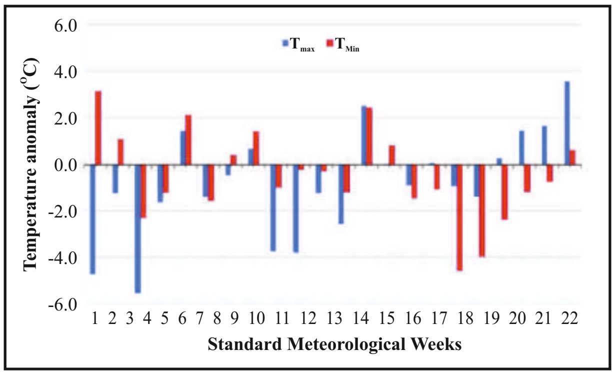

Fig. 2.3 Weekly anomaly pattern of maximum (T_{Max}) and minimum (T_{Min}) temperature during *rabi*

Mean T_{Max} and T_{Min} for the period 23-52 SMW were 33.7 and 20.4°C, respectively which were higher by 1.5 and 1.0°C, respectively from their corresponding normal value (T_{Max}=32.2°C and T_{Min}=19.4°C) (Fig. 2.4). In *kharif* season (27-42 SMW), the anomaly in T_{Max} varied between -2.3°C (27th and 37th SMW) to 4.5°C (29th SMW). Similarly, during 43-52 SMW, the T_{Max} and T_{Min} were higher in the range of 1.8 and 0.1°C, respectively from their corresponding normal values.

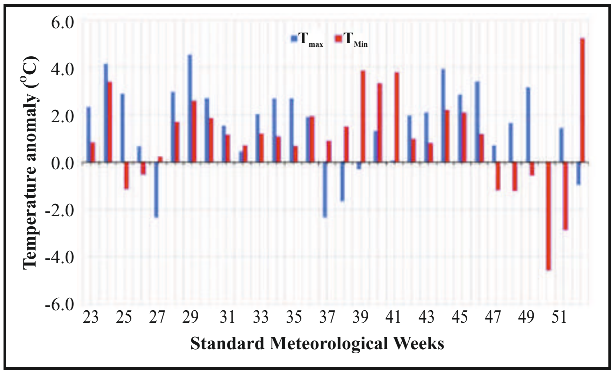

Fig. 2.4 Weekly anomaly pattern of maximum and minimum temperature during *kharif* season

2.3 Evaporation

Mean *rabi* (1-22 SMW) evaporation rate (4.0 mm day^{-1}) was lower by 37.1% than the normal evaporation rate (6.34 mm day^{-1}) (Fig. 2.5). Evaporation rate during 1 to 22 SMW period experienced lower evaporation rate in the range of 1.3 to 6.9 mm day^{-1} against its normal range (1.69 to 12.5 mm day^{-1}). Mean evaporation rate during *kharif* (26-52 SMW) was recorded to be 3.4 mm day^{-1} and it was lower by 8.1% from its long period average (3.7 mm day^{-1}). Weekly evaporation rate during monsoon (27-37 SMW) fluctuated between 2.4 to 4.7 mm day^{-1} against their corresponding normal values (3.2 to 7.0 mm day^{-1}). In the post-monsoon (40-48 SMW), evaporation rate oscillated from 2.0 to 4.2 mm day^{-1} against its corresponding normal values (2.6-4.1 mm day^{-1}). Overall, majority of weeks have experienced lower evaporation rate than corresponding normal values.

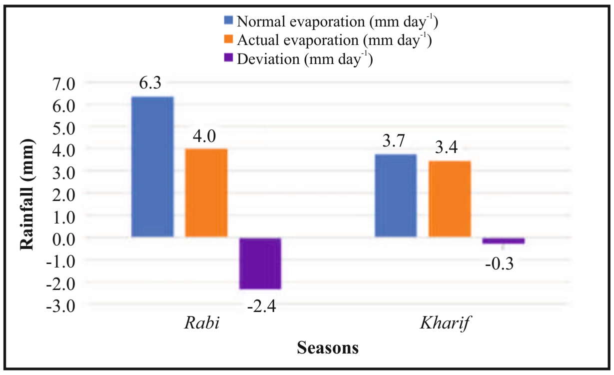

Fig. 2.5 Seasonal actual and normal evaporation along with deviation from its normal values

2.4 Relative humidity pattern

Mean morning relative humidity for both *rabi* (RH1) and *kharif* (RH1) were found to be 66.7 and 87.9%, respectively and both were deficient by 12.6 and 2.1% from their normal values (76.4 and 89.8% during *rabi* and *kharif*, respectively) (Fig. 2.6). Morning relative humidity during the period (1-12 SMW) and (13-22 SMW) fluctuated between 59.9-88.7% and 44.9-71.7%, respectively. Similarly, morning relative humidity during the period 26-39 SMW and 40-52 SMW ranged between 82.6-93.8 and 76.0-91.6%. The morning relative humidity was found to be lower by 0.7% from their corresponding normal values during monsoon season (27-39 SMW).

Mean afternoon relative humidity during *rabi* (RH2) and *kharif* (RH2) was found to be 47.4 and 62.0%, respectively and these were significantly higher by 47.1 and 20.1%, from their normal values. Afternoon relative humidity oscillated between 23-86% during 1-22 SMW. The afternoon relative humidity ranged between 68-88% and 35-73% for the period 26-39 and 40-52 SMW, respectively.

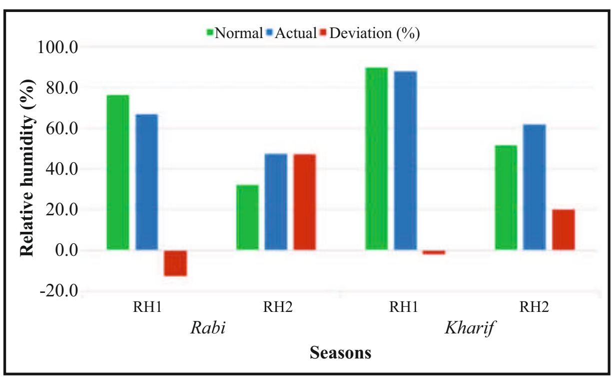

Fig. 2.6 Seasonal actual and normal relative humidity along with deviation (%) from normal

Chapter 3

Research Achievements

3.1 Genetic enhancement of forage crops with emphasis on quality, multicut, stress tolerance and biofortification utilizing conventional, apomixes and new breeding tools

3.1.1 Augmentation, characterization, conservation and documentation of forage genetic resources (CRSCIGFRISIL20100 101)

Collection, evaluation and characterization

During the year, 973 accessions of forage crops and grasses (*Cenchrus, Bothriochloa, Heteropogon, Dichanthium, Panicum, Medicago,* maize, and sorghum) were evaluated. Berseem (222) and napier grass (23) were characterized and conserved. Seeds of 140 dinanath grass accessions were sent to ICAR-NBPGR for long term conservation in national gene bank. Through diversity analysis, 146 accessions of dinanath grass were classified into three major clusters. For berseem, whole 222 accessions were divided into four major clusters for future genetic program based on qualitative and quantitative traits.

National active germplasm site

Fourteen varieties are maintained in field gene bank. Ploidy series of *P. maximum* (3x, 4x, 5x, 6x, 8x, 9x, 7x, 11x and *Pennisetum squamulatum* are also maintained. Six entries of *Dichanthium-Bothriochloa* complex *viz.*, JHD-22-1, JHD-22-2, JHD-22-3, JHD-22-4, JHD-22-5, JHD-22- 6 are under AICRP (FC) trial.

3.1.2 Genetic improvement of maize for high biomass and fodder quality (CRSCIGFRISIL20200105)

Development of inbreds

Fifty-five maize inbreds were advanced to S3 generation, 68 inbreds to S4 generation, and 139 inbreds to S5 generation. Twenty inbreds were stabilized to S7 generation, which were characterized for 31 DUS (Distinctness, Uniformity and Stability) traits and 13 SSR markers.

Per se performance of S2/S3 inbreds and hybrids

A total of 245 S2/S3 inbreds were evaluated for various fodder traits. Twenty three S2/S3 inbreds were selected based on the performance for green fodder yield (GFY). These selected inbreds were crossed in random fashion to generate 26 F_1 combinations. The F_1s were evaluated for fodder traits along with two checks (African tall and J-1006). Eight crosses were identified with high GFY over checks. The inbreds with high GFY in cross combinations could be utilized for developing fodder composite varieties.

Interspecific hybridization

The F_2 (130), F_3 (126), and BC_1F_3 (93) progenies of African tall × Teosinte crosses were characterized for tillering and branching traits. In F_2, the tillering, branching and maize type plants were segregated at 1:53:76 ratio. In F_3, out of 126 progenies, 9 progenies showed tillering, 53 progenies showed branching, while 64 progenies were maize type. Of the 93 BC_1F_3 progenies, 3 and 29 progenies showed tillering and branching, respectively, whereas 61 progenies resembled maize phenotype. Fresh crosses were attempted between African tall × *Zea mexicana* and African tall × *Zea diploperennis.* F_1 progenies were evaluated for tillering and branching traits. In African tall × *Zea mexicana* F_1s, 2-8 tillers had been observed and all the plants exhibited branching. In African tall × *Zea diploperennis* F_1s, 2-3 tillers were observed; however, branching was not common.

Combining ability analysis of forage maize inbreds

One hundred and ninety hybrids derived from diallelic crosses among 20 maize inbreds were evaluated for twelve forage quantity and quality traits. The better parent heterosis ranged from 37.5 to 112.7%, 25.3 to 109.9%, -7.4 to 11.0%, -8.0 to 7.7%, -13.3 to 9.4%, -8.2 to 6.7% and -11.8 to 12.4% for GFY, DFY, CP, NDF, ADF, ADL and DM digestibility, respectively. The general combining ability (GCA) and specific combining ability (SCA) effects were significant for all the forage quantity and quality traits. The greater proportion of SCA to GCA for most of the forage quantity and quality traits suggested the importance of non-additive gene effects in inheritance of these traits. Inbreds IGMI-2, IGMI-9 and IGMI-20 were the best general combiners for GFY, while inbreds IGMI-2, IGMI-11, IGMI-19 and IGMI-20 were the best general combiners for DFY. For CP and DM digestibility, inbreds IGMI-2, IGMI-6 and IGMI-11, and IGMI-9, IGMI-15 and IGMI-20 showed significant positive GCA effects. Based on the SCA values, crosses IGMI-2 × IGMI-5, IGMI-3 × IGMI-11, IGMI-6 × IGMI-11, IGMI-9 × IGMI-18 and IGMI-9 × IGMI-20 were the best hybrids for GFY, and crosses IGMI-3 × IGMI-11, IGMI-9 × IGMI-18, IGMI-14 × IGMI-20 and IGMI-17 × IGMI-19 for DFY. For CP and DM digestibility, the best hybrids were IGMI-7 × IGMI-11 and IGMI-5 × IGMI-11, and IGMI-3 × IGMI-19 and IGMI-9 × IGMI-20. These hybrids can be used for exploiting hybrid vigour for forage yield and quality in maize.

3.1.3 Breeding of pearl millet for deriving multicut and dual-purpose cultivars with high forage yield and quality (CRSCIGFRISIL20200101)

Multiplication of high biomass lines

The developed high biomass yielding OPVs, IGBV9, IGBV95, IGBV97, IGBV17, IGBV4, IGBV98, IGBV8, IGBV15, IGBV10, IGBV94, IGBV18-15222 and IGBV3-18 were multiplied through bulk pollination during summer 2024 and *kharif* 2024. Further during *kharif* 2024 IGBV15, IGBV97, IGBV18-15222 and IGBV95 were multiplied through isolation by random mating. Among 25 different S2/S3 family crosses and Elite x Elite crossing populations generated during 2023, six promising crosses were selected and maintained through bulk pollination.

Novel genetic materials

A multi-location trial comprising 26 pearl millet genotypes was conducted, including five BMR genotypes with low lignin content, three with high tillering, three with a higher leaf-to-stem ratio, two with high leaf length, seven with high re-growth potential and late flowering, three with high sugar content, and two with higher digestibility. Additionally, two check cultivars, Baif Bajra 1 and Giant Bajra, were included. From these 26 genotypes, ICMbmr2402 and ICBbmr07 were identified as low lignin genotypes (3.0%). ICFPM 05 exhibited a higher number of tillers with longer leaf length (11–18 tillers and a leaf length of 74.55 to 85 cm). IGBV100 had the highest leaf-to-stem ratio (1.8 to 2.3), while ICMFV2308 and ICMFV2401 were identified as late-flowering genotypes.

Forage pearl millet inbred line development

A total of 210 inbred lines including three male sterile lines were multiplied during summer season. These inbreds will be utilized for hybrid development and also contribute to the development of synthetics and composites.

Contribution of fodder pearl millet entries to AICRP (FCU)

Three entries JHMCB-24-1, JHMCB-24-2 and JHMCB-24-3 were submitted to pearl millet initial varietal trial 2024 to AICRP (FCU). Two entries (JHPM 23-1 and JHPM 23-2) were promoted from IVT to AVT1 and one entry (JHPM-22-2) promoted from AVT1 to AVT2.

3.1.4 Development of genetic and genomic resources for low moisture stress tolerance in berseem (CRSCIGFRISIL20180101)

Station trial

A trial with 17 late selections against four check varieties (Wardan, BB-2 and BL 44, BL 180) was conducted. Data on GFY, DMY (four cuts) and flowering time were recorded. High biomass (>10%) producing 03 lines (JHB-24-1, JHB-24-2 and JHB-24-3) were selected for multi-location testing.

Evaluation of berseem lines under low moisture stress

A total 315 mutant lines were evaluated under low moisture stress in augmented block design with check varieties *viz.*, Wardan, BB-3, JBSC-1, JHB-18-1. The mutant lines showed variability for plant height (46-115 cm), basal branching plant^{-1} (2.33-21.33), days to 50% flowering (90-121 days), green biomass, and SPAD (34.5-58.3). The available soil moisture (under stress) at 0-15, 15-30, and 30-45 cm soil depth were 3.3, 13.4 and 20.03% respectively. Based on these traits, best performing lines were identified for further evaluation and utilization in breeding programme.

Nucleus seed production

Nucleus seed of IGFRI berseem varieties *viz.*, BB-5 (15), BB-6 (20), BB-7 (15), BB-8 (03 kg) were produced.

Morphological and molecular characterization of powdery mildew pathogen infecting berseem and *Trifolium* spp.

The symptoms of powdery mildew was first observed on leaves of mutant lines of berseem. Small circular to irregular white patches were observed on leaves. Subsequently, abundant mycelial growth covered entire leaves. Microscopic observation confirmed the presence of hyaline, septate mycelium and oidium with oidiophore. Molecular characterization of powdery mildew pathogen with *Erysiphe* genus specific primers- Ery F and Ery R confirmed the pathogen *Erysiphe trifoliorum.*

3.1.5 Identification and characterization of multicut sorghum lines for low HCN and moisture stress tolerance (CRSCIGFRISIL20230l01)

Twenty fodder sorghum genotypes with three checks (MP chari, CSV 33 MF, and CO-FS29) were screened for multicut and low HCN contents under water regimes. The water regimes at field conditions (control, moderate, and high-water stress) were maintained by irrigation management. The first cut was taken at 55 days after sowing and second and subsequent cuts were taken at 30 days intervals. The fresh biomass at second cut was greater than first cut and with increasing water stress the fresh biomass decreased (Fig. 3.1.1a). The HCN content was higher at 55 DAS and subsequently decreased. The HCN content was higher under drought condition followed by moderate drought and control (Fig. 3.1.1b). Based on the fodder biomass, physiological and morphological attributes, the sorghum genotypes SMC-81, IGS-68 and IGS-D2 performed better under high water stress treatment.

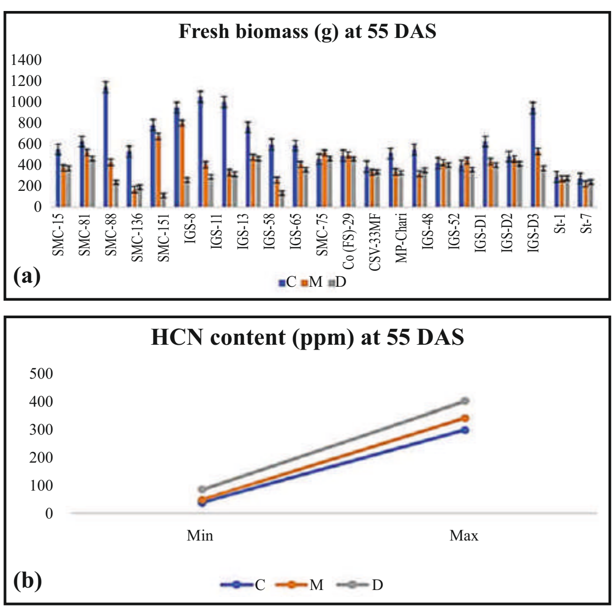

Fig. 3.1.1 The fresh biomass (a) and HCN content (b) of fodder sorghum genotypes under control (C), moderate (M) and high-water stress (D) conditions

3.1.6 Breeding oat for improved productivity and quality (CRSCIGFRISIL20150103)

Characterization of germplasm

From 800 oat germplasm, 20 grain purpose and 30 multipurpose trait lines were selected.

Generation advancement

Thirteen base F_3 populations segregating for various agro-morphological and blotch disease resistance trait were advanced to F_4 generation.

Station trial

Three station trials were conducted. In single cut trial, 15 lines along with one check JHO-99-2 were tested. Four lines performed (40.0-50.0 Mg ha^{-1}) better than check (37.8 Mg ha^{-1}) in terms of green fodder yield. In multi cut trial, 03 lines were selected out of 12 lines tested (39.5 Mg ha^{-1}) for GFY. In dual purpose trial, 12 lines were evaluated along with two checks, 05 lines performed better (28.5 Mg ha^{-1} for GFY) than check.

Exploring resources for drought and salt tolerance

Drought stress: From oat core, 130 lines were tested for water stress in field condition (2023-24). Stress was imposed by withholding 2nd irrigation in stressed plants. Treatment included control with 5 irrigations; stressed treatment with 3 irrigations. Morphological and fodder traits (days to 50% flowering, leaf length, tiller number, leaf width, internode length, GFY, DMY, test weight, panicle length and panicle weight) were recorded under control and water stress condition. Ten oat lines were selected on the basis of their performance. Leaf vein density and stomatal frequency (Fig 3.1.2), canopy temperature depression (CTD), and SPAD values were also recorded. High and low stomata and low and high vein density were observed in susceptible and resistant lines, respectively.

For salt stress

One hundred and five oat core materials were tested for germination attributes under lab conditions. Selected 21 lines were characterized for root architecture traits in hydroponic system. Ten further selected lines were evaluated under pot condition

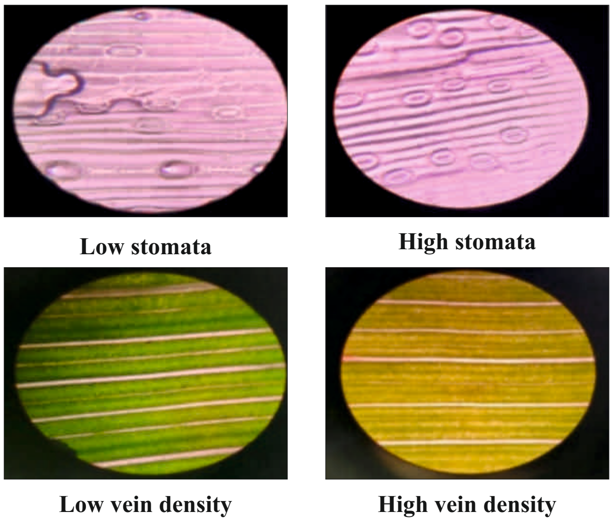

Fig. 3.1.2 Diversity in stomatal and leaf vein density attributes under drought stress

at IGFRI and field condition at CSSRI, Karnal. Genotype IGFRI-OS 2 showed 13.5% superior in terms of GFY and 6% in DMY over check variety Kent.

AICRP-FC trials and status of IGFRI oat entries in all India testing

Five AICRP (FCU) oat trials were conducted. Six entries were under testing during 2024. One each in AVTO-2 MC and AVTO-2 SC; one in AVTO-1 (dual); one each in IVTO MC-1, IVTO (dual) and IVTO SC-1.

Maintenance of advanced breeding material and nucleus seed production

For all India testing, 09 advanced breeding materials (single cut, multicut, and dual purpose) were multiplied. Nucleus seed production (30 kg each) was carried out for JHO-822, JHO-851, JHO-99-1, JHO-99-2, JHO-2000-4, JHO-10-1, JHO-09-1, JHO-12-2 and JHO-15-1.

3.1.7 Developing erect type and multicut fodder cowpea with enhanced nutritional quality (CRSCIGFRISIL20210103)

Characterization of cowpea germplasm

A total of 230 cowpea genotypes were characterized for various quantitative and qualitative traits at Jhansi and Dharwad. Plant height, no. of branches, leaf length and leaf width varied from 52.0-197.7 cm, 2.0-9.0 cm, 5.3-18.1 cm and 3.5-11.0 cm, respectively, while CP, NDF and ADF varied from 15.62-26.88, 34.89-53.65 and 23.44-37.74% DM, respectively. Wide variations were observed for quantitative traits (Fig. 3.1.4). Seven genotypes *viz.*, IGC167, IGC193, IGC205, IGC230, IGC242, IGC245 and IGC247 recorded high GFY (3594-5370 g/row of 3 m) as compared to checks, BL-1, BL-2 and BL-4 (3284-3525 g row^{-1} of 3 m).

Evaluation of cowpea core set for growth habit and regrowth potential

The cowpea core set (203 genotypes) was evaluated for growth habit and regrowth (regeneration) potential (Fig.3.1.5). Five genotypes (IGC21, IGC48, IGC121, IGC202 and IGC241) were identified with high regrowth potential (>91%), while two genotypes (IGC-59, IGC-167) were identified with acute erect growth habit (Fig. 3.1.6).

Crossing of selected cowpea genotypes and generation advancement (pedigree selection)

The F_2 populations of 9 different crosses of 8 parents with different traits, erect, high biomass & pod size) were advanced to F_3 generation having progenies between 12-71.

Station trial

A station trial comprising of 19 cowpea entries along with three checks (BL-1, BL-2 and BL-4) was conducted. Entries CST-8, CST-12 and CST-18 showed >10% superiority over the checks were selected for multi-location trials.

AICRP entries contribution and nucleus seed production

Three cowpea entries were submitted to AICRP (FC&U) for conducting IVT in *kharif* 2024. Nucleus seed of three forage cowpea varieties *viz.*, BL-1, BL-2 and BL-4 (5 kg each) was produced.

Fig. 3.1.4 Variability for qualitative traits in cowpea genotypes

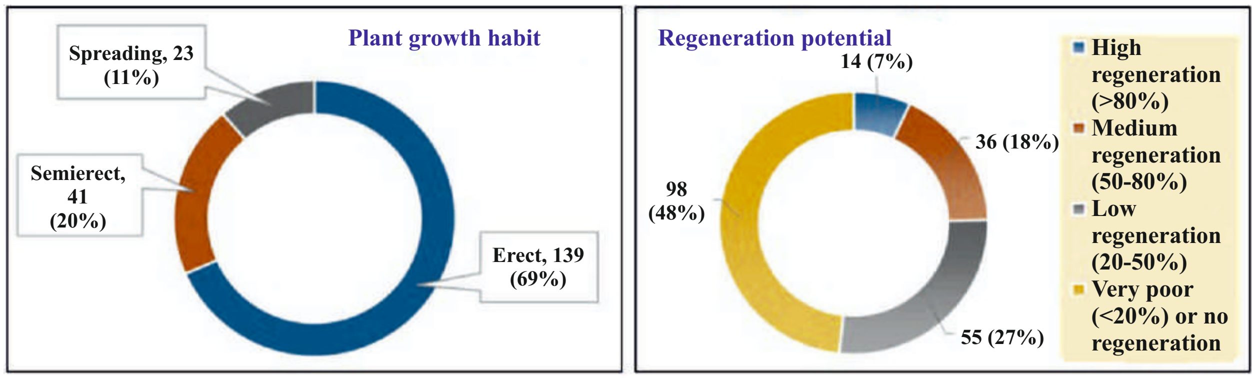

Fig. 3.1.5 Grouping of cowpea genotypes for growth habit and regrowth potential (after first cut at 50 days after sowing)

3.1.8 Genetic improvement of novel fertile Bajra-Napier hybrid for enhanced productivity and quality traits (CRSCIGFRISIL20220101)

Development of advanced breeding lines of fertile BN hybrid

For stabilization of fertile BN hybrid, F_4 population comprising of 750 individuals were advanced to F_5 generation using rapid generation advancement (RGA) technique during *kharif* 2023 under field conditions and were subsequently advanced to F_6 generation during summer 2024 under glass house conditions (Fig. 3.1.6).

Fig. 3.1.6 Tetraploid BN hybrid F_4 population during *kharif* 2023 under field conditions and summer 2024 under glass house conditions

Further, keeping in view the success of TBN-20-15 x *Pennisetum squamulatum* cross, more number of crosses were attempted during last year with *P. squamulatum* using TBN-20-15 (T15), TBN-21-19 (T19) and some superior F_2 plant (best F_2) as female parent. From this, 39 new plant-types were obtained, of which 17 were found to be apomictic and rest 22

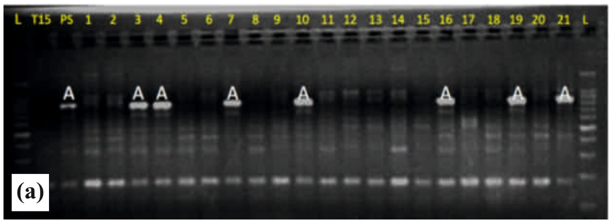

Fig. 3.1.7 Marker assisted selection of apomictic individuals using apomictic-specific Apo #562 Q8M marker in (a) TBN-15 x PS crosses

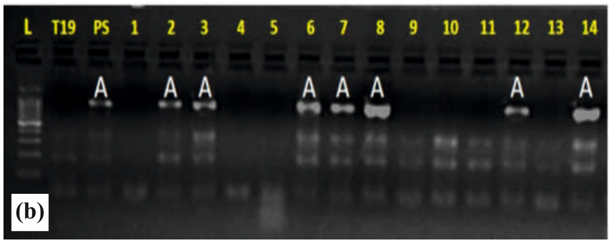

Fig. 3.1.7 (b) TBN-19 x PS crosses

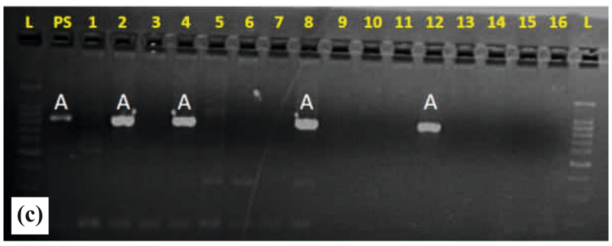

Fig. 3.1.7 (c) Best F_2 x PS crosses

were sexual types based on marker assisted selection using Apo #562 Q8M marker (Fig. 3.1.7 a, b & c)). These apomictic types were of immense importance for fodder and seed quality traits.

Improvement of fodder and seed quality traits in fertile BN hybrid

Wide range of variability was observed for biomass and seed related traits. Remarkably, F_2 population was segregating for various agro-morphological and seed related traits especially, number of seeds per panicle (NSPP) and thousand-seed weight (TSW). Interestingly, all the F_2 lines were fertile and produced viable seeds in differential pattern with NSPP varied from 13 to 550 with TSW ranged from 0.62-4.77 g. From this, contrasting F_2 individuals were identified and were crossed to generate superior genotypes with enhanced fertility, biomass, and other desirable traits.

Establishment of fertile BN hybrid F_6 population

F_6 population of fertile BN hybrid was established in field conditions under augmented design. A total of 118 F_6 individuals were sown in field following recommended agronomic practices.

3.1.9 Genomics assisted breeding for zinc and iron bio-fortification in oat (CRSCIGFRISIL20210102)

Phenotyping of association mapping panel for Zn, Fe and other fodder traits

The association mapping panel was sown at three locations *viz.*, Jhansi, Palampur, and Hisar during *Rabi* 2023-24 for phenotyping of Zn and Fe content along with various agro-morphological traits. Wide range of variation was observed for all the traits.

Development of F_2 mapping population segregating for Zn and Fe

Four mapping populations derived from high Zn and high Fe lines with oat varieties *viz.*, JHO-99-2 and JHO-15-1 were advanced to F_4 generation.

3.1.10 Identification and characterization of cowpea genotypes for phosphorus use efficiency (CRSCIGFRISIL20220102)

In the *kharif* 2023, a diverse core set of cowpea comprising 250 genotypes was evaluated in field conditions under low phosphorus (P), (10.2 kg P ha^{-1}) and optimum P (19.71 kg P ha^{-1}) regimes. The performance was recorded for early plant vigour, morpho-physiological traits (SPAD chlorophyll meter readings, no. of branches, no. of nodes, plant height, stem diameter, GFY and DFY). Subsequently, a sand culture experiment was conducted with selected 54 cowpea genotypes to evaluate the seedling traits under low P and sufficient P conditions. P-efficient genotypes showed a dry matter reduction ranging from 5.8 to 11.9% under low P conditions, whereas, phosphorus-inefficient genotypes exhibited reductions by 45.5-60.3%. During summer 2024, 14 contrasting cowpea genotypes were grown under both sufficient and low P regimes in field conditions. P-use efficient cowpea genotypes (IC 202781 and IC 202790) exhibited a smaller reduction (4.5-5.9%) in dry biomass under low P conditions compared to P-use inefficient genotypes (EC 390281 and IC 39905), which showed reductions of 23.1-29.1%. Across both field trials (*kharif*-2023 and summer-2024) and sand culture experiment, three genotypes (IC 202781, IC 202789, and EC 99573) consistently exhibited high P use efficiency.

3.1.11 Identification and characterization of genes involved in expression of apomixis component-traits in polyploidy series of Guinea grass (*Megathyrsus maximus*) (CRSCIGFRISIL20210101)

Transcriptome analysis was conducted for 16 samples of *M. maximus*, which were categorized into apomictic, sexual, and facultative reproductive stages. Raw data statistics indicated high read quality, with Q30 values above 90% for most samples. Transcriptome assembly initially produced 1,704,099 transcripts and finally reduced to 906,885 after clustering, with a GC content of 46.60%. Differential gene expression analysis identified significantly up-regulated and down-regulated genes across comparisons, with the highest differential expression observed in sexual-post meiotic *vs.* facultative-post meiotic samples. Gene ontology analysis classified genes into biological processes, molecular functions, and cellular components, with 263,758 genes annotated from a total of 782,156. The differentially expressed genes were annotated based on the *UniProt* grass data base.

3.1.12 Genome-wide identification, characterization and expression analysis of flowering locus T (FT) genes controlling floral induction in cowpea (CRSCIGFRISIL20230102)

In-silico analysis led to identification of 13 flowering locus T (FT) and its related genes across cowpea genome. The gene structure analysis revealed presence of 4 exons and 3 introns in all genes. The genes are mainly localized to chromosome number 1, 3, 4, 5 and 7. Phylogenetic relationship studies with other plant species revealed that these genes were highly conserved across the plant species. The FT proteins were mostly basic and hydrophilic in nature and secreted as extracellular protein.

3.1.13 Genetic improvement of temperate forage crops (CRSCIGFRISIL20211002)

Eighteen varieties of berseem were evaluated under irrigated conditions for two cuts. Maximum height was gained by JHB17-2 variety (80.2 cm). Maximum number of tillers per plant were observed in JHB 20-1 (44.7). Maximum number of tillers per metre row length was observed in JHB20-1 (141.0). Maximum biomass yield was observed in Wardan (240.67 g plant^{-1}). Maximum dry matter was observed in BL-10 (43.29 g plant^{-1}). The highest GFY was observed for JHB-17-1 (35.7 Mg ha^{-1}), followed by JHB-17-2 (32.4 Mg ha^{-1}). A total of 37 accessions were collected from Mirgund, Pattan, Kreeri, Baramulla, Rafiabad, Handwara, Sopore, Kupwara and Lolab valley, which included red clover (13), brome grass (9), white clover (2), rye grass (4), tall fescue (2) and *Elymus* spp. (7).

3.1.14 Evaluation of berseem gene pool for herbicide tolerance (CRSCIGFRISIL20200401)

To search for herbicide resistant lines of berseem against glyphosate, five putative lines of berseem, showing moderate to high level of tolerance against glyphosate after three rounds of screening were selected. In order to reconfirm their tolerance, these lines were resown and repeated glyphosate screening experiment with dose of 0.8 kg *a.i.* ha^{-1}. After screening, individual plants of various lines which could be able to tolerate screening dose were found.

3.1.15 Breeding lucerne (*Medicago sativa* L.) for high forage yield and nutritional quality for different eco-systems (Phase II) (CRSCIGFRISIL20200903)

Lucerne variety IGFR-DL-5 (IGFRI-Dharwad Lucerne-5) was recommended for release and identification by 92nd meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, Gazette Notification; SO 4388 (E) dt 8th Oct 2024. It produces GFY of 9-11 Mg ha^{-1} year^{-1} and DMY of 1.5-2.0 Mg ha^{-1} year^{-1}. It has 15-20% CP with 65-68% *in-vitro* DM digestibility and lower ADF (25-30%) and NDF (35-40%).

One entry AWL-6 of lucerne (annual) was promoted to AVT-1 in central zone and one new entry of lucerne (annual) - IGFRI-DL-3 was contributed for *rabi* 2024-25.

Multi-location trial on lucerne (annual) with 6 entries (2+4 checks) was initiated in collaboration with UAS, Dharwad and being conducted at 6 locations (Dharwad, Hukkeri, Bailhongal, Bijapur, Bagalkot and Belvatgi) during *rabi* 2024-25.

3.1.16 Combined stress tolerance of water logging and salinity in fodder grasses (CRSCIGFRISIL20180901)

Induced metabolites were compared in NB-21 and DHN-6 under control and salt stress. PCA and PLS-DA analysis suggested metabolites exhibited discriminative metabolic profiles. The common metabolites included cyano amino acid metabolism, arginine and proline biosynthesis metabolism, isoquinoline biosynthesis, foliate biosynthesis and fatty acyl biosynthesis metabolites. Pathway analysis represented more amino acid metabolites produced in NB-21 compared to DHN-6.

3.1.17 Studies on invasive pest *Spodoptera frugiperda* in fodder maize (CRSCIGFRISIL20180901)

Correlations between seasonal incidence of maize fall army worm and weather parameters indicated a significant negative correlation with rainfall (-0.50**) and morning humidity (-0.42*). Entomo-pathogen *Metarhizium (Nomoraea) rileyi* at 2 g l^{-1} followed by neem at 5 ml l^{-1} proved to be the better sequence of sprays with GFY and DFY of 3.50 and 7.75 Mg ha^{-1}, respectively and next to the insecticidal sprays of two rounds of Emamectin benzoate at 0.4 g l^{-1}. Among the intercropped leguminous fodder crops, sole cowpea recorded higher fodder yield, net returns and B:C ratio. The magnitude of intensity of maize fall army worm observed in descending order of sole maize < maize + soybean (3:1) < maize + *Dolichos* (3:1) < maize with bund planting of BN hybrid < maize + cowpea (3:1). The extent of damage to the crop also showed the similar pattern. Parasites like *Campoletis chlorideae, Brachymeria* and *Exorista xanthaspis* and predators like Coccinellids were reported on *Spodoptera frugiperda.*

3.2 Diversification and sustainable intensification of fodder production in different land use systems including assessment and rejuvenation of grasslands and other resources for improving productivity and livelihood options

3.2.1 Sustainable forage production through lopping management in three tier silvipasture systems (CRSCIGFRISIL20220301)

In a three tier silvipasture system, *Ziziphus mauritiana* recorded maximum top feed (4.48 Mg ha^{-1}) and fire wood yields (5.05 Mg ha^{-1}) followed by *Ziziphus xylopyrus* (4.18 and 4.73 Mg ha^{-1}) and *Acacia catechu* (3.12 and 3.47 Mg ha^{-1}) in association with *Hardwickia binata*, respectively. Lopping of shrubs and *H. binata* at 70% intensity resulted in higher top feed (4.33 Mg ha^{-1}) and fire wood yields (4.88 Mg ha^{-1}) as compared to 50% lopping intensity (3.52 and 3.95 Mg ha^{-1}). *Z. mauritiana* recorded maximum carbon stock (44.40 Mg ha^{-1}) followed by *A. catechu* (32.03 Mg ha^{-1}) and *Z. Xylopyrus* (24.88 Mg ha^{-1}) in association with *H. binata.* Similarly, lopping of shrubs and *H. binata* at 50% intensity recorded higher carbon stock (38.60 Mg ha^{-1}) as compared to 70% lopping intensity (28.94 Mg ha^{-1}).

Twenty-five growing *Jalauni* sheep and *Bundelkhandi* goat were allowed to graze in three-tier silvipasture system (Fig. 3.2.1) during growing season (August-October) as well as post growing season (November-January). Herbage biomass crude protein was higher during growing season (8.97%) compared to post growing season (7.28%). However, NDF, ADF and lignin (76.12, 54.32 and 8.84%, respectively) increased with maturity of herbage during post growing than growing season (66.01, 45.96 and 7.57%), respectively. Grazing with 1% concentrate supplementation indicated that average daily gain in both sheep and goats was higher during growing season (60.30 and 65.1 g) than post growing season (39.60 and 44.30 g, respectively).

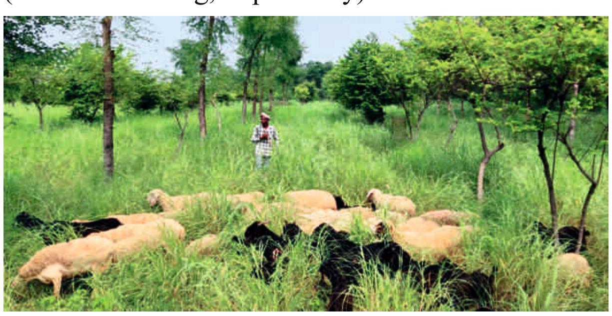

Fig. 3.2.1 Mixed herd grazing in three-tier silvipasture system

3.2.2 Studies on temperate pasturelands for enhanced forage yield, quality and environmental sustainability (CRSCIGFRISIL20201001)

The analysis of grasslands in the Shopian (a), Kulgam (b), and Budgum (c) districts (Fig. 3.2.2) revealed notable variations in key environmental and soil parameters. The soil organic carbon (SOC) varies between 0.38-0.73%, reflecting differences in soil fertility across sites. The available nitrogen spans from 94.65 to 354.07 kg ha^{-1}, while available phosphorus ranges from 5.19 to 12.27 kg $ha^{-1}$and available potassium from 94.41 to 221.28 kg ha^{-1}. These findings underscore the ecological diversity of grasslands in these districts, which may influence their management and utilization for sustainable development.

Fig. 3.2.2a Pirki Gali alpine pasture in Shopian district

Fig. 3.2.2b Kugwattan sub-alpine pastureland in Kulgam district

Fig. 3.2.2c Doodhpathri sub-alpine pasure in Budgam district

The grasses and legumes mixtures @ 20% (red fescue, Timothy, *Chrysopogon gryllus*, red clover, and *Lotus corniculatus*) had the highest GFY of 33.68 Mg ha^{-1} and DMY of 8.54 Mg ha^{-1}.

3.2.3 Pruning management for optimizing forage and wood productivity from *Hardwickia binata* based silvipasture systems (CRSCIGFRISIL20230304)

In *H. binata* based silvipasture systems (Fig. 3.2.3), understorey pasture yield (9.94 Mg ha^{-1}) increased with 60% pruning intensity of *H. binata* branches than 30% pruning intensity (7.25 Mg ha^{-1}) and 45% pruning intensity (8.29 Mg ha^{-1}) respectively. Pruning of *H. binata* branches at 60% intensity also resulted in significantly higher top feed (4.88 Mg ha^{-1}) and fire wood yields (7.70 Mg ha^{-1}) compared to 30% pruning intensity (3.13 and 5.02 Mg ha^{-1}) and 45% pruning intensity (4.26 and 6.74 Mg ha^{-1}), respectively. However, in term of bole wood volume, 30% pruning intensity of *H. binata* branches recorded significantly higher bole wood volume (2138 cubic feet ha^{-1}) compared to 45% pruning intensity (1894 cubic feet ha^{-1}) and 60% pruning intensity (1625 cubic feet ha^{-1}). Among grasses, *C. fulvus* recorded maximum pasture yield (9.06 Mg ha^{-1}) followed by *C. ciliaris* (8.68 Mg ha^{-1}) and *P. maximum* (7.75 Mg ha^{-1}) in association with *H. binata* had 32.20 Mg ha^{-1} year^{-1} carbon.

Fig. 3.2.3 *H. binata* based silvipasture system

3.2.4 Sustaining productivity in grown up Hortipastoral system for fruit and forage security with soil and tree management practices (CRSCIGFRISIL20230303)

Evaluation of decomposer accelerator to promote natural farming in aonla-based horti- pasture system

Seven treatments of decomposer accelerator *viz.*, T_1 (livestock slurry-livestock urine 100 l ha^{-1} + 100 kg dung ha^{-1}), T_2 (jeevamrit @ 500 l ha^{-1}), T_3 (ghanjivamrit @ 500 kg dry cow dung ha^{-1} using 50 litre jeevamrit), T_4 (Pusa decomposer), T_5 (FYM 2 Mg ha^{-1}), T_6. (RDF – 30 kg N, 20 kg P & 20 kg ha^{-1}) and T_7 (control) were applied twice in the month of February- March and June (2024) to the understorey pasture. The fruit production was higher with the T_1 (7.67 Mg ha^{-1}) as compared to control. The understorey pasture production was highest in T_6 (6.5 Mg DM ha^{-1}). The system productivity was also significantly higher in all treatments as compared to control.

Improvement of ecosystem productivity in guava based horti-pastoral system with foliar application of micronutrients on fruit trees.

In the second year of experiment to improve ecosystem productivity in guava based horti-pastoral system (Fig. 3.2.4) with foliar application of micronutrients at five levels *i.e.* T_1 [Boron (Borax) (0.25%) + $ZnSO_4$ (0.5%)], T_2 [Boron (Borax) (0.25%) + $ZnSO_4$ (0.75%)], T_3 [Boron (Borax) (0.5%) + $ZnSO_4$ (0.5%)], T_4 [Boron (Borax) (0.5%) + $ZnSO_4$ (0.75%)] and T_5 (control water spray) was applied as foliar spray in the 1st week of August at flowering and 1st week of October at fruit set on trees of 16 years old guava *cv.* Lalit and Shweta. The fruit set and fruit retention increased (54.7-64.8, 58.5-66.8%, respectively) with the application of micronutrients. Lalit produced (14.9 Mg ha^{-1}) higher yield compared to Shweta (13.4 Mg ha^{-1}). The physico-chemical composition was significantly influenced with foliar spray of micronutrients. The understorey pasture (*C. ciliaris* + *S. hamata*) production ranged from 3.3-4.5 Mg DM ha^{-1} .

Fig. 3.2.4 Foliar application of micronutrients on guava plants and fruit production

3.2.5 Study of restoration ecology in silvipasture system for semiarid region (CRSCIGFRISIL20200301)

During 2024, GFY was higher in *P. maximum* (42.46) followed by *C. fulvus* (32.17) and *S. seabrana* (12.75 Mg ha^{-1}) with tree or shrub combinations of silvipastoral system. Maximum GFY was obtained from *Leucaena leucocephala* (15.01) followed by *F. infectoria* (6.07), *A. nilotica*

(4.53), and *M. alba* (4.05 Mg ha^{-1} yr^{-1}). The annual leaf litter production among trees/shrubs was found to be maximum in *A. nilotica* (4.07) followed by *F. infectoria* (4.05), *L. leucocephala* (3.74) and *M. alba* (3.69 Mg ha^{-1} yr^{-1}). Grazing along with supplementation of concentrate @ 1% body weight supported a daily body weight gain of around 50-60 g for Jalauni sheep in *L. leucocephala* and *F. infectoria* based system (Fig. 3.2.5).

Fig. 3.2.5 Grazing in silvipasture

3.2.6 Recuperated canopy architecture for higher *bael* (*Aegle marmelos*) productivity and forage security in semi-arid region (CRSCIGFRISIL20200302)

Fruits per tree varied from 19-28 with maximum in central leader system (27.98) and minimum in untrained tree with pasture (19.04). Fruit weight varied from 1.47-1.83 kg in different canopy architects. In *bael* fruit, highest TSS (36.95 °Brix), ascorbic acid (22.91 mg 100 g^{-1}) and total sugar (16.79%) was observed in NB-9 however, CISHB-2 recorded higher phenol content (35.89 mg GAE 100 g^{-1}) and TSS: acidity ratio (34.67). TSS varied from 32.21-41.24 (°brix), ascorbic acid from 21.18-23.21 (mg 100 g^{-1}), total sugar from 15.42-17.92 and phenol content varied from 32.98-36.87 mg GAE 100 g^{-1}) in different plant canopy architects. Grazing along with supplementation of concentrate @ 1% body weight supported a daily body weight gain of around 70-75 g for Jalauni sheep in bael based system.

3.2.7 Evaluation of *Ailanthus excelsa* and *Morus* species germplasm for growth performance, fodder yield and nutritional traits under various agro-climatic zones (CRSCIGFRISIL20200303)

Seventy-three germplasm collections of *Morus* species were evaluated in semi-arid conditions for growth performance and leaf yield (Fig. 3.2.6). Height among various germplasm varied from 90 to 480 cm; collar diameter varied from 14.8 to 67.7 mm and green leaf yield from 53.5 to 1,372.5 g $plant^{-1}$. Among twenty germplasms of *Morus* species being evaluated under temperate conditions at Srinagar, height varied from 141.5 to 214.0 cm and collar diameter varied from 1.05 to 3.26 cm; number of leaves per plant varied from 131-490; leaf length varied from 4.79-8.47 cm; leaf width varied from 3.43-5.87 cm and fresh weight of 10 leaves varied from 3.43-5.87 g. Zust variety was found to outperform among all the germplasm.

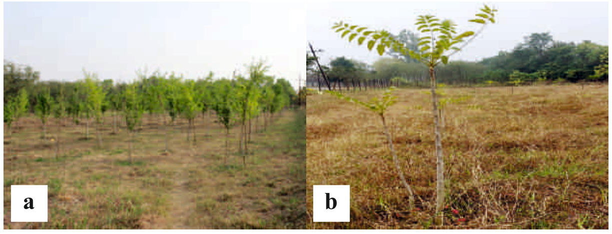

Fig. 3.2.6 Field view of (a) *Morus* spp. and (b) *Ailanthus excelsa* germplasm

3.2.8 Improved pasture management for sustaining soil-pasture-animal productivity (CRSCIGFRISIL20230301)

SR1 (Stocking rate 1) and SR2 (Stocking rate 2) resulted in ~ 7 and 11% greater biomass yield over SR3 (Stocking rate 3) after two years of grazing withdrawal. However, control plot had significantly greater biomass yield. In both 0-20 cm and 21-40 cm soil layers organic carbon is the highest in SR3 and the lowest in SR1 as compared with control. Similar results were true for N and P also. In 0-20 cm soil layer, dehydrogenase was the highest under SR3 and lowest under SR1. But at 21-40 cm soil layer, SR2 & SR3 had higher dehydrogenase as compared to control, and it was similar to control under SR1.

A carbon migration scheme under grazing systems were developed. The $\delta^{13}C$ analysis indicated that roots, feces, and urine contributed to 3.3-21.7%, 4.9-32.5%, and 2.3-14.9% to total SOC stock in aggregates and bulk soil. The large macroaggregates contributed to carbon sequestration mostly (Fig. 3.2.7).

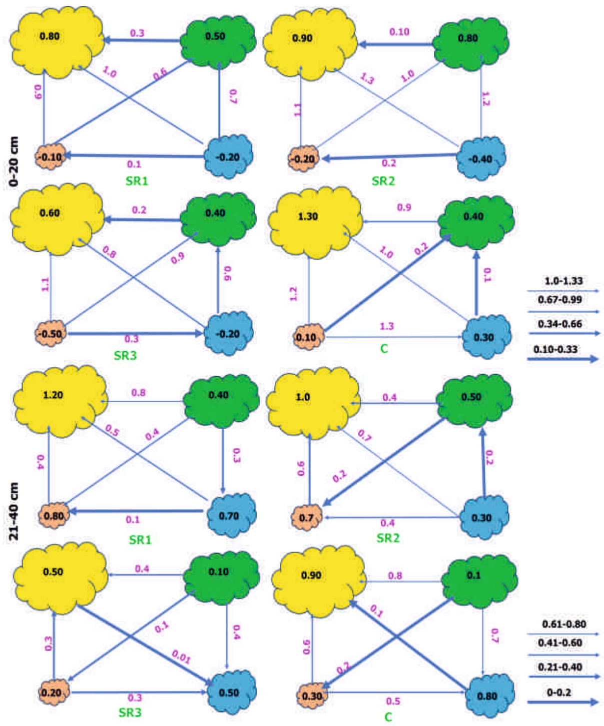

Fig. 3.2.7 Flow of carbon within aggregates under pasture system

3.2.9 Solubilization of native soil phosphorus using natural silicon sources and P solubilizing microbes (CRSCIGFRISIL20230301)

An experiment was conducted for solubilization of native soil phosphorus (P) using natural silicon (Si) sources and P solubilizing microbes. As natural source of Si, fresh wheat straw, rice straw, and sugarcane bagasse were used. *Burkholderia cepacia* was used as P solubilizing bacteria. Soil was collected from institute CR farm and treated as T0 (control: no PSMs and no RS), T1 (6 Mg ha^{-1} soil + PSMs), T2 (8 Mg ha^{-1} + PSMs), T3 (10 Mg ha^{-1} soil + PSMs), T4 (12 Mg ha^{-1} soil + PSMs), T5 (PSMs only). The treated soils were incubated under two different temperatures (25 and 35°C) and two different moisture regimes (0.33 bar and 1.0 bar) for 90 days. Wheat straw application could mobilize ~0.68-2.96% inorganic P and mineralize ~6.4-8.17 ppm organic P. Rice straw application could mobilize ~1.11-3.26% inorganic P and mineralize ~7.88-9.22 ppm organic P. Bagasse application could mobilize ~0.68-2.36% inorganic P and mineralize ~2.60-4.43 ppm organic P. Overall, T3 could mobilize greater amount of P. Indeed, the application of RS and PSMs resulted in release of organic acids, silicon and enhanced activities of soil enzymes and helped in solubilisation of inorganic P. With the increase of the silicate concentration and temperature in the solution, adsorption decreased (Fig. 3.2.8).

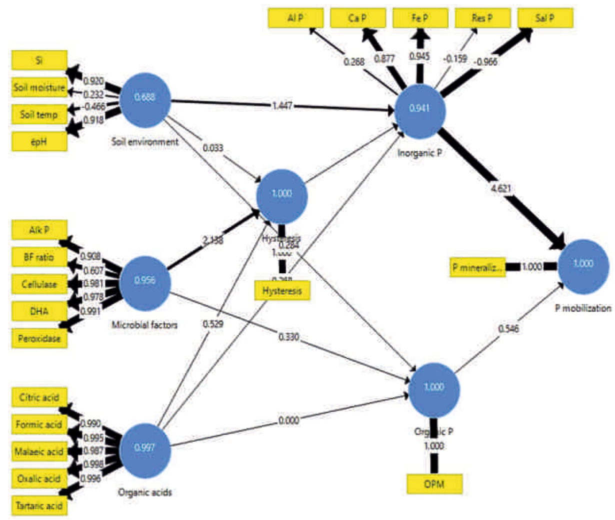

Fig. 3.2.8 Path analysis to depict impact of soil environment, microbial factors and organic acids on phosphorus (P) mobilization. Models satisfactorily fitted to data based on χ^2 and RMSEA analyses [χ^2=101.37, GFI=0.84, RMSEA < 0.001]. Solid arrows represent the significant effects. Widths of the arrows indicate the strength of the casual relationship

3.2.10 Development of grassland assessment system using geospatial technology (CRSCIGFRISIL20210301)

The study was conducted in the Lalitpur, Chhatarpur and Hamirpur districts of semi-arid Bundelkhand region (Fig. 3.2.9). Landsat 8 Operational Land Imager (OLI) data was acquired from USGS Earth Explorer. Soil samples were collected from the surface (0–15 cm) in October-November 2021, 2022 and 2023 at the end of the harvesting season for soil chemical analysis from each site. For rainfall investigation, daily rainfall data spanning 1901–2021 (121 years) was utilized, maximum & minimum temperature (1951-2023) were provided by the India Meteorological Department at a grid size of 0.25° latitude × 0.25° longitude. Machine learning models like ELNET, SVM, MARS, PLSR, RF, KNN, XGBoost and Cubist were employed to predict biomass productivity. Grassland health was estimated by assimilating satellite (19 Spectral indices), soil (6 parameters) and weather data (3 parameters) into 9 machine learning models. Coefficient of determination for the entire machine learning model ranged from 0.53 to 0.80, RMSE ranged from 15.66 to 22.55 g m^{-2} and NSE varied between 0.47 to 0.74 g m^{-2}. Random forest model (R^2= 0.80, NSE = 0.74 g m^{-2}, RMSE = 15.66 g m^{-2}, RPIQ= 1.70) out performed other models.

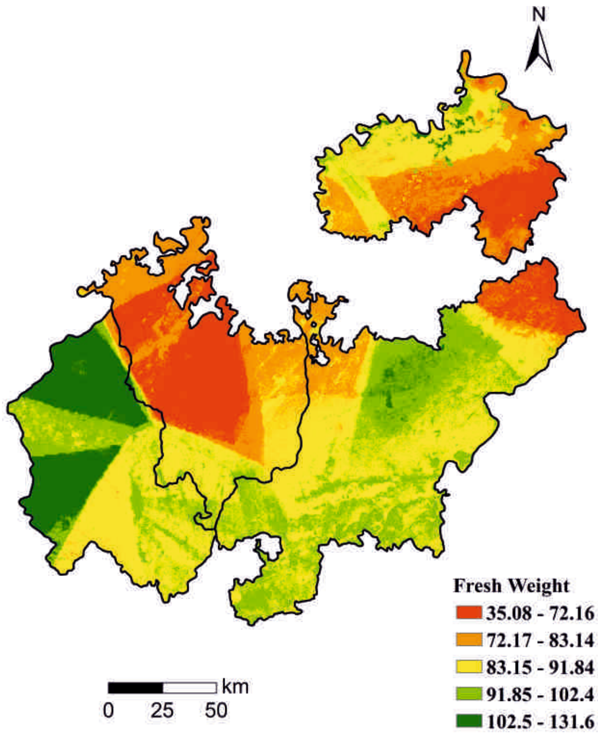

Fig. 3.2.9 Predicted pasture biomass productivity (g m^{-2}) in Lalitpur, Chhatarpur and Hamirpur districts

3.2.11 Assessment of water requirement for fodder based cropping systems in different parts of Uttar Pradesh (CRSCIGFRISIL20220202)

The crop coefficient (Kc) of different fodder crops/system was established cut-wise. The net water requirement (WR) of berseem crop varies from 826 to 2221 cubic meter (m^3) in different (five) cuts and the total water requirement for one production cycle amounts to 7232 m^3 ha^{-1}. In BNH + berseem system, the estimated Kc varies from 1.14 to 1.43 in four cuts. The results revealed that the net WR varies between 948 to 1651 cubic meter (m^3) in four cuts and the total WR amounts to 4844 m^3 ha^{-1}. The irrigation water requirement (IWR) for drip irrigation varies from 1185 to 2063 m^3 whereas, it varied from 1354 to 2358 m^3 for sprinkler method of irrigation. The estimated Kc of Guinea + berseem varies from 1.23 to 1.28 in four cuts. The net water requirement of system varies from 841 to 1246 cubic meter and the total water requirement was found to be 4397 m^3 ha^{-1}. In maize + cowpea, the crop coefficient varied between 1.21 to 1.78 during different stages and the total water requirement of above system was estimated to be 3934 m^3 ha^{-1}. However, the total water requirement for sorghum was 3467 m^3 ha^{-1}.

3.3 Management of natural resources and soil health of arable and non arable lands for climate resilient sustainable fodder production

3.3.1 Precision nitrogen management in forage crops (CRSCIGFRISIL20190202)

After five cuts of BN hybrid, successive increase in N fertilizer dose from 0 to 50 kg N ha^{-1} after each cut significantly increased the GFY and DFY in all harvests (Fig. 3.3.1). The increase in the N fertilizer from 30 to 50 kg N ha^{-1} after a cut led to increase in GFY by 19.5%. Among SPAD based treatments, N application at SPAD value 41-45 recorded highest GFY (118.7 Mg ha^{-1}) and DFY (24.7 Mg ha^{-1}) fodder yield which was significantly higher by 19.2 and 21.7% over SPAD 33-37. The increasing N fertilizer dose from 30 to 40 kg N ha^{-1} increased the use efficiency of applied fertilizer thereafter marginally decreased with 50 kg N ha^{-1}. However, SPAD based N fertilizer application increased the NUE and being the highest (41 kg DM gain kg^{-1} N) with SPAD 41-45 treatment.

Fig. 3.3.1 Chlorophyll meter-based nitrogen fertilizer application in BN hybrid

3.3.2 Nutrient and water management in BN hybrid through drip irrigation in semi-arid region of India (CRSCIGFRISIL20210203)

Fertigation with 100% NPK and irrigation at 75% available soil moisture (ASM) recorded the highest GFY of the BN hybrid (Fig. 3.3.2), which was 23.6% higher than the farmer's practice (100% NPK and flood irrigation). Water use efficiency under fertigation was 40–108% higher than under flood irrigation (~25 kg DM ha-mm^{-1}), with the highest efficiency (52.05 kg DM ha-mm^{-1}) observed under 100% NPK with irrigation at 50% ASM. Under flood irrigation, only 60 kg of dry matter can be produced per kg of nutrients, whereas under fertigation treatments, it varied from 62 to 170 kg.

Fig. 3.3.2 BN hybrid under 75% ASM with 100% NPK

3.3.3 Manipulating the rhizosphere microbiome using plant growth promoting microbes to enhance soil and plant health (CRSCIGFRISIL20210201)

Oat rhizosphere microbiome was manipulated by seed inoculation with plant growth promoting microbes (PGPMs). Two PGPMs (one bacterium and one fungus each) with 3 fertilizer doses combinations were used. In field evaluation, all PGPM treatments recorded greater GFY (23.60-31.00 Mg ha^{-1}) and seed yield (805.0-990.0 kg ha^{-1}) compared with 100% RDF in the nutrient poor - light textured soil. All PGPMs recorded similar or greater soil microbiological properties (i.e. microbial counts, acid and alkaline phosphatase enzyme activities) than 100% RDF. Collected root exudates were analyzed through HPLC and its chromatogram revealed enhancement of the peaks of root exudates in bacteria and fungi inoculated plants.

3.3.4 Development of microbial inoculants for enhancing ensiling (CRSCIGFRISIL20210202)

About 100 lactic acid bacterial cultures (LAB) were isolated from phyllosphere region and endophytes of different grasses using MRS agar media. About nine LAB isolates were chosen based on their lactic acid production and they were used as inoculant additives (@ ~$1x10^8$ CFU ml^{-1}) for ensiling BN hybrid. The average LAB count in the inoculated grass ranged from $42.5x10^3$ to $75x10^3$ CFU g^{-1}. The average pH drops in silage inoculated with LAB ranged from 4.82 to 4.21. Percent reduction in dry matter weight of silage ranged from 1.65 - 2.76%. Volatile fatty acid profile showed that acetic, propionic, isobutyric, butyric, isovaleric, valeric were found in lower concentration than the control, while lactic acid was higher (0.264-0.697%) in inoculated treatments than control (0.26%). Another batch of selected 9 LAB were used for ensiling temperate grasses (LA: 116.8-246.3 mg and pH: 4.87-4.58 *vs*. 69.5 and 5.07 in control) and *C. ciliaris* silage (LA: 221.3-240.1 mg; pH: 4.79-3.86; %DM loss: 1.43-0.96 *vs*. control 214.4, 5.23 and 1.55, respectively). About 4 efficient LAB isolates were chosen for enhancing the ensiling process and quality of silage.

3.3.5 Intensive fodder production through crop diversification and zinc fortification in Kashmir Himalaya (CRSCIGFRISIL20221001)

Cropping systems and zinc fertilization significantly influenced forage quality of maize and cowpea (Fig. 3.3.3). Cowpea recorded highest crude protein (CP) however, maize + cowpea recorded highest CP yield (1.43 and 1.45 Mg ha^{-1}). Soil + foliar application of zinc increased CP by 3.18% and CP yield by 17.61% over control. Soil + foliar Zn application recorded highest DMI (2.22%), DDM (63.39%) and RFV (109.38%) as compared to soil application (2.18%, 62.33% and 105.99%, respectively) and control (2.13%, 61.01% and 100.88%, respectively). In *rabi* (2023-24), maize + cowpea - oat + berseem cropping system also recorded highest GFY 49.44 Mg ha^{-1}) and DMY (12.37 Mg ha^{-1}). Zinc @ 5 kg ha^{-1} as basal soil application + one foliar spray of $ZnSO_4$ @ 0.5% resulted in 16.11% increase in GFY and 19.71% increase in DMY.

Fig. 3.3.3 Maize-cowpea intercropping system at RRS Srinagar

3.3.6 Agronomical trait(s) improvement in forages using plant associated microbes from the North-Western Himalaya (CRSCIGFRISIL20221101)

Soil samples were collected from different regions of NW Himalayas (HP) including Kangra (Palampur), Hamirpur (Bhoranj), Mandi (Joginder Nagar), Chamba (Holi, Chamba, Jot *etc.*) with an altitude range (700 -2250 m amsl; soil temperature range 12-25 °C) from grasslands, perennial grasses and cultivated field crops. Soil samples collected from five rhizospheric soils were used for isolation of culturable microbes on different media.

Total 25 different bacterial isolates and 11 fungal isolates were obtained based on distinct morphological characteristics, selective growth on different media, growth time (24 to 72 h), and colony morphology (colour, growth pattern, time) (Fig. 3.3.4.).

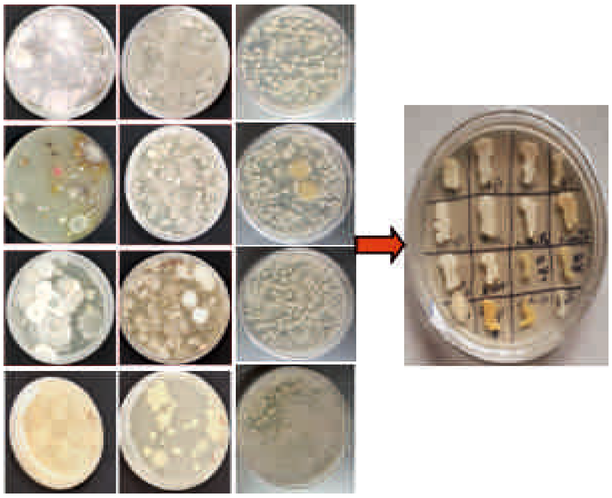

Fig. 3.3.4 Microbial diversity in soil sample

3.4 Accelerating seed biology research and technology development for enhanced quality forage seed production and strengthening national forage seed network

3.4.1 Development of seed standards in temperate grasses and legumes (CRSCIGFRISIL20180402)

Five temperate forages *viz.,* timothy, red fescue, white clover, sainfoin and persian clover were evaluated for seed standards. Different types of seed dormancy were found in studied crops such as physical, physicochemical and incomplete seed developmental emerging from asynchronous seed maturation.

3.4.2 Role of smoke derived compounds in early establishment of forages (CRSCIGFRISIL20190402)

The study evaluated the impact of smoke water (SW) on seed viability and vigor in *H. contortus* (BL-1) and *P. pedicellatum* (BD-2), identifying 1% SW concentration as the most effective for both species. In *H. contortus*, this concentration enhanced seedling length, vigor index, and germination percentage while reducing mean germination time. Similarly, in *P. pedicellatum*, 1% SW improved seedling growth and germination traits, outperforming lower concentrations (0.02–0.05%). Additionally, SW prepared using green grass significantly improved germination, seedling length, and vigor index in both species compared to dry grass, with *P. pedicellatum* exhibiting faster germination and stronger growth responses. These results highlight the effectiveness of 1% SW in enhancing seed performance.

3.4.3 Study of berseem (*Trifolium alexandrium* L.) seed coat dynamics (CRSCIGFRISIL20200104)

This study on berseem (*Trifolium alexandrinum* L.) seed discoloration and its effects on viability and vigor in three varieties (Wardan, BB-3 and JBSC-1) revealed that polythene bag storage at low temperatures effectively preserved seed quality over four years. Wardan exhibited the highest germination rates (up to 95.8%), while aging-induced membrane integrity loss reduced germination, as indicated by increased electrical conductivity, especially in seeds stored in cloth bags. Seed color transitions from yellow to dark red were linked to aging, with metabolic activity and enzymatic efficiency declining in red and dark red seeds. Aging also influenced phenolic and flavonoid accumulation, microflora shifts (*Fusarium* sp., *Alternaria* sp., *Aspergillus* sp.) and structural seed coat degradation. These changes progressively reduced seed viability, highlighting the importance of optimal storage conditions for long-term seed preservation.

3.4.4 Development of seed standards in forage grasses and legumes (CRSCIGFRISIL20210901)

Effect of temperature, light and medium on germination in *Heteropogon* and *Sehima* grasses

Effect of medium (sand, between paper- BP and top of paper- TP), temperature (25°C, 30-20°C and 35-20°C) and light (presence of light and dark) was evaluated for germination of one year old seed for developing seed standards in *Heteropogon* and *Sehima* grasses. Among the medium, highest germination was recorded in TP (60.3 and 49.3%, respectively in *Heteropogon* and *Sehima*), and was found better than other two mediums. The germination was significantly higher than sand in *Heteropogon* and BP in *Sehima*. Among the temperature 25°C was found better than 30-20°C and 35-20°C. Absence of light (dark) favoured better germination than light in both the species. The study recommended TP medium and 25°C in dark for better germination in both the species.

3.5 Nutritional evaluation and post-harvest management of forage resources for sustainable and improved crop-livestock production systems

3.5.1. Ensiled TMR (Total Mix Ration) for livestock production (CRSCIGFRISIL20220701)

TMR silage (Fig. 3.5.1) using guinea grass and concentrate mixture consisting of mustard cake (35%), wheat bran (15%), maize (47%), mineral mixture (1%) and salt (1%) at the ratio of 70:30 was prepared. After 42 days of ensiling the color of the ensiled material was greenish brown and the odor was pleasant, there was no fungal/mould growth. DM content of TMR silage was 33.16% whereas CP, NDF and ADF contents were 13.28, 61.15 and 32.04%, respectively. Silage pH and lactic acid contents were 4.11 and 4.99%. Jalauni lambs weighing around 17.5 kg were fed control TMR (G_1) consisting of chaffed guinea grass and concentrate mixture (70:30) and TMR silage (G_2) to study the nutrient utilization, rumen metabolism and growth performance of animals. DMI was higher in G_2 (3.83%) than in G_1 (3.42%). Similarly, DM, NDF, and CP digestibility were higher in G_2. N intake (g) per kg digestible OM was 39.63 in the G_1 and 38.10 in the G_2. At 90 days of feeding, body weight gain improved in G_2 (84.7 g) over G_1 (78.6 g).

Fig. 3.5.1 Total mixed ration silage

3.5.2. Grazing behaviour of small ruminants on natural pasture during summer (CRSCIGFRISIL20220703)

A comparison was made between the grazing patterns of Jalauni sheep (n=10) and Bundelkhandi goats (n=10) on natural pastures during summer (Figure 3.5.2) for fifteen days in 0.5 ha area using video footage of 9 hours daily.

Goats exhibited a considerably longer average grazing time (32.79 min h^{-1}) than sheep (22.30 min h^{-1}) during the summer season. In contrast, sheep exhibited substantially longer walking time (5.43 versus 3.65 min h^{-1}), standing time (13.44 versus 11.73 min h^{-1}), and sitting time (18.92 versus 11.82 min h^{-1}) than goats (Fig. 3.5.2).

Sheep favored grasses majorly during morning, afternoon, and evening. Goats, on the other hand, exhibited a preference for a wider variety of plant species, including grasses during the morning and thorny vegetation, followed by shrubs during the afternoon and evening.

Fig. 3.5.2 Goat and sheep grazing in pastures

3.5.3 *In-vitro* phytochemical essential oils to control aflatoxins-producing fungi (CRSCIGFRI20220702)

Essential oils from *Curcuma longa*, *Ageratum conyzoides*, *Brassica nigra*, *Moringa oleifera*, *Citrus limmata*, and neem seed kernel (NSK) extract (at 250, 500, and 1000 µl l^{-1}), were tested to control *Aspergillus flavus* and *Aspergillus parasiticus*. At a concentration of 1000 µl l^{-1} of *Curcuma* essential oil (EO), there was an inhibition of 81.11% for *A. flavus* and 63.41% for *A. parasiticus*. Similarly, at 1000 µl l^{-1}concentration of *Citrus* EO, the inhibition rates were 13.31% for *A. flavus* and 23.16% for *A. parasiticus*. With *Ageratum* EO at the same concentration, the inhibition rates were 47.59% for *A. flavus* and 39.02% for *A. parasiticus*. At 1000 µl l^{-1} concentration of NSK extract, the inhibition was 55.60% for *A. flavus* and 70.38% for *A. parasiticus* (Fig. 3.5.3). Notably, *Brassica nigra* EO showed 100% inhibition at concentrations of 40 µl l^{-1} and above, while no inhibition was observed in the growth of both fungi at 1000 µl $l^{-1}$of *Moringa* EO.

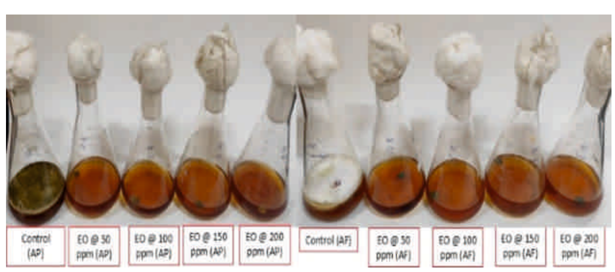

Fig. 3.5.3 Inhibition of the growth of *A. parasiticus* and *A. flavus* using *Brassica* EO

3.5.4 Utilization of millet byproducts in the total mixed ration (TMR) for goats (CRSCIGFRISIL20190602)

Millets based TMR was developed for commercial goat production (Fig. 3.5.4). The density of prepared TMR was 261 kg m^{-3}. Twelve growing male goats were divided into two groups having six animals each group. One group was fed with prepared TMR *ad lib* and another control group was fed with the traditional system of feeding, as lentil hay *ad lib* with concentrate. The feed intake was higher in TMR fed group (4.09 kg 100 kg^{-1} body weight) as compared to the control (3.44 kg 100 kg^{-1} body weight). Dry matter digestibility in TMR fed group and the control was 68% and 65%, respectively.

Fig. 3.5.4 TMR for goats

3.5.5 Bundelkhandi goats: Conservation and improvement of the breed (CSRCIGFRI20180701)

In 2024, 130 households and 2387 goats were registered. Average ranged from 3 to 66, with flock sizes of 18.5 goats per household predominantly composed of adult/yearling females, making up 65%, followed by growing kids at 32%. Breeding bucks were available for only 3% of the flock.

The average body weights at birth, 3, 6, and 12 months were 2.40±0.08, 9.60±0.29, 13.56±0.25, and 20.34±0.30 kg, respectively. The average daily milk yield was 0.491±0.16 liters, while the average lactation milk yield was 43±3.87 liters in a lactation of 90.2±7.69 days. A total of 13 selected bucks and 5 goats were distributed among the farmers registered under the project.

Fig. 3.5.5 Bundelkhandi goats in the PAR farm

Vaccinations were carried out against ET (1076 goats), PPR (903 goats), and FMD (1149 goats). Periodic treatment of diseased animals was conducted, with 3950 cases being treated.

3.5.6 Ensiling characteristics of temperate grasses and legumes for sustainable livestock production (CRSCIGFRISIL20211001)

Apple pomace (AP) was used as additive in different proportions (10, 25 and 50%) to apple leaves (AL), apple leaf-legume/grass and apple leaf-grass-legume based diets (D_1: AL 75% + AP 25%, D_2: AL 50% + AP 5%, D_3: AL 50% + legume 25% + AP 25%, D_4 : AL 30% + grass 60% + AP 10%, D_5 : AL 25% + legume 25% + grass 25% + AP 5% and D_6 : AL 50% + grass 25% + AP 25%). AP has low CP (4.51) and also low NDF, ADF and cellulose (35.61, 23.56 and 14.30%). Lignin of AP was 8.66%. Fresh diets CP, NDF, ADF, cellulose and lignin ranged between 8.10- 15.52, 37.01-54.80, 22.89-26.15, 14.59-19.14 and 5.12-10.97%, respectively, while silage diets between 9.63-13.78, 41.12-1.51, 22.07-30.39, 17.50-22.01 and 4.45-8.16%, respectively. The TDN, DE and ME of fresh diets and silage diets were in range of 70.39-75.17, 3.10-3.31 & 2.55-2.72 and 65.40-76.24%, 2.88-3.36 kcal g^{-1} & 2.37-2.76 kcal g^{-1}, respectively. Silage prepared from different diets had pH within standard values (3.74-4.10) recommended for good quality silage (3.8-4.2) except for Al75% + AP25% diet (4.56). Silages lactic acid varied from 2.21-6.98% DM, while DM ranged from 19.48 to 30.87%.

3.5.7 Development of automatic seed coating machine (CRSCIGFRISIL20190605)

A forage seed coating machine was developed to apply polymer-based chemical agents. The polymer-based coating agent was prepared by mixing different ingredients in a chemical mixer provided over the machine. The machine had coating capacity of 60 kg h^{-1} and 6.5 kg h^{-1} for berseem and cowpea seeds, respectively. This machine can be used for seed treatment with powder/granular chemical material/liquid chemical agent/polymer. Application of the machine had been demonstrated to more than 2000 farmers in the Bundelkhand region (Fig. 3.5.6).

Fig. 3.5.6 Demonstration of seed coating machine at Hastinapur Village, Jhansi

3.5.8 Design and development of solar powered self-propelled multipurpose machine for agricultural operations (CRSCIGFRISIL20190604)

The solar-powered self-propelled multipurpose machine consists of a power source, solar panel, DC motor, spraying unit and rotary tilling unit had been developed for spraying and tilling operation in forage crops. It was fabricated using an inch MS angle and four traction wheels fitted over the corner of the frame for transportation as well as to provide traction force during operation. DC motor was used to provide power to the rear wheels. For installing the spraying unit, a transparent water tank was kept over the frame for filling liquid chemicals. The tilling unit is comprised of two rotors with 180 rpm speed and it has a 30 cm cutting width with 3-5 cm depth of cut, based on field conditions. The solar panel provides the necessary voltage and current for charging the whole system. The machine field capacities for spraying and tilling were 0.75 ha h^{-1} and 0.09 ha h^{-1} with field efficiencies of 93% and 90%, respectively, for different forage crop fields (Fig. 3.5.7).

Fig. 3.5.7 Solar-powered self-propelled multipurpose machine developed by institute

3.5.9 Development of drudgery reducing farm machines and tools for forage and livestock production (CRSCIGFRISIL20190604)

An animal-drawn shed scraper was fabricated for collecting/cleaning the dung, straw, and feed lying over the animal shed surface. Two wheels were provided at both the sides of scraper for easy transportation and animal drudgery reduction. It was tested in the animal shed and the actual field capacity of the developed prototype was found 0.08 ha h^{-1} at 89% field efficiency. This intervention is very helpful in saving 2-3 labors involved in animal shed cleaning operations (Fig. 3.5.8).

Fig. 3.5.8 Developed animal-drawn shed scraper

3.5.10 Development of forage-based feed making machine for commercial goat farming (CRSCIGFRISIL20190602)

An animal feed-making machine was developed for the preparation of total mix ration (TMR) mainly consisted of mixing, compression and bagging units. Ingredients are entered into a mixing chamber through the hopper to get uniform mixed TMR. Then TMR passes through a compression chamber for required densification or compression (adjustable). Finally, the compressed TMR is entered into the bagging unit for proper packaging and getting the TMR bag at the end. The machine capacity to prepare TMR was 400 kg h^{-1}. The machine can pack 26 bags per hour, each weighing 15 kg (Fig. 3.5.9).

Fig. 3.5.9 Developed animal feed-making machine

3.6 Social, economic, policy and translational research and capacity building

3.6.1 Livestock based integrated farming system for sustainable productivity at farmers' field of Bundelkhand region (CRSCIGFRISIL20190501)

The study on 'livestock based integrated farming system (LIFS) for sustainable productivity at farmers' field' was carried out during 2019-2024 at 10 farmers sites of Jhansi district. The final year assessment of the LIFS indicated that the adoption of an IFS having dominance of livestock (average 6-8 ACUs ha^{-1}) + food crops (wheat, rice, mungbean, urdbean, groundnut) + vegetables (cucurbits, cole crops, brinjal, tomato, leafy vegetables) + fruits (citrus, mango, guava, jackfruit, *karonda*) + fodder crops (maize, sorghum, cowpea, berseem, oat, BN hybrid, cactus, moringa, azolla) + allied activities (mushroom, vermicompost, silage, milk processing *etc.*) could provide 3.3-4.5 times higher system productivity, income and employment as compared with a traditional double crop based groundnut-wheat cropping system. On an average, the adoption of such livestock dominant IFS provided net returns with a cost of production of Rs. 6.3 lacs ha^{-1} $year^{-1}$ in a B:C ratio of 1.76, along with generation of sustained employment of 707 man-days ha^{-1} $year^{-1}$ and improvement in soil fertility by 11-16%. Besides, LIFS technology found with enabling the recycling of farm residues and by-products by >95%. The pre- and post impact analysis indicated that the adoption of LIFS model for 3-5 years, the annual production, income and employment from unit area was enhanced by 23, 27 and 33%, respectively. LIFS assisted in reducing fodder deficit by 22% within 3-5 years of adoption.

3.6.2 Ex-post development impact evaluation of ADARSH CHARA GRAM project (Scaling up of fodder technologies at farmers' field) (CRSCIGFRISIL20210503)

Ex-post impact of Model Fodder Villages (*Adarsh Chara Gram* project**)** on the livelihood security of dairy farmers in the Bundelkhand region was conducted. The study used cross-sectional data from 437 farmers and employed the inverse-propensity-weighting regression adjustment method for impact evaluation and verified the robustness of our results through matching methods. The estimated impact revealed that dairy farmers from the model fodder villages had 14-19% greater likelihood of improving habitat security, while economic and food security improvements ranged from 19-21% and 13-16%, respectively. Factors such as age, education, household size, dependency ratio, off-farm income, adult cattle units, and access to roads, markets, credit, and training significantly affected the adoption of improved forage technologies among dairy farmers.

3.6.3 Participatory fodder production in fruits and plantation crops (CRSCIGFRISIL20200901)

This study was conducted using an action research design, aimed to investigate the integration of fodder crops into mango orchards in Chintamani and Dharwar, Karnataka, and Lucknow, U.P. The research focused on identifying socio-economic factors influencing the non-utilization of interspaces in fruit and plantation crops, determining the factors affecting fodder cultivation, analyzing the spread of fodder crops, and understanding the impact of fodder interventions on animal husbandry profitability.

The study also observed a significant spread of fodder crops within and outside villages through discussions and seed material requests among farmers. Fodder interventions led to a reduction in extent of green and dry fodder shortage (Table 3.6.1) and in average expenditure on animal husbandry from Rs. 4587 to Rs. 1228 and an increase in net returns from Rs. 2691 to Rs. 4649. The benefit-cost ratio improved significantly from 1.01 to 2.35 after the project interventions.

Table 3.6.1. Percentage of fodder shortage experienced by the respondents before and after fodder intercropping (n=100)

Extent of green fodder shortage			Extent of dry fodder shortage		
Before	After	t-value	Before	After	t-value
59.17%	16.30%	2.88**	48.00%	31.67%	0.36

3.7 All India Coordinated Research Project on Forage Crops and Utilization

3.7.1 Forage Crop Improvement

***Rabi* 2023-24**

In *rabi* 2023-24, 20 multi-locational trials were conducted at 33 locations on berseem, oats, lucerne, lathyrus, bajra (multi-cut, summer) orchard grass and tall fescue. For berseem none of the entries promoted to AVT-1. In IVT oat single cut, two entries *i.e.* HFO-1240, HFO-1206 were promoted to AVT-1 out of thirteen entries. In IVT oat multicut, OL-2011 was promoted to AVT-1 out of ten entries. In AVT-1, none of the oat multi cut entries were superior over check. In IVT oat dual, two entries *i.e.* JHO 23-3 and JO 13-654 were promoted to AVT-1 out of eight entries.

In IVT lucerne, four entries *i.e.* LLC-10, AL 101, FL 23-1 and Alamdar 82 were promoted to AVT-1 out of seven entries. None of the entries were promoted to AVT-1 for lathyrus. In combined AVT-1 and AVT-2 lathyrus, out of eight entries BCK-19-21A, JCL-21-1, and BAUL-106 were promoted to AVT-2. In IVT multi-cut summer bajra, out of 14 entries, one entry ADV5138 was promoted to AVT-1. In combined AVT-1 + AVT-2 summer bajra (MC), out of 4 entries, one entry TSMCBH-2301 was promoted to AVT-2.

***Kharif* 2024**

Multi locational trials (20) comprising of test entries along with their respective checks were conducted at 34 locations for fodder maize, fodder pearl millet, fodder cowpea, fodder rice bean, dinanath grass, *Stylosanthes seabrana, Setaria anceps, Dichanthium annulatum, Desmanthus virgatus* and BN hybrid. In IVT maize, 10 entries *i.e.* KDFM-11, TNFMH-2308, IFH 11-241, IFH 11-246, ADFM-7, PFM-17, MAH 20-45, MFH 2445, AH 4750 and AH 4754 were promoted to AVT-1 out of 30 entries. In AVT maize-1, 8 entries (DFH 2023-1, JHFM 2023-3, TNFMH 21-25, GK 3271, GK 3270, NMH 40F, BAIF maize 8 and JH 19014) were promoted to AVT-2 out of 13 entries. In IVT pearmillet-1, 6 entries (FSB 2024-1, IIMR-FB-MC-24-3, AFB- 68, FBL 11, FBL 12 and ADV 5001) were promoted to AVT-1 out of 19 entries. In AVT pearmillet-1, 4 entries (ADV 2386, SBH 105, FSFBH 502 and IIMR FB MC-2022-1) were promoted to AVT-2 out of 8 entries. In IVT cowpea, 8 entries (UPC 24-1, FSCP 2024-1, MFC 18-2, BL 24-1, BL 24-2, BL 24-3, BL 24-4, PFC 54) were promoted to AVT-1 out of 15 entries. In AVT cowpea -1, one entry UPC 23-1 was promoted to AVT-2. In IVT dinanath grass JHD 24-4, IGKVDG-41 and IGKVDG-20 were promoted to AVT-1.

3.7.2 Forage Crop Production

***Rabi* 2023-24**

Application of 3 t ha^{-1} biogas slurry + 50% RDF produced maximum green fodder yield (GFY), crude protein yield, grain and straw yields of dual purpose oat. Higher GFY and DMY were noted with application of 25% RDN + 75% N through FYM in chicory. On locational mean basis, 75% recommended dose of N + nano urea @ 6 ml l^{-1} of water recorded higher dry matter yield and crude protein yield but on par with 100 kg N ha^{-1} through chemical fertilizers for single cut fodder oat. In multicut oat highest GFY, DMY and economics were obtained with 125% RDF (75 kg N basal + top dressing of 37.5 kg N ha^{-1} each at 1st cut (40 DAS) and 2nd cut (75 DAS). The highest GFY was recorded in *Azotobacter* (seed treatment) @ 10 g kg^{-1} seed + 75% RDF + Panchagavya @ 3% in dual-purpose oats. At Ludhiana application of Pyroxasulfuron 125 g *ai* ha^{-1} pre-emergence and at Jabalpur Oxyfluorfen 100 g *ai* ha^{-1} + Imazethapyr 15 g *ai* ha^{-1} after first and second cut reduced cuscuta and other weed density in berseem. Pre-emergence application of Pendimethalin @ 750 g ha^{-1} *fb* post-emergence Metsulfuron methyl @ 4 g ha^{-1} at 20 DAS recorded highest weed control efficiency (WCE) at 30 (93.3%) and 60 (90.5%) DAS for oat.

Panchagavya @ 3%, NPK (19:19:19) @ 1% were significantly superior for grass pea fodder yield and quality. Application of FYM @ 10 t ha^{-1} resulted in significantly more plant height, green, dry matter and crude protein yield of sorghum - rye grass cropping system.

For soil health and sustainability of round the year fodder production of sorghum-oat cropping system, 5 t ha^{-1} FYM basal + natural farming with mulch recorded maximum GFY, DFY, and B:C ratio. Hedge lucerne with 100 cm row to row distance and 9 kg per hectare seed rate resulted in higher seed yield. Sorghum (MC) + cowpea (4: 2) - maize + cowpea (4: 2) - bajra (MC) + cowpea (4: 2) cropping system produced higher gross returns, net returns and B:C ratio at Hyderabad. At Anand, RDF 80:40:0 kg NPK + foliar spray of Zn NPs at 500 ppm + soil application of Zn NPs at 0.50 kg ha^{-1}

reported higher GFY of fodder sorghum-oat-fodder bajra cropping sequence. Effect of nano urea on perennial grasses (BN hybrid and Congo signal) in terms of fodder productivity and quality was started at Jorhat. Application of 75% recommended dose of N + nano urea @ 2 ml l^{-1} recorded highest in GFY, DFY and CP yield of perennial grasses (BN hybrid and Congo signal). Significant response of N was observed up to 140 kg N ha^{-1} for dual purpose oat (OL-1967-1 and JO-13-518). Significant response of N was observed up to 105 -140 kg N ha^{-1} for GFY and DMY of BAIF bajra-10.

***Kharif* 2024**

Recommended NPK + FYM (10 Mg ha^{-1}) + micronutrients mixtures @ 1% (20 & 40 DAS) + BFC (5 kg ha^{-1}) recorded higher GFY, DMY, and net monetary returns for fodder maize at Ranchi, Ayodhya, Jabalpur, Mandya and Coimbatore. Comparative study of zinc sulphate and nano zinc of summer fodder sorghum was conducted at four locations. The highest GFY, DMY and CPY recorded in RDF + soil application of $ZnSO_4$ 8 kg ha^{-1} followed by foliar application of 0.5% $ZnSO_4$ for summer fodder sorghum. Application of 75% RDN & P + nano urea & nano DAP @ 6 ml l^{-1}, respectively + soil application of *Azospirillum* @ 2 kg ha^{-1} and PSB @ 2 kg ha^{-1} proved best for multicut fodder sorghum. Barnyard millet with 60 kg N ha^{-1} was found better.

3.7.3 Breeder seed production

During the last 02 years breeder seed production had steady growth and indent almost doubled (Fig. 3.7.1). During *rabi* 2023-24, indent for the breeder seed production was received from DACF&W, GOI for 60 varieties of oat (33), berseem (18), lucerne (7) and hedge lucerne (2). Seed quantity indent was maximum for oat (107.79 t) followed by berseem (29.4 t), lucerne (2.12 t) and hedge lucerne (500 kg). The overall breeder seed production was 99.93 t against the allocation of 105.91 t, with 5.98 t deficit. While during the *kharif* 2024, breeder seed productions were taken for 8 crops covering 39 varieties. Total 24.94 t breeder seed was produced compared to indent of 22.31 t, achieved 2.63 t of surplus breeder seed production.

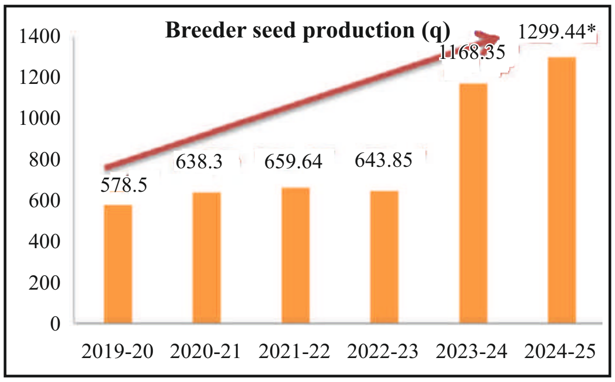

Fig. 3.7.1 Trends in breeder seed production (*Estimated)

3.7.4 New fodder varieties notified for the cultivation

The 92nd CVRC meeting held on 02/08/2024, recommended for release and notification of following fodder crop varieties, tested and identified through AICRP (Forage Crops and Utilization) (Table 3.7.1).

Table 3.7.1. New fodder crop varieties notified for the cultivation during 2024

Crop	Variety	Recommended area	Developed by
Berseem	JB-07-15	West Bengal, Jharkhand, Bihar, Odisha, Maharashtra, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh	JNKVV, Jabalpur
	JB 08-17	Maharashtra, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh	JNKVV, Jabalpur
Forage maize	DHF-2 (Hybrid)	Punjab, Haryana, Rajasthan, Tarai parts of Uttarakhand, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra and Uttar Pradesh.	GBPUA&T, Pantnagar
	AFH-7 (Hybrid)	Punjab, Haryana, Rajasthan, and Tarai parts of Uttarakhand.	ICAR-IARI, New Delhi
	HQPM-28 (Hybrid)	Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, and Uttar Pradesh.	CCSHAU, Hisar
	J 1009	Maharashtra, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh	PAU, Ludhiana

Forage pearl millet	JPM-18-37	Punjab, Haryana, Rajasthan, and plain parts of Uttarakhand.	JNKVV, Jabalpur
	JPM-18-7	Punjab, Haryana, Rajasthan, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka.	JNKVV, Jabalpur
	FBL-4 (PCB 166)	Punjab, Haryana, Rajasthan, Uttrakhand, Tamil nadu, Telagana, Andhra Pradesh and Karnataka	PAU, Ludhiana
	PCB 168	Punjab, Haryana, Rajasthan, Uttrakhand, Uttar Pradesh	PAU, Ludhiana
Oat	PLP-24	Hill zone comprising states of Himachal Pradesh, Uttarakhand and UT of J&K	CSHHPKV, Palampur
	JO 07-310	Maharashtra, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh	JNKVV, Jabalpur
	SKO-244	Punjab, Haryana, Rajasthan, Uttrakhand, Himachal Pradesh and Jammu Kashmir	SKUAST, Srinagar
	JO-13-513	Punjab, Haryana, Rajasthan, Uttrakhand, Uttar Pradesh, Odisha, Bihar, Jharkhand, Assam, Uttar Pradesh	JNKVV, Jabalpur
Lucerne	BAIF Lucerne-5	Punjab, Haryana and Rajasthan	BAIF Urlikanchan, Maharashtra

3.8. Externally Funded Projects

3.8.1 Bioprospecting of abiotic stress tolerance genes in grasses (EEQ/2020/000394)

Chloris gayana was grown in pots and subjected to salinity and drought stress by exposure to 300 and 400 mM NaCl, as well as withholding water.. The selected genes for validation, based on transcriptome sequencing, included lipoxygenase-5, flavonoid 3', 5'-hydroxylase 1, abscisic acid 8'-hydroxylase 2, phospholipase D alpha 1, calcium-dependent protein kinase 7, cell wall-associated receptor kinase 3, hydroxyacyl-CoA dehydratase, and cinnamoyl-CoA reductase 1. These genes were validated using qRT-PCR under both drought and salinity stress conditions. The expression levels of lipoxygenase-5, calcium-dependent protein kinase 7, cell wall-associated receptor kinase 3, and hydroxyacyl-CoA dehydratase were significantly higher in both drought and salinity stress conditions compared to control. These genes played major role in abiotic stress tolerance in *C. gayana*.

3.8.2 Mapping and validation of genomic regions associated with brown midrib mutant in pearl millet (CRG/2022/000524)

BMR mapping population

The generation advancement of Recombinant Inbred Line (RIL) populations RIL1 (ICbmr07 × ICBP19) and RIL2 (ICBbmr09 × ICBP01), from F5 to F7, were done during *kharif* and summer season 2024.

Modified sodium dodecyl sulphate DNA isolation protocol for bmr seedling of pearl-millet DNA was extracted from the parental lines and selected bmr and non-bmr genotypes using the CTAB method. However, initially failed to obtain good quality DNA from the bmr genotype (Fig. 3.8.1 a and b). A modified DNA extraction method (replacing CTAB with 5% SDS (w/v) and 2% 2-β-mercaptoethanol, as well as adding 6 M NaCl) successfully yielded high-quality DNA (Fig. 3.8.1).

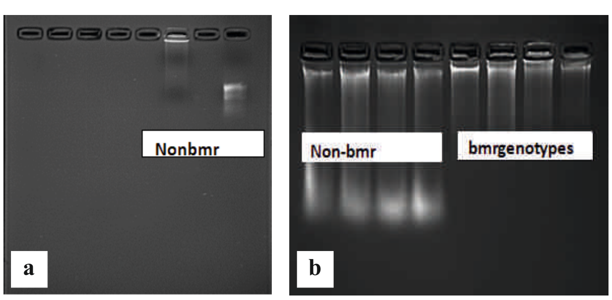

Fig. 3.8.1 Gel electrophoresis of isolated DNA by (a) CTAB protocol; (b) SDS protocol

Mapping of bmr trait in pearl millet using bulk segregant analysis approach

Leaf samples from both parents of RIL 1 (ICbmr07 and ICBP19), along with 20 non-bmr genotypes and 20 bmr genotypes selected from the RIL families, were used for bulk segregant analysis. A total of 752 SSR markers were tested for polymorphism between the parents ICbmr07 and ICBP19. Of these, 98 SSR markers were found to be polymorphic between the parents. These 98 markers were then tested for polymorphism between the parents and both bulks (bmr and non-bmr). One SSR marker *XPSPM2077* found polymorphic between parents and bulks. This marker *XPSPM2077* located on linkage group 2 in pearl millet found associated bmr trait. This marker was successfully validated on different genetic backgrounds carrying bmr loci. The marker clearly differentiated bmr and non bmr lines in segregating generation developed by crossing between Motibajra × ICbmr07, IP2269 × ICbmr07 and AVKB34 × ICbmr07 (Fig. 3.8.2).

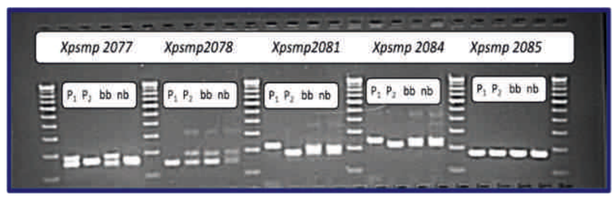

Fig. 3.8.2 The SSR marker *XPSPM2077* showing polymorphism between parents, bmr and non bmr bulk population

Development of high biomass bmr genotypes

The S2 generation bmr inbreds were developed by crossing ICBbmr07 with high biomass genotypes, including TSFB 15-8, Giant bajra, Baif bajra 1, Moti bajra, IGBV9, IGBV24, ICMV05222, ICMV1702, and IP2269. These inbreds were selected based on plant height, biomass, and diverse parental backgrounds. They were then crossed with each other to generate F_1 lines. During the *kharif* 2024, the diverse F_1 lines were once again crossed to develop high-biomass yielding bmr pearl millet composites (Fig. 3.8.3).

Fig. 3.8.3 High biomass yielding bmr pearl millet genotypes

3.8.3 All India Coordinated Research Project on Dryland Agriculture (CRSCIGFRISOP20170203)

Out of seven cropping systems, sweet corn-chickpea cropping system had the highest system productivity (4.6 Mg ha^{-1}) in terms of chickpea equivalent yield, followed by baby corn–taramira (3.4 Mg ha^{-1}) (Fig. 3.8.4) and fodder sorghum-mustard (2.5 Mg ha^{-1}) under rainfed conditions. However, the mungbean-linseed system recorded the lowest system productivity. The cost of cultivation ranged from Rs. 51,480 in the sorghum-mustard system to Rs. 74,800 ha^{-1} in the sweet corn-chickpea system. Despite the highest cost of cultivation, the sweet corn-chickpea system yielded the highest net returns (Rs. 176,295 ha^{-1}) and a benefit-cost ratio of 2.45.

Fig. 3.8.4 Baby corn-taramira and sweet corn-chickpea system

3.8.4 Developing hybrid nano-fertilizers by using zeolite and hydroxyapatite for sustainable fodder production (DST-SERB)

Hybrid nanofertilizers were prepared using zeolite and hydroxyapatite to improve nutrients utilization efficiency while minimizing losses of nutrients. Zeolite nanoparticles (~50 nm) were prepared using a co-precipitation method. The surface of the zeolite was modified using a surfactant to ensure adequate affinity for anionic nutrients. Similarly, hydroxyapatite nanoparticles (~98 nm) were prepared by following the drop-cast method. Nano urea (~27.5 nm) was synthesized by blending urea particles and trisodium citrate under optimal conditions. Nanourea-modified zeolite and hydroxyapatite nanoparticles were then prepared. Micronutrient nanoparticles (Cu, Fe, and Zn) were also prepared using the drop-cast method, with particle sizes of Cu (~45 nm), Fe (~17 nm), and Zn (~11 nm). These nanoparticles were characterized using XRD, DTA/TGA, SEM, and TEM. Desired amounts of nanourea-modified hydroxyapatite nanoparticles and nano urea-modified zeolite nanoparticles were taken in separate beakers, and the micronutrient nanoparticles were carefully mixed together to get hybrid nanofertilizers. The efficacy of these hybrid nanofertilizers for the sustainable nutrition of fodder oat is currently under investigation (Fig.3.8.5a, b).

Fig. 3.8.5 (a) Developed hybrid nanofertilizer (b) Its effect on fodder oat's growth attributes

3.8.5 Natural grassland ecosystem monitoring system for peninsular and Trans Himalayan India to sustain pastoral communities

The project was initiated in 2024-25. The spectral indices have been estimated for three grasslands (Amrit Mahal, Banni, and Changthang) (Fig. 3.8.6). The area of amrit mahal grassland (AMG) was estimated to be 33931 acre, declining by 46% over that in 1947. The air quality parameters (methane, NMVOC, SO_2, and NO_2) was better in grassland as compared to the city areas. The net primary productivity of AMG did not change significantly in 2024 over 2014. The grassland productivity in Mabdya and Chikkamangaluru was higher than other districts of AMG.

Data collected from 300 Kangayam grassland owners of two districts of Tamil Nadu (Karur and Thiruppur) covering 28 villages was analysed. Estimation of biophysical and soil health parameters of grassland through sentinel 2 satellite data was done using spectral indices, soil parameters and 3 climatic parameters for 204 locations in (Lalitpur, Tikamgarh, Chhatarpur and Hamirpur). Grassland health was estimated by assimilating satellite (16 Spectral indices), soil (6 Parameters) and weather data (3 Parameters) into 9 Machine learning models. Out of these Support vector machine performed better (Fig. 3.8.6).

3.8.6 CIAT- Bioversity international project

Use and conservation of agrobiodiversity for food and nutrition security, increased agricultural

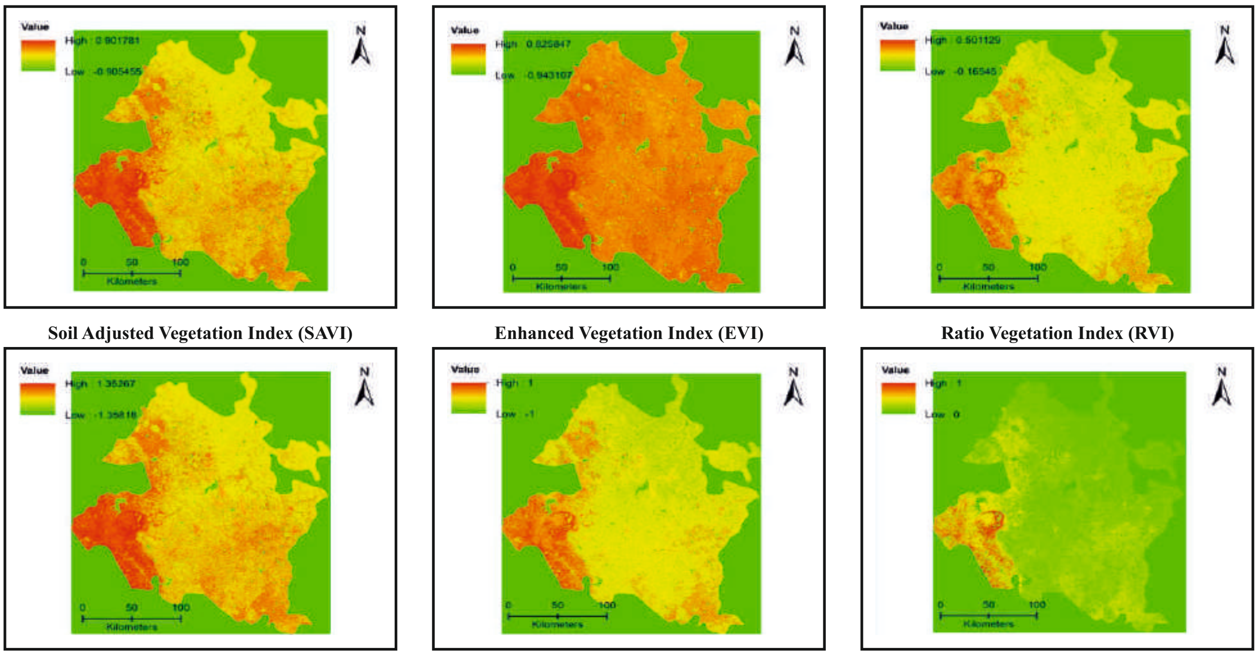

Fig. 3.8.6 Spectral vegetation indices for Amrit Mahal grasslands

sustainability, and resilience to climate change in India

C. ciliaris genotypes were evaluated for salinity stress condition. Evaluation of guinea grass (*P. maximum*) germplasm was also done.

Sixteen diets formulated using straws, green grass and concentrate mixtures were evaluated for their *in vitro* gas and methane production under *in vitro* fermentation using sheep inoculums. It was observed that barley straw (BS) based diets produced both less gas and CH_4 than gram straw (GS) based diets.

3.8.7 NLM Funded Project: Grassland restoration and rejuvenation for enhancing grazing resources using remote sensing and drone technologies

Grassland established on the degraded land patch of the central research farm using a drone with seed pellet technology (Fig.3.8.7**)**. Double-layer biofencing with bamboo + alternate *Morus* and subabul plants was established in the fields. Three grasses *C. ciliaris*, *P. maximum,* and *P. pedicelletum* were selected based on climatic conditions, soil, and survivability. *P. maximum***,** *P. pedicellatum and C. ciliaris* attained the green fodder yield of 1.54, 1.95 and 0.68 Mg ha^{-1}.

Pennisetum pedicellatum *Megathyrus maximus*

Fig. 3.8.7 Grassland restoration using drone technology

3.8.8 Use of fly ash in agriculture for sustainable crop production and environmental protection

Fly ash application @ 80 Mg ha^{-1}(alternate year) and 100 Mg ha^{-1} (once) resulted in similar yield of sorghum and cowpea after 4 cropping seasons. Fly ash application @ 200 Mg ha^{-1}(once) and 400 Mg ha^{-1} (once) resulted in highest fodder yield of sorghum and cowpea. Fly ash application significantly improved infiltration and porosity. The content of Pb, As, Ni, Cr, Cd, and Hg in cowpea and sorghum was below the FAO permissible limit.

3.8.9 Network project on ecosystems, agribusiness and institutions component 1: Impact of agricultural technology (crop science technologies) Sub title: "Impact analysis of grassland and fodder technologies"

Thirteen popular varieties of forage crops namely IGFRI-727 of *C. ciliaris*, BD-2 of *P. pedicellatum*, Wardan, BL-10 and BB-2 of *T. alexandrinum*), JHO-822 and UPO-212 of *A. sativa*, African tall and J-1006 of *Z. mays*, EC-4216 of *Vigna unguiculata*, and AL-3, RL-88 and Anand-2 of *M. sativa* were selected for assessing their impact in India. The estimation of area under each variety was based on truthfully labelled and breeder seed production. The total estimated surplus from the selected varieties amounts to Rs. 495.9 billion, with an annual impact of Rs. 18.6 billion. Across the thirteen selected varieties of forage crops, consumer surplus accounted for approximately 60%, while producer surplus constituted 40% of the total economic surplus, indicating that consumers derived relatively greater benefits than the producers. Among the selected varieties, African tall demonstrated the highest economic surplus (Rs. 33,812 crore). The estimated impact of another maize variety J-1006 was around Rs 5975 crore for the period. Berseem BL-10 generated highest net economic surplus of Rs 1210 crore followed by Wardan (Rs. 789 crore). Among the lucerne varieties, the impact was higher for Anand-2 (Rs. 4319 crore) than AL-3 (Rs. 643 crore). The surplus from cowpea variety EC-4216 was also notable at Rs. 1334 crore. The net surplus from oat varieties was Rs. 66 and 38 crore from UPO-212 and Rs. 28 crore from JHO-822.

3.8.10 Building resilience model for the vulnerable hotspots to climate change in smallholder dairy production system of Indo-Gangetic plain region of India using GIS and fuzzy cognitive mapping approach

Climate risk hotspots in the dairy production system of the Indo-Gangetic Plain (IGP) were identified and found that 28.94% of the livestock were under the climatic stress zone in 2021 which may increase to 35.88 to 39.50% in 2050. According to Temperature Humidity Index (THI), dairy animals of the districts of IGP were under severe stress during May to September. The Comprehensive Climate Index (CCI) indicated dairy animals of the majority of the districts of IGP face 104 to 118 days moderate stress during April to October. Panel data modeling showed that unit increase in CCI, significantly decreased the daily milk yield of the *Tharparkar* by 13.33 ml. Critical threshold of CCI to climate stress on the *Tharparker* was 22.86.

3.8.11 Performance evaluation and improvement of Bhadawari buffaloes

In 2024, Bhadawari buffaloes average lactation milk yield, lactation length, standard lactation milk yield, and peak yield were 1557.40 ± 60.6 kg, 322.8 ± 15.4 days, 1470.86 ± 52.8 kg, and 8.12 ± 0.11 kg, respectively. The milk quality metrics were average milk fat at 8.27 ± 0.17%, SNF at 9.82 ± 0.14%, protein at 3.57 ± 0.04%, and lactose at 5.35 ± 0.08%. The average age at first calving was 47.97 ± 1.72 months, with a conception rate of 60.24%. There were 31 calvings, with an average birth weight of calves at 26.62 ± 0.50 kg and the dam's weight at calving 420.2 ± 10.30 kg. A total of 8100 semen doses were frozen from breeding bulls.

3.8.12 Breeding dual-purpose barley varieties for fodder and grains

Fifty-nine advance breeding lines of barley developed from nine single crosses (NDB-1545 / K-1185, NDB-1545 / JB-240, NDB-1545 / RD-2835, JB-240 / RD-2552, JB-240 / NDB-1545, JB-240 / K-1185, K-1185 / JB-240, RD-2835 / NDB-1545 and HUB-225 / EC-631733) following bulk breeding and six released varieties (RD-2715, HUB-113, RD-2552, RD-2668, RD-2899 and DWRB-137) were grown during *rabi* 2023-24 for fodder and seed production. GFY (at 55-DAS) ranged between 17.8-32.2 Mg ha^{-1} with highest for JHSBK-19. Grain yield from rejuvenated lines was superior for JHSBF-21. The line JHSBD-22 of the cross JB-240 / RD-2552 had 26.2 Mg ha^{-1} GFY at 55-DAS and then 3.17 Mg ha^{-1} grain yield in dual purpose trial and 6.31 Mg ha^{-1} grain yield in normal trial. Among the 6 lines entered in IVT DPB 2023-24 trial had GFY between 19.6 (JHSBF-28) to 26.2 Mg ha^{-1} (JHSBD-22), grain yield in dual purpose ranged between 2.45 (JHSBD-11) and 3.71 Mg ha^{-1} (JHSBF-21). Among the advance lines, 7 lines (JHSBA-13, JHSBA-22, JHSBE-2, JHSBI-19, JHSBK-1, JHSBK-5 and JHSBK-19) gave high cut green fodder yield (25.0 – 32.2 Mg ha^{-1}), grain yield in dual purpose (2.26-3.13 Mg ha^{-1}).

3.8.13 NLM Project: Genetic improvement of forage crops for sustainable livestock production

Pennisetum pedicellatum (132) accessions along with three varieties were evaluated for biomass yield and forage quality traits. Accessions average GFY and DMY was 247.07 g plant^{-1} and 75.58 g plant^{-1}, respectively. Based on the GFY, D6, D15, D46, D29 and D124; and based on DMY, D6, D35, D29, D11 and D46 accessions were selected. One

Pennisetum line was identified for silage making. In pearl millet, 229 genotypes were evaluated for NDF, ADF and lignin. F_1s were generated by crossing between diverse multicut genotypes for developing multicut pearl millet cultivars. In BN hybrid, F_2 population was phenotyped for 13 biomass and seed related traits for further validation of QTLs. For stabilization of fertile BN hybrid, F_5 generations were planted in field using rapid generation advancement technique and F6 seeds were harvested. In maize, 96 landraces with African tall, J-1006, J-1007 and KDFM-1 checks were analysed for NDF, ADF, ADL, IVDMD and CP and micronutrients content (Fe, Zn, Cu and Mn). F_1 seeds were obtained from the crosses between recurrent (PMIPV-3 & PMIPV-4) and donor parent (PMIPV-5) for pyramiding opaque2 and crtRB1 genes into parental inbreds of Vivek hybrid 27 improved for lysine, tryptophan and provitamin A. F_1 seeds were obtained from the crosses between recurrent (PMIPV-3 & PMIPV-4) and donor parent (SWT-019) for introgressing shrunken2 gene into parental inbreds of Vivek hybrid 27 improved for kernel sweetness. In cowpea, 220 accessions were analysed for CP, NDF, ADF, ADL and IVDMD. In oats, 140 genotypes (selected from previous drought experiment) were sown in field for re-validation of morphological and yield traits. In sorghum, 150 genotypes were tested for higher water use efficiency under different levels of polyethylene glycol (PEG) concentration (5 and 10%) at early stages and germination & seedling. Fifteen drought sensitive and tolerance genotypes were selected on the basis of performance at early stages. In sorghum, analysis of chlorophyll content, total soluble protein, and enzymatic activity (Nitrate reductase, glutamine synthase, and protease) has been carried out under both nitrogen-sufficient and nitrogen- deficient conditions.

3.8.14 AMAAS project: Microbe based drought and nutrient management in forage crops

Five drought tolerant PGPR consortia [DTP1-DTP5; comprised *Burkholderia cepacia* + *Bacillus subtilis* as common with each of *Pseudomonas putida* (T5), *Enterobacter cloacae* (T6), *Actinobacter sp.* (T7), *Achromobacter insolitus* (T8) and *Ensifer* sp. (T9)] were developed based on their compatibility among the selected microbes and were evaluated in forage crops with four control treatments. In MP chari, soil moisture content measured using HH2 moisture meter during 20, 45 and 75 DAS) were 25.5±2.8, 24.5±3.2 and 30.3±2.9 cm^3, respectively, under irrigated condition while 4.82±1.8, 3.25±1.9 and 10.15±2.7 cm^3, respectively, under drought imposed condition. Impact of DTP consortium on SPAD values and photosynthesis rate in sorghum under drought stress (45 DAS) had indicated that SPAD values were higher in T6 and T8 than UIC under drought stress, while photosynthesis rate measured using portable photosynthesis system was found relatively higher in T5 and T8 than UIC under drought stress. The impact on photosynthesis parameters in sorghum after drought stress recovery (47 DAS) revealed T5 and T8 recorded photosynthesis rate (Pn) at par with irrigated; T7 and T8 recorded higher stomatal conductance and higher WUE while T5 and T9 recorded higher transpiration rate; Evaluation of drought tolerant bacterial consortium for fodder sorghum production (75 DAS) showed that T8 recorded higher green fodder yield (25.6 t ha^{-1}) and many growth parameters *viz*., plant height (189.6 cm), no. of leaves per plant (8.3) and leaf length (59.0 cm) which was comparable with 100% RDF well watered uninoculated control treatment (T1). Impact of DTP consortium on RWC and SPAD values of sorghum under drought stress (75 DAS) indicated that RWC was found relatively higher in T6, T7 and T8 while SPAD values were higher in T5, T7 and T8 than UIC under drought stress. Impact of consortium on fodder sorghum roots was also studied, wherein 50% RDF drought induced T8 recorded higher root length (cm), root surface area (cm^2), root volume (cm^3) and average root diameter (cm) *viz*., 226, 29.3, 7.4 and 0.11, respectively at 20 DAS, 672, 125.3, 162 and 0.24 at 45 DAS and 826, 132, 221 and 0.43, respectively at 75 DAS. Based on the results obtained, drought tolerant microbial consortia T8 (*Achromobacter insolitus* + *Burkholderia cepacia* + *Bacillus subtilis*) can be recommended for drought stress tolerance in sorghum and cowpea.

Chapter 4

Forage Seed Production

4.1 Seed production 2023-24

4.1.1 Variety-wise seed production of fodder crops

***Rabi* 2023-24**

Crop	Variety	Breeder seed (kg)	Truthfully labeled (kg)	Total (kg)
Oat	KENT	3841	327	4168
	JHO-822	6590	5779	12369
	JHO-851	149	30	179
	JHO-2009-1	661	0	661
	JHO-2000-4	350	104	454
	JHO 99-2	60	0	60
	JHO 2015-1	150	10	160
	JHO 2012-2	42	0	42
	JHO 2010-1	281	0	281
	JHO-99-1	0	330	330
	Total	**12124**	**6580**	**18704**
Berseem	Wardan	663	286	949
	BB-2	60	0	60
	BB-3	37	128	165
	JHB-17-1	16	0	16
	JHB-17-2	69	0	69
	JHB-18-1	62	0	62
	JHB-18-2	30	0	30
	JBSC-1	400	58	458
Tall fescue	Non-specific	0	82	82
White clover	Non-specific	0	9	9
	Total	**1337**	**563**	**1900**

***Kharif* 2024**

Crop	Variety	Breeder seed (kg)	Truthfully labeled (kg)	Total (kg)
Sorghum	MP chari	285	0	285
	CoFS-29	0	1000	1000
	Total	**285**	**1000**	**1285**
Fodder cowpea	EC4216	63	0	63
	Kohinoor	0	200	200

	BL1	50	0	50
	BL2	404	0	404
	BL4	504	0	504
	Total	**1021**	**200**	**1221**
Maize	African tall	228	0	228
Bajra	AVKB-19	658	0	658
Guar	BG-1	380	0	380
Finger millet	VL-376	0	115	115
	Total	**2572**	**1315**	**3887**

4.1.2 Grasses and legumes seed production

Grasses name	Variety	Breeder seed (kg)	Truthfully labeled (kg)
Pennisetum pedicellatum	Bundel Dinanath-2	15	30
Panicum maximum	DGG-1	10	75
	BG-2	10	105
	BG-1	10	10
	G-2	00	32
	Grazing guinea	00	240
	Total	**45**	**492**
Sehima nervosum	BSG-1	05	0
Cenchrus ciliaris	Bundel Anjan -4	20	0
	Bundel Anjan-1	00	15
Cenchrus setigerus	Bundel Dhaman-1	12	03
Chloris gayana	Non-specific	0	05
Heteropogon	Non-specific	0	02
Brachiaria ruziziensis	DBRS1	0	10
Themada spp.	Non-specific	0	20
Macrotyloma uniflorum	Non-specific	0	250
	Total	**82**	**787**

4.1.3 Planting materials/tissue culture plants

Crop	Production (Numbers)
BN hybrid	14,92,395
Guinea grass (root slips)	2,38,475
Brachiaria (root slips)	33,400
Rhodes grass (root slips)	3,162
Cactus cladodes	60,000

4.2 Seed sale (2024)

4.2.1 Total seed and planting materials sale

Class of fodder seed	Sale (kg)
Breeder seed	11,730
Truthfully labelled seed	3,623
Total	**15,353**
Perennial grasses root slips (no.)	7,28,783
Cactus cladodes (no.)	70,125

4.2.2 Variety-wise seed sale (kg) in cultivated fodder crops

Crop	Variety	Breeder (kg)	TFL (kg)	Total (kg)
Oat	JHO-822	5062	494	5556
	Kent	3283	78	3361
	JHO-851	52	25	77
	JHO-2000-4	50	304	354
	JHO 99-2	25	-	25
Berseem	BB-2	20	5.5	25.5
	BB-3	2	86	88
	BB-5 (JHB 17-2)	41	-	41
	BB-6 (JHB 17-1)	11	-	11
	BB-7 (JHB 18-1)	36	-	36
	BB-8 (JHB 18-2)	21	-	21
	JBSC-1	250	85	335
	Wardan	527	117	644
Sorghum	MP chari	271	1599	1870
	PC-6	-	280	280
	PC-615	-	150	150
Cowpea	BL-4	250	3	253
Maize	African tall	20	51	71
Subabul	Non-specific	-	1.5	1.5
	K-8	-	2	2
	S-22	-	2	2
	S-24	-	2.5	2.5
	S10	-	1	1
	Total		9	9
Moringa	PKM-1	-	1.7	1.7
	Non-specific	-	0.25	0.25
Dinanath	BD-2 fluffed	-	41.25	41.25

4.2.3 Planting materials sale (kg) in grasses and non-conventional fodder crops

Tropical grasses: *Brachiaria, Heteropogon, P. maximum, C. ciliaris, C. setigerus etc.* = 57.8 (kg)

Sale of planting materials/tissue culture plant (nos.): 9,61,547 (BN hybrid root slips) + 150 (stem cuttings); 11350 (guinea root slips); 70,195 (Cactus cladodes); 400 (fodder sugarcane root slips)

Chapter 5

Outreach Programmes

5.1 Scheduled Caste Sub-Plan (SCSP)

Institute implemented Scheduled Caste Sub-Plan (SCSP) in 2024 with the aim to uplift scheduled caste farmers by promoting fodder-livestock based agricultural technologies across six states-Uttar Pradesh, Madhya Pradesh, West Bengal, Karnataka, Himachal Pradesh and Jammu & Kashmir (Fig. 5.1 to 5.5) The program facilitated 22 training sessions that benefitted around 1,000 farmers. Extensive demonstrations were conducted: 245 on fodder technologies over 35.5 ha, and 525 on livestock-based technologies. Over 400 other demonstrations involving more than 550 farmers were also conducted. In Jhansi and Datia districts, modern agricultural equipment demonstrations were conducted, and inputs such as 150 tool kits, 100 sprayers, and 100 seed storage bins were distributed. Fodder variety demonstrations benefitted numerous farmers, with crops like MP chari, BN hybrid, thornless cactus, oat, berseem, and bio-inoculants were promoted. Furthermore, 100 livestock medicine kits were distributed, and training sessions and farmer meetings (*Kisan goshtis*) were organized. On Foundation Day, sessions on intellectual property rights and interactive forums engaged about 110 farmers.

Fig. 5.1 SCSP activities in UP and MP states

In Cooch Behar district, SCSP activities included distribution of an automatic egg hatching incubator, a chaff cutter, and 50 hydroponic fodder trays. Livestock interventions were made through the distribution of 40 Black Bengal goats and 32 backyard pigs to 60 families. Fodder demonstrations with cowpea and mineral supplements were conducted across multiple units. Three-days on-campus training and a workshop engaged 310 farmers, and 11 informational leaflets in *Bengali* were disseminated widely.

Fig. 5.2 SCSP activities in Cooch Behar, West Bengal

In Karnataka, the institute Southern Regional Research Station supported SC farmers in Kalaburgi and Kolar districts by distributing 2,00,000 rooted slips of BN hybrid and 100 kg of horse gram seeds. Training programs were conducted for 200 beneficiaries and extension literature were shared to guide farmers on fodder cultivation practices.

Fig. 5.3 SCSP activities in Karnataka

In Himachal Pradesh, the Palampur Centre organized two major training programme with 150 farmers each, offering 1,350 rooted slips of perennial grasses and essential tools such as spades, sprinklers, and cutters. Farmers also received oat and fescue seeds. A national capacity-building program at Career Point University, Hamirpur, had a participation of 500 farmers, each receiving farming tools and learning materials.

Fig. 5.4 SCSP activities in Himachal Pradesh

The Regional Research Station in Srinagar organized five training programs in Jammu, Samba, Reasi, and other districts with 379 participants. Demonstrations included fodder sorghum, supplements, deworming medicine, and rooted slips of perennial grasses. Pamphlets and stationery were distributed, and 150 farmers were further engaged during the *Kisan Ghoshti* cum Fodder Mela held in Palampur.

Fig. 5.5 SCSP activities in Jammu & Kashmir (UT)

5.2 Tribal Sub Plan (TSP)

Tribal Sub-Plan (TSP) was implemented in Rajasthan, Maharashtra, Jammu & Kashmir, Madhya Pradesh, and Himachal Pradesh (Fig. 5.6). In Rajasthan, various seeds, mineral mixtures, and plant micronutrients were demonstrated among 668 tribal farmers. Two training programme and a farmers' gathering (*Chara Mela*) engaged over 200 participants. In Jammu & Kashmir, eight awareness programs were held, reaching 442 tribal beneficiaries. Farmers were provided seeds, rooted slips, supplements, medicines, and solar lamps. Pamphlets and stationery items were also distributed.

In Madhya Pradesh, the TSP project led by KVK Barwani focused on introducing improved seeds, livestock (*e.g.*, Kadaknath poultry), and training on modern agricultural practices, benefiting 110 farmers. Maharashtra's TSP efforts in Nandurbar district, through IGFRI-Dharwad, provided training on improved fodder crop cultivation. Sixty tribal farmers participated, with 17 receiving knapsack sprayers and 17 receiving ploughs to improve field operations.

In Himachal Pradesh, a TSP training was held in Chamba district for 64 farmers, who received oat seeds, deworming medicine, mineral mixtures, and other inputs to support their agricultural and livestock activities.

Fig. 5.6 TSP activities in Rajasthan, Maharashtra, J&K, MP and HP

5.3 North Eastern Hill (NEH) Plan

Under the North Eastern Hill (NEH) Plan, the institute collaborated with institutes in Manipur, Assam, Nagaland, and Mizoram to promote fodder and livestock-based interventions. The plan emphasized training, field demonstrations, and input distribution across Manipur, Assam, and Mizoram. About 850 farmers, extension workers, and officials benefitted. Field demonstrations focused on maize, sorghum, oat, and BN hybrid cultivation, along with fodder planting material units and horti-pastoral systems. Assamese-language literature and tools were distributed to aid technology adoption. This initiative significantly supported the livelihoods of NEH farmers by promoting sustainable and region-specific practices.

5.4 Establishment of 150 Vanaspati Seed Bank in Rajasthan

The station provided technical inputs for formulation and implementation of 150 Vanaspati Seed Bank in Rajasthan in the Compliance Rajasthan Government Budget 2024-25. Department of Watershed Development & Soil Conservation (WD&SC) is the Nodal Agency for implementing this programme. Station participated in the formulation of these banks and fodder technology demonstration scheme of Deptt of Agriculture, Govt of Rajasthan *i.e.* 0.2 ha area of BN hybrid plantation for demonstration by farmers in every *Gram Panchayat* of Rajasthan.

5.5 Agricultural Technology Information Centre (ATIC)

Total visitors at ATIC unit were 10,900 (Farmers/ Govt. employees/Students/Pvt. companies/NGO *etc.*). ATIC generated revenue of Rs. 18760 through production of *Azolla,* bio-fertilizer, vermicompost, and sale of institute publications.

*Krishi mela/*exhibition*/Goshthis* organized and participated

- ♣ At the "Regional Agriculture Fair" at IIVR, Varanasi (UP), during 3-5 February, 2024.
- ♣ "All India Farmer's fair & International Agriculture Technology Exhibition-2024", held at *Krishi Vigyan Mela* Ground, RVSKVV, Gwalior during 3-6 February, 2024.
- ♣ "*Kisan Mela evam Krishi Pradarshni*", held at RLBCAU, Jhansi during 8-10 February, 2024.
- ♣ "Forage Technology Exhibition cum Industry Meet", during 12-13 February, 2024 and "Technology and Machinery Demonstration Meet" on 13 February, 2024 were organized at ICAR-IGFRI, Jhansi.
- ♣ Foundation Day and Exhibition of ICAR-CAFRI, Jhansi on 08 May, 2024.

- “Joint *Kharif* Production *Gosthi* 2024”, for Jhansi, Kanpur, and Chitrakoot divisions, held at *Pandit Deendayal Upadhyaya Sabhaghar*, Jhansi on 20 June, 2024.
- Institute Foundation Day 2024 – 63rd Institute Foundation Day 2024 was celebrated on 8th November, 2024. A farmer’s fair was organized wih 80 farmers from nearby villages participated in the institute foundation day/ celebration.
- *Kisan Diwas* – organized in the Institute on 23rd December, 2024.

5.6 Farmer FIRST Programme (FFP)

In 2024, five farmer-scientist interactions were held in Dhikoli, Nayakheda, Ganeshgarh, Ramgarh, and Kanchanpur. Project promoted high-yielding, disease-resistant crop varieties like DBW-187 in wheat, DHBM93-1 in Banyard millet, and TG 37-A in groundnut. Vegetable varieties like *Kashi Sandesh* (Brinjal), *Kashi Abhiman* (Tomato), and *Kashi Ratna* (Chilli) were introduced to diversify incomes and better productivity. Improved fodder varieties like, berseem BL-10, oat (JHO-822), sorghum (MP chari), and IGFRI-6 (BN hybrid) were promoted in selected villages. Three training programmes and on-field farmers’ activities (Fig. 5.7) were also organized focusing on summer ploughing for soil health, effective farmyard manure application, and the use of vermin compost. Soil testing and zinc sulphate application were emphasized to address nutrient deficiencies in soil. Training also covered line sowing, optimal seed rates, irrigation, and integrated weed management. Five field days and *Kisan Gosthis* were organized in the villages to enhance farmers' knowledge on fodder cultivation and overall agricultural management. Moreover, 254 demonstrations on forage as well as crop production conservation and utilization, balance feeding were also conducted.

Adoption of improved varieties increased groundnut yield by 26%, green gram by 23%, and wheat by 13%. Despite higher adoption costs for brinjal (*Kashi Sandesh*) and tomato (*Kashi Abhiman*), their improved yields led to higher profitability. In fodder crops, oats and berseem BL-10 boosted yields and fodder availability, while BN hybrid was adopted for continuous green fodder.

Fig. 5.7 “On field” Farmer’s FIRST activity

Chapter 6

Training and Capacity Building

The unit places strong emphasis on training and capacity building for a wide range of stakeholders-government, non-government organizations and farmers involved in forage and livestock development. It offers a dedicated knowledge hub; provides advanced forage production technologies to users and producers in adopting improved practices. Human resource development activities within the institute personnel were given priority to scientific, technical, and administrative categories and were deputed to attend specialized training programs offered by various organizations across the country. Several sponsored programmes were designed and executed as well as finalized Memoranda of Understanding (MoUs) and agreements. The unit has also established strong academic and research linkages with other ICAR and research institutions such as RLBCAU and Bundelkhand Uni. Jhansi, for academic, exposure, internships, Rural Agricultural Work Experience (RAWE), dissertation projects, and entrepreneurship development programs.

6.1 Capacity building and skill improvement thrust to IGFRI personnel

Under the capacity building mode of activities, 20 scientists, 01 technical officer and 04 Administrative staff received various specialized training organized by different national institutes and agencies on a wide spectrum of topics including finance management. Human resource development programs covered both genders in institute building.

Table 6.1. Participation of Institute's personnel in off campus/on line specialized courses

Scientific Category				
S.No.	**Name**	**Period**	**Institute**	**Training programme**
1. 2. 3. 4. 5.	Dr. B.K. Mehta Dr. Maharishi Tomar Dr. Prabha Singh Dr. S.K. Meena Dr. R.P. Saini	19th Feb. to 10th Mar., 2024	RLBCAU, Jhansi	Summer School on "From genes to proteins: Addressing molecular complexity of agriculturally important traits in crops
6. 7. 8.	Dr. Kamini Dr. S.R. Kantwa Dr. Mukesh Choudhary	13th-15th Feb., 2024	NASC Complex, New Delhi	SRIJAN 2.0: Empowering ZTMCs/ ITMUs of ICAR Institutes by IP &TM unit, ICAR-HQ, New Delhi
9.	Dr. S.S. Bhat	04th-05th Mar., 2024	University of Kashmir, J&K, India	Monitoring Plant Phenology in an Era of Climate Change
10.	Dr. Surinder Paul	14th-20th Mar., 2024	ICAR-IASRI, New Delhi	RNAome: Profiling and characterization of non-coding RNAs
11. 12.	Dr. Amit Kumar Singh Dr. Samir Barman	18th-20th Mar., 2024	NASC Complex, New Delhi	Cultivating tomorrow: Advancing digital agriculture through IoT and AI
13.	Dr. P.N. Dwivedi	06th-10th May, 2024	NAARM Hyderabad	MDP on Business Plan Development and Accelerating FPOs/FPCs (On-line mode)
14.	Dr. Atufa Regu	02nd Sep., 2024	SKUAST-K, Kashmir (J&K)	Training cum awareness program on J-Gate @ CeRA for northern region organized by ICAR

15.	Dr. Atufa Regu	30th Sep.- 05th Oct., 2024	NRRI, Cuttack	Developing simulation model of technology diffusion (TechSIM), adoption & impact for forecasting using techno-socio-psycho-economic-ecological factors.
16.	Dr. V.K. Yadav	07th-10th Oct., 2024	ICAR-NAARM, Hyderabad	EDP for project Coordinators of AICRPs/Network Projects
17.	Dr. Sadhna Pandey	14th-18th Oct., 2024	ICAR-NAARM, Hyderabad	MDP on Leadership for Head of Social Sciences Div. of NARES
18.	Dr. Amit Singh	11th-15th Nov., 2024		Advanced Data analysis using R
19.	Dr. R.P. Saini	02nd-06th Dec., 2024	IARI, New Delhi	Genome Editing- Basic Principles & Practices
20.	Dr. D.R. Palsaniya	02nd-13th Dec., 2024	ICAR-NAARM, Hyderabad	MDP on Leadership (a pre-RMP programme)
21.	Dr. Samir Barman	18th Oct. to 17th Jan., 2024	ICAR-NAARM, Hyderabad	Professional Attachment Training (PAT)
22.	Dr. Sadhna Pandey	14th-18th Oct., 2024	ICAR-NAARM, Hyderabad	MDP on Leadership for Heads of Social Sciences Division of NARES

Technical Category

S.No.	Name	Period	Institute	Name of training programme attended
1.	Dr. Anjaly M.V.	25th-27th May, 2024	ICAR-IVRI, Izatnagar, Bareilly	Effective Academic writing for young researchers of livestock & amp; allied sectors

Administrative Category

S.No.	Name	Period	Institute	Name of training programme attended
1.1. 2.2.	Ms. Sanjana Yadav Ms Priyanka Prajapati	21st Aug. to 6th Sep., 2024	ICAR-NIASM, Baramati, Pune	Limited Departmental Competitive Examination for the post of UDC
3.3.	Sh. P.S. Naveen	16th Sep.- 05th Oct., 2024	NIFM, Faridabad & NASC, New Delhi	Training at NIFM, Faridabad & NASC, New Delhi
4.4.	Sh. Dinesh Kumar Namdev	13th Aug., 2024	New Delhi	Training on e HRMS

6.2 Capacity building for forage resource development

Three sponsored trainings and visits were organized in various areas related to livestock health, fodder production, conservation and utilization. The details are as in Table 6.2 & 6.3

Table 6.2. Sponsored capacity building programmes

S.No.	Training programme	Sponsor	No. of participants	Duration
1	Chara Utpadan, Sanrakshanevam Upyog Takanikiyan	ATMA, Ghazipur	50	08-09 Sept., 2024
2	Fodder production, and Utilization Technologies	ATMA, Lalitpur	60	19 Sep., 2024
3	Fodder production, conservation and utilization technologies for improved livestock production Batch-I	VOTI, Bhubhaneshwar, (Odisha)	20	04-07 Nov., 2024
4	Fodder production, conservation and utilization technologies for improved livestock production Batch-II	VOTI, Bhubhaneshwar, (Odisha)	20	11-14 Nov., 2024

Table 6.3. Institutional Capacity Building Programmes

S.No.	Training programme	No. of participants	Duration
1	Farmers training on scientific method of goat farming under SCSP, IGFRI, Jhansi	30	17.01.2024
2	Farmers training on health & disease management of small ruminants under SCSP, IGFRI, Jhansi	30	28.02.2024
3	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Datia district KVK	35	11.08.2024
4	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Jhansi district KVK	50	22.08.2024
5	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Jhansi district KVK	13	23.08.2024
6	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Jhansi district KVK	50	30.08.2024
7	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Datia district KVK	50	03.09.2024
8	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Jhansi district KVK	50	26.09.2024
9	Kishan Goshthi & Training under SCSP, IGFRI, Jhansi - KVK Datia district KVK	50	27.09.2024
10	Silage production and forage management for officers from Gangpur Ventures Private Limited, Rourkela, Odisha	03	26-27.09.2024

6.3 Training cum exposure visits at institute

Institute has kept its door always open to all those have keen interest on fodder production, related technologies. During the year 2024 total visits conducted (211) included farmers/FPOs)/ Officers (5450) and students & teachers (5450). The entrepreneurs, personnel, state and central governments and, NGO,s also visited IGFRI and interacted -KVK experts in related subject through different sponsored visits. Visits by farmers, students and teachers to Technologies Park and its CR farm were always attended by our staff and expects. The details of visits are in table 6.4.

Table 6.4. Training cum exposure visits

S.No.	Date	Department	No. of visitors	Category
1.	15.01.2024	KVK, Faridabad (Haryana)	30	Farmers & Staff
2.	25.01.2024	Forest officers, Govt. of Uttar Pradesh	18	govt employees
3.	31.01.2024	Swami Vivekanand University, Sagar (MP)	23	Students & Teachers
4.	05.02.2024	ATMA, Guna (MP)	20	Farmers & Staff
5.	07.02.2024	ATMA, Damoh (MP)	20	Farmers & Staff
6.	07.02.2024	Agriculture Department, Morena (MP)	27	Farmers & Staff
7.	08-02-2024	KVK , Bhind (MP)	17	Farmers & Staff
8.	08-02-2024	KVK ,Vidisha (MP)	10	Farmers & Staff
9.	13-02-2024	KendriyaVidhyalay,Babina, Jhansi (UP)	99	Students & Teachers
10.	15-02-2024	ATMA, Shivpuri (MP)	32	Farmers & Staff
11.	16-2-2024	Rajkiya Balika Inter Collage, Baruasagar, Jhansi (UP)	57	Students & Teachers
12.	17-02-2024	Deepak Memorial Inter Collage, Mauranipur, Jhansi (UP)	171	Students & Teachers
13.	19-02-2024	ATMA, Rewa (MP)	50	Farmers & Staff
14.	21-02-2024	Saket P.G. Collage, Ayodhya (UP)	26	Students & Teachers
15.	24-02-2024	UFTA, Haldwani (U.K.)	57	Rangers
16.	28-02-2024	ATMA, Raibarelly (UP)	31	Farmers & Staff
17.	04-03-2024	ATMA, Mahoba (UP)	54	Farmers & Staff
18.	05-03-2024	Dayanand VedikCollaage, Jhansi (UP)	38	Students & Teachers
19.	07-03-2024	Asha Gramothan Sansthan, Urai (UP)	44	Farmers & Staff
20.	11-03-2024	ATMA, Ashok Nagar (MP)	8	Staff
21.	12-03-2024	ATMA, Niwari(MP)	10	Staff
22.	13-03-2024	Horticulture Department Gwalior (MP)	55	Farmers & Staff
23.	19-03-2024	ATMA, Bhopal (MP)	25	Farmers & Staff
24.	21-03-2024	KendriyaVidhyalay,Tikamgarh MP	83	Students & Teachers
25.	28-03-2024	Shrizan NGO Niwari (MP)	40	Farmers & Staff
26.	28-03-2024	Besik Shiksha Parishad Bangra, Jhansi (UP)	85	Students & Teachers
27.	28-03-2024	Besik Shiksha Parishad,Jhansi (UP)	108	Students & Teachers
28.	07-04-2024	BUAT, Banda (UP)	88	Students & Teachers
29.	03-05-2024	AMITY, University Gwalior (MP)	27	Students & Teachers
30.	22-05-2024	JNKV, Jabalpur (MP)	82	Students & Teachers
31.	25-06-2024	FFP Village, Jhansi (UP)	17	Farmers & Staff
32.	03-07-2024	RKS collage of Agriculture (Chhatisgarh)	74	Students & Teachers
33.	08-07-2024	IBTIDA NGO Babina, Jhansi (UP)	29	Farmers & Staff
34.	10-07-2024	IBTIDA NGO Bangra, Jhansi (UP)	29	Farmers & Staff
35.	11-07-2024	RamkrishanMission Gaushala, Gwalior (MP)	04	Farmers & Staff
36.	12-07-2024	CSAU, Kanpur (UP)	23	Students & Teachers
37.	11-08-2024	SCSP Kisan, Datia(MP)	35	Farmers & Staff
38.	22-08-2024	SCSP Kisan Jhansi (UP)	50	Farmers & Staff
39.	23-08-2024	FFP Jhansi (UP)	13	Farmers & Staff
40.	23-08-2024	ATMA, Jalaun (UP)	52	Farmers & Staff
41.	27-08-2024	G.B. Pant University Pantnagar (U.K.)	40	Farmers & Staff
42.	29-08-2024	ATMA Niwari (MP)	18	Farmers & Staff
43.	29-08-2024	ATMA Tikamgarh (MP)	35	Farmers & Staff

44.	30-08-2024	SCSP , Datia (MP)	50	Farmers & Staff
45.	30-08-2024	Mahatma Fullay Krishi Vidya Peeth Rauri (Maharashtra)	50	Students & Teachers
46.	03-09-2024	Tharmal Power Plant Pariksha (UP)	05	Farmers & Staff
47.	03-09-2024	SCSP, Jhansi (UP)	50	Farmers & Staff
48.	06-09-2024	SCSP, Datia (MP)	11	Farmers & Staff
49.	19-09-2024	ATMA, Lalitpur (UP)	65	Farmers & Staff
50.	20-09-2024	Parmarth,Sansthan,Rajsthan	18	Farmers & Staff
51.	23-09-2024	ATMA Shivpuri (MP)	175	Farmers & Staff
52.	24-09-2024	ATMA Damoh(MP)	31	Farmers & Staff
53.	26-09-2024	SCSP Jhansi (UP)	50	Farmers & Staff
54.	27-09-2024	SCSP Datia (MP)	50	Farmers & Staff
55.	30-09-2024	IPR trainnes Datia (MP) + Jhansi (UP)	50	Farmers & Staff
56.	01-10-2024	GIC, Lalitpur (UP)	123	Students & Teachers
57.	01-10-2024	GIC ,Lalitpur (UP)	240	Students & Teachers
58.	03-10-2024	GIC, Lalitpur (UP)	120	Students & Teachers
59.	07-10-2024	GIC, and Navoday Vidhyalay, Jhansi (UP)	46	Students & Teachers
60.	14-10-2024	Horticulture Department, Ashok Nagar (MP)	27	Farmers & Staff
61.	18-10-2024	PM shreeVidhyalay Shivpuri (MP)	109	Students & Teachers
62.	22-10-2024	GIC, Lalitpur (UP)	210	Students & Teachers
63.	25-10-2024	Agricultural Department, Raibarailley (UP)	42	Farmers & Staff
64.	08-11-2024	Farmers of Datia(MP) and Jhansi(UP)	100	Farmers & Staff
65.	09-11-2024	GIC, Hamirpur (UP)	65	Students & Teachers
66.	12-11-2024	ATMA Bhopal (MP)	7	Farmers & Staff
67.	14-11-2024	FFP Visit Jhansi (UP)	20	Farmers & Staff
68.	16-11-2024	ATMA Ashok Nagar(MP)	21	Farmers & Staff
69.	18-11-2024	GIC, Lalitpur(UP)	55	Students & Teachers
70.	18-11-2024	FFP, Jhansi (UP)	35	Farmers & Staff
71.	19-11-2024	ATMA,Panna (Bihar)	19	Farmers & Staff
72.	19-11-2024	FFP, Jhansi (UP)	35	Farmers & Staff
73.	20-11-2024	FFP,, Jhansi (UP)	35	Farmers & Staff
74.	20-11-2024	GIC, Mahoba (UP)	65	Students & Teachers
75.	21-11-2024	FFP, Jhansi (UP)	35	Farmers & Staff
76.	22-11-2024	FFP, Jhansi (UP)	10	Farmers & Staff
77.	22-11-2024	ATMA, Mahoba (UP)	45	Farmers & Staff
78.	23-11-2024	GIC, Lalitpur (UP)	90	Students & Teachers
79.	25-11-2024	ATMA, Datia (MP)	13	Farmers & Staff
80.	25-11-2024	GIC, Jhansi (UP)	258	Students & Teachers
81.	27-11-2024	GIC, Lalitpur (UP)	310	Students & Teachers
82.	27-11-2024	FFP, Jhansi (UP)	10	Farmers & Staff
83.	28-11-2024	FFP, Jhansi (UP)	10	Farmers & Staff
84.	02-12-2024	Horticulture Department ,Shivpuri(MP)	32	Farmers & Staff
85.	02-12-2024	Kendriy Vidhalaya, Lalitpur (UP)	143	Students & Teachers
86.	02-12-2024	Kendriy vidhalaya, Shivpuri (UP)	150	Students & Teachers
87.	03-12-2024	Kendriy vidhalaya, Lalitpur (UP)	98	Students & Teachers
88.	03-12-2024	Kendriy vidhalaya, Shivpuri (MP)	208	Students & Teachers
89.	04-12-2024	Kendriy vidhalaya, Shivpuri(MP)	107	Students & Teachers

90.	05-12-2024	Soil day	21	Farmers & Staff
91.	06-12-2024	Saint Francis college, Jhansi(UP)	188	Students & Teachers
92.	06-12-2024	GIC, Jalaun (UP)	21	Students & Teachers
93.	06-12-2024	GIC, Kashipura, Jhansi (UP)	16	Students & Teachers
94.	09-12-2024	GIC, Moth Jhansi (UP)	50	Students & Teachers
95.	11-12-2024	Bundelkhand Uni. Jhansi(UP)	21	Students & Teachers
96.	11-12-2024	Govt. Vidhyalay Babina, Jhansi (UP)	105	Students & Teachers
97.	11-12-2024	Govt. Girls School, Jalaun (UP)	72	Students & Teachers
98.	11-12-2024	GIC, Jalaun (UP)	46	Students & Teachers
99.	12-12-2024	Govt. Vidhyalay, Jhansi (UP)	75	Students & Teachers
100.	13-12-2024	Govt. Vidhyalay Gurusaray, Jhansi (UP)	112	Students & Teachers
101.	16-12-2024	GIC, Jhansi (UP)	258	Students & Teachers
102.	16-12-2024	GIC, Mauranipur, Jhansi (UP)	115	Students & Teachers
103.	18-12-2024	GIC, Lalitpur (UP)	150	Students & Teachers
104.	22-12-2024	Sarswatividhya Mandir, Mauranipur, (UP)	40	Students & Teachers
105.	23-12-2024	SCSP, Jhansi (UP)	60	Farmers & Staff
106.	23-12-2024	ATMA, Vidisha (MP)	37	Farmers & Staff
107.	23-12-2024	Rani Lakshmi Bai Public School, Jhansi(UP)	189	Students & Teachers
108.	24-12-2024	Pandit Deen Dayal Rajkiya Inter collage Jalaun (UP)	43	Students & Teachers
109.	26-12-2024	GIC, Mauranipur, Jhansi (UP)	180	Students & Teachers
110.	30-12-2024	Composite School Bangra, Jhansi v	41	Students & Teachers
111.	31-12-2024	GIC, Jalaun (UP)	80	Students & Teachers

6.4 Students dissertations/internship/RAWE

Human Resources Development team facilitated 12 M.Sc. students for dissertation, 04 M.Sc. (Biotech) students for one month training, one BSc student for RAWE. In addition team facilitated 05 Ph D students for dissertation.

6.5 Memorandum of Understanding (MoUs)

- MoU between ICAR-IGFRI, Jhansi & ITM University, Gwalior M.P. for Students' Training/Postgraduate Research/Research collaboration.
- MoU between ICAR-IGFRI, Jhansi & Dau shri Vasudev Chandrashekhar Kamdhenu Vishwavidyalaya, Durg (Chhattisgarh) for facilitating student's training/Postgraduate research.
- MoU between ICAR-IGFRI, Jhansi & Dayanand Vedic College, Orai, Jalaun for academic collaboration
- MoU between ICAR-IGFRI, Jhansi & Directorate of watershed development and soil conservation department rural development and Panchayati Raj Department, Jaipur, Government of Rajasthan for collaborative research.
- MoU between ICAR-IGFRI, Jhansi & SKUAST, Kashmir, Srinagar for research interactions and collaborative research.
- MoU between ICAR-IGFRI, Jhansi & Suresh Gyan Vihar University, Jaipur for Students' Training/Postgraduate Research.

6.6 Academic collaboration

Team HRD is facilitating the academic collaboration -KVK institutions like Rani Lakshmi Bai Central Agricultural University, Bundelkhand University. SR Group of Institution, Jhansi, *etc.* Institute 42 scientists are engaged in teaching courses at RLBCAU, Jhansi.

Chapter 7

Success Stories

7.1 Transforming Dairy Farming: Mr. Harish Chudhary's journey to sustainable and scientific practices in Nandurbar, Maharashtra

Sh. Harish Punamchand Chudhary, a 43-years-old businessman turned farmer from Bhadawad village in Nandurbar district, Maharashtra, has brought new hope to local farmers through scientific dairy farming. Initially running a small tea stall with his two brothers, he transitioned to dairy farming as an additional income source. Initially, he fed his livestock only dry fodder but soon realized the benefits of green fodder after seeking information from KVK Nandurbar in 2016, which led him to ICAR-IGFRI Dharwar. Under the Tribal Sub Project, scientists from ICAR-IGFRI's Southern Regional Research Station in Dharwar trained farmers in Nandurbar on forage technologies and distributed seeds and small implements. Sh. Harish received training on different fodder types, their cultivation, and harvest management. He was provided seeds for perennial fodder sorghum and DHN-6 variety of BN hybrid based on his farm's soil type and fodder requirements. The scientists provided technical support during planting and sowing and visited his farm annually to ensure maximum harvest. Starting with half an acre, Sh. Harish now cultivates these crops on 12 acres, providing green fodder (Fig. 7.1) year-round to his animals. He harvests two tractor trolley loads of fodder daily. This has increased milk production and reduced his dependence on concentrate feeds. Fodder cultivation also saved labor and controlled soil erosion. With adequate green fodder, he has increased his herd size to 25 buffalo, 22 Gir cows, 42 HF cows, and 10 goats, with an average milk yield of 35-70 litres day^{-1} animal^{-1}. Using cow dung slurry mixed with Go-Kripaamrut and Panchgavya for irrigation, Sh. Harish achieves luxuriant growth of fodder crops. He integrates vermi-compost production and silage making, using silage inoculum for fodder maize. His farm is now a model for many farmers from surrounding districts who visit to learn and purchase planting material at Rs.2/cutting. The farm's soil quality has improved significantly, contributing to national milk production and environmental sustainability without using chemicals. Sh. Harish is an educator and role model for dairy farming practices. Adoption of scientific dairy farming practices has transformed his farm into a sustainable and productive enterprise, benefiting both the local community and the environment.

Fig. 7.1 Adoption of forage crops for round the year green fodder production

7.2 Integrated Farming and Innovation: The Success of Shri Prabhudayal Rajput

Sh. Prabhudayal Rajput, a 55-years-old progressive farmer from Ramgarh village in Jhansi, has transformed his six-acre farm into a model of sustainable agriculture. By adopting improved crop and livestock production practices, he has become a source of inspiration for his community. Since 2022, Sh. Rajput has been a beneficiary of the *Farmer FIRST* project implemented by institute. Through this initiative, he received training, technical guidance, and essential inputs to adopt and implement sustainable farming practices. Sh. Rajput practices an Integrated Farming System that combines crop cultivation with livestock rearing. He utilizes dung and urine from his farm animals to prepare organic fertilizers, ensuring chemical-free farming. Additionally, he has dedicated around half an acre of land to fodder cultivation, which provides a consistent supply of green fodder for his livestock-significantly reducing input costs and improving overall farm profitability by 38%. Sh. Rajput is also cultivating millet on a portion of his land, recognizing its resilience to climate variability and nutritional value. To promote its conservation and accessibility, he has established a millet bank (Fig. 7.2a) that stores and distributes traditional millet seeds to fellow farmers in the community. This initiative is helping to revive indigenous crops and encouraging sustainable agriculture.

His farm had been evolved into an innovation hub, housing a custom hiring center (Fig. 7.2b) equipped with farm machinery such as millet threshers and wheat cleaning machines, which were made accessible to neighboring farmers. Furthermore, by preparing and distributing improved seeds and fodder root slips, he has empowered many farmers in the region. While his initial returns were modest, his persistent efforts bore fruit. In 2024, he achieved an average net annual income of Rs. 2,70,000, which notably includes Rs. 60,000 earned from the sale of fodder seeds and root slips.

Fig. 7.2 (a) Millet bank and (b) Custom hiring center at Prabhudayal's farm

7.3 Farm diversification through SCSP: A success story of Lakhan Banshkar

Sh. Lakhan Banshkar, a 35-year-old farmer from Khajraha Bujurg village in Jhansi, is a shining example of how farm diversification can lead to sustainability and increased income. With the support of institute Scheduled Caste Sub Plan (SCSP) programme, he has successfully transformed his 1.5-ha farm by integrating food and fodder crops, livestock, and poultry (Fig 7.3). Under this programme, he received technical guidance, improved seeds, training, and regular follow-ups from 2020 to 2024.

With SCSP support, Sh. Lakhan established a BN hybrid-based perennial fodder system on 0.08 ha, that provide regular green fodder for his livestock which significantly reduced dependence on cut-and-carry grass and decreased his daily drudgery in sourcing fodder by about one hour. His livestock includes cows, buffaloes, goats, and other small ruminants, and daily milk production on his farm is around 15 liters a key contributor to his growing income.

He also diversified his cropping system by cultivating barnyard millet- a climate-smart crop promoted under the SCSP programme during the *kharif*. In 2024, his estimated annual income reached approximately Rs. 2,00,000, marking a 37% increase compared to 2019, before he joined the SCSP programme. His success has not only improved his family's livelihood but also inspired many farmers in the region to adopt diversified farming practices.

Fig. 7.3 Diversified farming practices by Shri Lakhan Banshkar

Chapter 8

List of Publications

8.1 Research Papers

Antony, E., Kumar, S., Sridhar, K., Karthigeyan, S., Kulkarni, N.S. and Doddamani, M.B. 2024. Physiological adaptations of lucerne under a limited irrigation system. *Range Management and Agroforestry*, 45(1), pp.65-71.

Banerjee, R., Bharti, Das, P., Barman, S., Devi, S. and Ankita. 2024. Comprehensive analysis of millets in India: Area, production, cost of production and export statistics. *Current Agriculture Research Journal,* 12(3), pp.1181-1192.

Barman, S., Ramasubramanian, V., Singh, K.N., Ray, M., Bharadwaj, A. and Kumar, P. 2024. Predictive root based bootstrap prediction intervals in neural network models for time series forecasting. *Journal of the Indian Society for Probability and Statistics*, 25(2), pp.683-705.

Bhargavi, H.A., Singh, S.P., Goswami, S., Yadav, S., Aavula, N., Shashikumara, P., Singhal, T., Sankar, S.M., Danakumara, T., Kapoor, C. and Singh, N. 2024. Deciphering the genetic variability for biochemical parameters influencing rancidity of pearl millet (*Pennisetum glaucum* LR Br.) flour in a set of highly diverse lines and their categorization using rancidity matrix. *Journal of Food Composition and Analysis*, 128, p.106035.

Chand, G., Muthusamy, V., Zunjare, R.U., Mishra, S.J., Sharma, G., Mehta, B.K., Singh, S., Allen, T. and Hossain, F. 2024.Molecular analysis of opaque2 gene governing accumulation of lysine and tryptophan in maize endosperm. *Euphytica*, 220, p. 155.

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8.2 Prsentations/Papers/Abstracts in Seminar/ Symposia/Conference

International

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National

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8.3 Books/ Book Chapters

Book Authored

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8.6 Radio talks

Five numbers: Goat farming, animal diseases and their control, entrepreneurship in total mix ration, silage and hay as business, Adopt forage production for entrepreneurship.

Chapter 9

Approved Ongoing Projects

Programme 1: Genetic enhancement of forage crops with emphasis on quality, multicut, stress tolerance & bio-fortification utilizing conventional, apomixes and new breeding tools

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20230102.	Genome-wide identification, characterization & expression analysis of flowering locus T (FT) genes controlling floral induction in cowpea	*PI: P. Priyadarshini Co-PIs: K.K. Dwivedi, B.K. Mehta and S.K. Meena*	2023-26
CRSCIGFRISIL 20200103	Identification of oat (*Avena sativa*) lines for heat stress tolerance	*PI: P. Priyadarshini Co-PIs: Shashikumara P. and M. Tomar*	2020-25
CRSCIGFRISIL 20200101	Breeding of pearl millet for deriving multi-cut and dual purpose genotypes with high forage yield and quality.	*PI: P. Shashikumara Co-PIs: B.K. Mehta and K.K. Dwived*	2020-25
CRSCIGFRISIL 20200105	Genetic improvement of maize for high biomass and fodder quality	*PI: B.K. Mehta Co-PIs: Shashikumara P., K.K. Dwivedi and Firoz Hossain, IARI, New Delhi*	2020-25
CRSCIGFRISIL 20210103	Developing erect type and multi-cut fodder cowpea with enhanced nutritional quality	*PI: B.K. Mehta Co-PIs: N. Dikshit, S.K. Meena and K. Sridhar*	2021-26
CRSCIGFRISIL 20230101	Identification and characterization of multicut summer sorghum lines for HCN moisture stress tolerance	*PI: R.K. Singhal Co-PIs: Indu, S. Ahmed, Maneet Rana and Subhash Chand*	2023-26
CRSCIGFRISIL 20220102	Identification and characterization of cowpea genotypes for phosphorus use efficiency	*PI: S.K. Meena Co-PIs: B.K. Mehta, Maneet Rana and Mahendra Prasad*	2022-25
CRSCIGFRISIL 20220101	Genetic improvement of novel fertile Bajra-Napier hybrid for enhanced productivity and quality traits	*PI: Maneet Rana Co-PIs: Shashikumara P., S. Ahmed and R.K. Singhal*	2022-27
CRSCIGFRISIL 20210102	Genomics assisted breeding for zinc and iron bio-fortification in oat	*PI: Maneet Rana Co-PIs: K.K. Dwivedi, S. Ahmed, R.K. Singhal, S. Paul and (Satpal and Vinod Kumar, HAU, Hisar)*	2021-24
CRSCIGFRISIL 20180101	Development of genetic and genomic resources for low moisture stress tolerance in berseem	*PI: Tejveer Singh Co-PIs: S.R. Kantwa, H.S. Mahesha and R.P. Saini)*	2018-24
CRSCIGFRISIL 20200101	Identification and characterization of genes involved in expression of apomixes component traits and polyploidy series in guinea grass (*Panicum maximum* Jacq.)	*PI: K.K. Dwivedi Co-PIs: Maneet Rana and Tejveer Singh*	2021-25
CRSCIGFRISIL 20210104	Breeding oat for improved productivity and quality	*PI: Shahid Ahmad Co-PIs: Maneet Rana, Indu, R.K. Singhal, Sultan Singh and Subhash Chand*	2021-26

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20200102	Augmentation, characterisation, conservation and documentation of forage genetic resources	*PI: N. Dikshit* *Co-PIs: R.K. Singhal, E. Antony, S.S. Bhat, P. Shashikumara and B.K. Mehta*	2020-25
CRSCIGFRISIL 20190902	Studies on invasive pest *Spodoptera frugiperda* in fodder maize	*PI: N.S. Kulkarni* *Co-PI: B.G. Shivakumar*	2019-24
CRSCIGFRISIL 20200903	Breeding lucerne (*Medicago sativa* L.) for high forage yield and nutritional quality for different ecosystems (phase II)	*PI: K. Sridhar* *Co-PIs: E. Antony, N.S. Kulkarni, R.P. Nagar, Sultan Singh, Suheel Ahmad, Shahid Ahmed and Ramyashree Devi (study leave)*	2020-25
CRSCIGFRISIL 20120101	Genetic improvement of barley for forage and grain yield	*PI: A.K. Singh*	2012-24
RSCIGFRISIL 20211002	Genetic improvement of temperate forage crops	*PI: S.S. Bhat* *Co-PIs: Suheel Ahmad, Tejveer Singh, Shahid Ahmed and Susheel Kumar Raina (NBPGR RS, Srinagar)*	2021-26

Programme 2: Diversification and sustainable intensification of fodder production in different land use systems including assessment and rejuvenation of grasslands and other resources for improving productivity and livelihood options

CRSCIGFRISIL 20200302	Recuperated canopy architecture for higher bael (*Aegle marmelos*) productivity and forage security in semi-arid region	*PI: A.K. Shukla* *Co-PIs: Sunil Kumar, A. Ghosh, Amit Kumar Singh and Deepak Upadhyay*	2020-25
CRSCIGFRISIL 20210301	Development of grassland assessment system using geospatial technology	*PI: Amit Kumar Singh* *Co-PIs: J.P. Singh and A. Ghosh*	2021-24
CRSCIGFRISIL 20230303	Sustaining productivity in grown up hortipastoral system for fruit and forage security with soil & tree management practices	*PI: Sunil Kumar* *Co-PIs: Amit K. Singh, A. Ghosh, S.R. Kantwa and Srinivasan R.*	2023-27
CRSCIGFRISIL 20230304	Pruning management for optimizing forage and wood productivity from *Hardwickia binata* based silvopasture systems	*PI: S.N. Ram* *Co-PIs: Kamini, A. Ghosh and A.K. Shukla*	2023-26
CRSCIGFRISIL 20200303	Evaluation of *Ailanthus excelsa* and *Morus* species germplasm for growth performance, fodder yield and nutritional traits under various agro climatic-zones	*PI: Kamini* *Co-PIs: A.K. Handa (CAFRI), S.S. Bhat, Maneet Rana, Anup Kumar and R.P. Nagar*	2020-25
CRSCIGFRISIL 20230301	Solubilization of native soil phosphorus using natural silicon sources and P solubilizing microbes	*PI: Avijit Ghosh* *Co-PIs: Amit Kumar Singh, Srinivasan R. and Mukesh Choudhary*	2023-26

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20230302	Improved pasture management for sustaining soil-pasture-animal productivity	*PI: Avijit Ghosh Co-PIs: Amit K. Singh, Srinivasan R, Sultan Singh, S.N. Ram, R.V. Kumar and Sunil Kumar*	2023-28
CRSCIGFRISIL 20200301	Study of restoration ecology in silvipasture system for semiarid region	*PI: R.V. Kumar Co-PIs: Sunil Kumar, Amit K. Singh, Kamini and A. Ghosh*	2020-25
CRSCIGFRISIL 20201001	Studies on temperate pasturelands for enhanced forage yield, quality and environmental sustainability	*PI: Suheel Ahmad Co-PIs: S.S. Bhatz, J.P. Singh, A. Ghosh, N. Biradar, N.H. Mir and Ms Atufa Regu*	2020-25
CRSCIGFRISIL 20220201	Studies on natural farming practices in forage crops	*PI: S.R. Kantwa Co-PIs: D.R. Palsaniya, S.K. Mahawer, R. Srinivasan, Mahendra Prasad and Nazim Hamid Mir*	2022-27
CRSCIGFRISIL 20220202	Assessment of water requirement for fodder based cropping systems in different parts of Uttar Pradesh	*PI: J.B. Singh Co-PIs: Amit Kumar Singh, S.R. Kantwa and Ramesh Singh*	2022-25
CRSCIGFRISIL 20190802	Canopy management for enhanced productivity and sustainability of neem based silvi-pastoral system in semi arid tropics	*PI: H.S. Meena Co-PI: Kamini, A. Ghosh and R.P. Nagar*	2019-24

Programme 3: Management of natural resources and soil health of arable and non arable lands for climate resilient sustainable fodder production

CRSCIGFRISIL 20190201	Livestock based integrated farming systems for sustaining livelihood of Bundelkhand farmers	*PI: D.R. Palsaniya Co-PIs: M.M. Das, R.K. Patel, A.K. Dixit, Gaurendra Gupta and Mahendra Prasad*	2019-24
CRSCIGFRISIL 20190202	Precision nitrogen management in forage crops	*PI: Mukesh Choudhary*	2019-24
CRSCIGFRISIL 20210203	Nutrient and water management in BN hybrid through drip irrigation in semi-arid region of India.	*PI: Mukesh Choudhary Co-PI: Samir Barmam*	2021-25
CRSCIGFRISIL 20210201	Manipulating the rhizosphere microbiome using plant growth promoting microbes to enhance soil and plant health	*PI: Srinivasan R. Co-PIs: Mahendra Prasad, R.P. Saini, Mukesh Choudhary and Anup Kumar*	2021-26
CRSCIGFRISIL 20210202	Development of microbial inoculants to enhance ensiling.	*PI: Srinivasan R. Co-PIs: Sultan Singh and K.K. Singh*	2021-24

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20200201	Development of decision support system for fodder crops with a special reference to climate change.	*PI: S.K. Rai Co-PIs: A.K. Dixit, R.K. Singhal, Reetu, B.K. Mehta, Mahendra Prasad and Sangeeta Lenka (IISS Bhopal)*	2020-25
CRSCIGFRISIL 20220301	Sustainable forage production from different densities of shrubs and tree through lopping management in three tier silvopasture systems.	*PI: S.N. Ram Co-PIs: R.V. Kumar, M.M. Das, Avijit Ghosh and Kamini*	2022-26
CRSCIGFRISIL 20200902	Studies on fodder production potential of fodder shrub based alley cropping systems in Peninsular India.	*PI: B.G. Shivakumar Co-PI: N.S. Kulkarni*	2020-24
CRSCIGFRISIL 20221001	Intensive fodder production through crop diversification and zinc fortification in Kashmir Himalaya.	*PI: N.H. Mir Co-PIs: Suheel Ahmad and S.S. Bhat*	2022-25
CRSCIGFRISIL 20221101	Agronomical trait(s) improvement in forages using plant associated microbes from the North-Western Himalaya.	*PI: Surinder Paul Co-PI: S. Radotra*	2021-25
CRSCIGFRISIL 20240201	Harnessing the potential of invasive weed biochar as fertilizer coating material for improving fodder productivity, nutrient use and soil health.	*PI: Mahendra Prasad, Co-PIs: D.R. Palsaniya and S.K. Mahawer*	2024-27

Programme 4: Accelerating seed biology research and technology development for enhanced quality forage seed production and strengthening national forage seed network

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20190402	Identification and utilization of smoke derived compounds in early establishment of forages .	*PI: Prabha Singh Co-PIs: R.P. Saini, Amit Patil and Anup Kumar*	2019-24
CRSCIGFRISIL 20230401	Development of seed standards in temperate forages.	*PI: Sunil Swami Co-PIs: Vijay Kumar Yadav, Awnindra Kumar Singh and Suheel Ahmad*	2023-26
CRSCIGFRISIL 20200104	Study of berseem (*Trifolium alexandrinum* L.) seed coat dynamics.	*PI: Prabha Singh Co-PIs: Tejveer Singh, R.P. Saini, H.S. Mahesha and Maharishi Tomar*	2020-24
CRSCIGFRISIL 20210401	Development of Near-infrared spectroscopy (NIRS) based prediction models for the assessment of seed viability and vigour in tropical grasses.	*PI: Maharishi Tomar Co-PIs: V.K. Yadav and Prabha Singh*	2021- 26

Programme 5: Nutritional evaluation and post harvest management of forage resources for sustainable and improved crop-livestock production systems

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20230701	Feeding efficiency improvement through micro climatic stress amelioration for bovines.	*PI: P. Sharma Co-PIs: K.K. Singh, Pooja Tamboli, Deepak Upadhaya and Amit Patil*	2023-26

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20220702	Phytochemical nano-formulations to control aflatoxins in animal feeds.	*PI: Anup Kumar Co-PIs: Deepak Upadhaya, Srinivasan R. and S.K. Mahawer*	2022-27
CRSCIGFRISIL 20220702	Foraging behaviour of small ruminants under natural grassland in Bundelkhand region.	*PI: Pooja Tamboli Co-PIs:Deepak Upadhyay, Anup Kumar, N. Dikshit, K.K. Singh and M.M. Das*	2022-26
CRSCIGFRISIL 20220701	Ensiled TMR (Total Mix Ration) for livestock production.	*PI: M.M. Das Co-PIs: Sultan Singh, Anup Kumar, K.K. Singh and Pooja Tamboli*	2022-25
CRSCIGFRISIL 20190602	Development of forage based feed for commercial goat farming.	*PI: P.N. Dwivedi Co-PIs: P.K. Pathak, Amit K. Patil and S.K. Singh*	2019-25
CRSCIGFRISIL 20240701	Evaluation of forage based ration on lactation performance of dairy animal.	*PI: Deepak Upadhyay Co-PIs: K.K. Singh, P. Sharma, P.N. Dwiwedi, B.B. Choudhary and R.K. Agrawal*	2024-29
CRSCIGFRISIL 20240702	Identification and characterization of volatile metabolites during ensiling.	*PI: P. Koli Co-PIs: Sultan Singh, Sonu Kumar Mahawer and Parshant Kaushik (ICAR-IARI)*	2024-27
CRSCIGFRISIL 20240601	Development of drudgery reducing farm machines and tools for forage and livestock production.	*PI: Amit Kumar Patil Co-PIs: S.K. Singh, Ajay N. Satpute, Deepak Upadhyay, P. Sharma and S.R. Kantwa*	2024-28
CRSCIGFRISIL 20190605	Development of automatic seed coating machine.	*PI: Amit K. Patil Co-PIs: S.K. Singh and Sunil Swami*	2019-24
CRSCIGFRISIL 20190604	Design and development of solar powered self-propelled multipurpose machine for agricultural operations.	*PI: Amit Patil Co-PIs: S.K. Singh and Gaurendra Gupta*	2019-24
CRSCIGFRISIL 20211001	Ensiling of temperate grasses/legumes for increased livestock productivity.	*PI: S. Ahmad Co-PIs: S.S. Bhat, Sultan Singh, K.K. Singh, R. Srinivasan and N.H. Mir*	2021-24
Programme 6: Social, economic, policy and translational research and capacity building			
CRSCIGFRISIL 20210503	Ex-post development impact evaluation of ADARSH CHARA GRAM project (Scaling up of fodder technologies at farmers field).	*PI: P. Sharma Co-PIs: B.B. Choudhary, Gaurendra Gupta and Avinash Chandra*	2021-24

Project Code	Title	PI & Co-PIs	Duration
CRSCIGFRISIL 20190501	Livestock based integrated farming system for sustainable productivity at farmer's field of Bundelkhand region.	*PI: Gaurendra Gupta Co-PIs: D.R. Palsaniya, S.S. Manjanagouda (Transfered), Deepak Upadhyay, R.K. Patel, B.B. Choudhary, Manju Suman, Sadhna Pandey and S.K. Singh*	2019-24
CRSCIGFRISIL 20210502	Impact of fodder and livestock technologies on livelihood of farmers of SCA schemes of IGFRI. Sub project I: Impact of fodder and livestock technologies on livelihood of farmers of SCSP.	*Coordinator: Sadhana Pandey PI: B.B. Choudhary Co-PIs: Gaurendra Gupta, B.G. Shivkumar, S.S. Bhat, R.S. Radotra, Avinash Chandra, Shailendra Sinha, Nazim Hamid Mir and Atufa Regu*	2021-25
CRSCIGFRISIL 20200901	Participatory fodder production in fruits and plantation crops.	*PI: N. Biradar Co-PIs: B.B. Choudhary and S.K. Shukla, CISH, Lucknow*	2020-24
CRSCIGFRISIL 20200401	Evaluation of berseem gene pool for herbicide tolerance.	*PI: R.P. Saini Co-PIs: Tejveer Singh, Prabha Singh and V.K. Yadav*	2020-24

Externally funded projects

Project Title	PI and Co-PIs	Duration	Funding Agency
Development of climate resilient and sustainable agri-based systems for better food, feed nutritional and livelihood security options to farming community of cold arid regions-Ladakh	*Lead centre: NDRI Karnal Collaborating center : IGFRI-RRS Srinagar (S.S. Bhatt and S. Ahmed)*	2023-26	DST (NMSHE) Rs. 27.19 lacs
AMAAS project: Development of microbial consortia for enhancing drought tolerance and efficient nutrient management in forage crops	*PI: R. Srinivasan*	2017- continue	ICAR-NBAIM Mau Rs. 10.0 lacs (2024-25)
Developing hybrid nano-fertilizers by using zeolite and hydroxyapatite for sustainable fodder production	*PI: Mahendra Prasad*	2023-26	SERB, DST Rs. 51.51 lacs
AICRP on Dryland Agriculture (Voluntary Centre)	*PI: S.R Kantwa Co-PI: Mukesh Choudhary and R.K. Agrawal*	2018-continue	ICAR-CRIDA, Hyderabad Rs. 2.27 lacs (2024-25)
Building resilience model for the vulnerable hotspots to climate change in smallholder dairy production system of Indo-Gangetic plain region of India using GIS and Fuzzy cognitive mapping approach	*PI: B.B. Choudhary Co-PIs: P. Sharma, Samir Barman and Sadhna Pandey*	2024-2027	ICAR-NASF Rs. 24.67 lacs

Network project on ecosystems, agribusiness and institutions Component 1: Impact of Agricultural Technology (Crop Science Technologies) Subtitle : "Impact analysis of grassland and fodder technologies"	*PI: B.B. Choudhary, Co-Pis: P. Sharma, Gaurendra Gupta, Avijit Ghosh and Sunil Swami*	2021-26	ICAR-NIAP New Delhi Rs. 16 lacs
AICRP (FIM)	*PI: P.K. Pathak Co-PIs: A.K. Patil and S.K. Singh*	2023-24	AICRP (FIM), ICAR-CIAE, Bhopal Rs. 10.69 lacs
Enhancing climate resilience and ensuring food security with genome editing tools	*PI: P. Priyadarshini Co-PIs: K.K. Dwivedi, Maneet Rana and Ravi Prakash Saini*	2023-26	ICAR Rs. 144.0 lacs
Identification and characterization of candidate genes related to polyploidy and /or apomixes in guinea grass	*PI: K.K. Dwivedi Co-PI: Maneet Rana*	2024-27	DST-SERB Rs. 35.0 lacs
Mapping and validation of genomic regions associated with brown midrib mutant in pearl millet	*PI: Shashikumara P. Co-PIs: B.K. Mehta and Anup Kumar*	2023-26	SERB Rs. 36.83 lacs
Bioprospecting of abiotic stress tolerance genes in grasses	*PI: Shashikumara P.*	2020-24	DST-SERB Rs. 34.24 lacs
Characterization and multiplication of forage crops	*PI: Shahid Ahmed Co-PIs: Tejveer Singh, B.K. Mehta, Maneet Rana, Indu, Shashikumara P., R.K. Singhal, S. Ahmed, S.S. Bhat, S. Radotra and H.S. Mahesha*	2022-26	ICAR-NBPGR Rs. 7.0 lacs
Synthetic seed production in sterile Bajra-Napier hybrid via encapsulation of somatic embryos	*PI: Maneet Rana*	2021-2024	DST- SERB Rs. 29.65 lacs
NTPC: Fly ash use in agriculture for Sustainable Crop Production and Environmental Protection	*PI: Avijit Ghosh Co-PIs: R.V. Kumar, Sunil Kumar, Amit K. Singh and Kamini*	2021-2031	NTPC Rs. 177.00 lacs
RKVY-ICAR: Agri-Drone project	*PI: Amit Kumar Singh Co-PIs: Avijit Ghosh, Gaurendra Gupta*	2022-Continue	RKVY Rs. 36.00 lacs
NASF: Natural Grassland Ecosystem monitoring system for peninsular and trans Himalayan India to Sustain Pastoral communities	*PI: Avijit Ghosh Co-PIs: Amit K. Singh, J.P. Singh, A.K. Shukla and Nagratna Biradar*	2024-27	NASF Rs. 106.23 lacs
AICRP on Buffalo Improvement. Performance Recording and Improvement of Bhadawari Buffaloes	*PI: B.P. Kushwaha Co-PIs: Sultan Singh, Deepak Upadhyay and Pooja Tamboli*	2021-continue	ICAR Rs. 50.00 lacs

AICRP on Goat Improvement Bundelkhandi Goat Unit	*PI: Deepak Upadhyay Co-PIs: B.P. Kushwaha, P. Tamboli and P. Sharma*	2018-continue	ICAR Rs. 27.35 lacs
Development of effective mass propagation techniques for rapid multiplication and easy transportation of quality planting material in Bajra Napier hybrid	*PI: V.K. Yadav Co-PIs: Vinod Kumar and Edna Antony*	2023-2026	NLM Rs. 179.39 lacs
Grassland restoration and rejuvenation for enhancing grazing resources using remote sensing and drone technologies	*PI: Amit Kumar Singh Co-PIs: Sunil Swami, A. Ghosh, Deepak Upadhyay A.K. Patil and R.V. Kumar*	2023-2026	NLM Rs. 117.41 lacs
Genetic improvement of forage crops for sustainable livestock production.	*PI: Sultan Singh Co-PIs: P. Shashikumara, Maneet Rana, B.K. Mehta, Shahid Ahmed, R.K. Singhal and Prabha Singh*	2023-26	NLM Rs. 376.84 lacs
Use and conservation of agrobiodiversity for food and nutrition security, increased agricultural sustainability, and resilience to climate change in India	*PI: V.K. Yadav Co-PIs: Sultan Singh, Amit K. Singh, A. Ghosh, N. Biradar, Tejveer Singh, P. Sharma, Shahid Ahmed, Srinivasan R. and Anup Kumar*	2021-2024	ICAR-IGFRI-CIAT-Bioversity Rs. 77.61 lacs
Harnessing genetic diversity in pearl millet and sorghum for identification of trait specific gentoypes and trait mapping for fodder yield and quality component traits	*PI: R.V. Kumar Co-PIs: Shashikumara P., Subhash Chand, R.K. Singhal, Gaurendra Gupta and K.K. Singh*	2023-26	ICAR-IIMR Hyderabad Rs. 50.00 lacs
Farmer's FIRST Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity and livelihood security in Bundelkhand region	*PI: Purushottam Sharma Co-PIs: Sunil Kumar, S.K. Singh, Mukesh Choudhary, B.B. Choudhary, Awninder K. Singh and K. Sahu*		Rs. 13.85 lacs

Chapter 10

Events and Meetings

10.1 Institute Foundation Day

ICAR-IGFRI celebrated its 63rd Foundation Day with great enthusiasm and a series of impactful events. Dr. C.D. Mayee, Former Chairman ASRB, graced the occasion as Chief Guest and delivered the Foundation Day Lecture. The event was also attended by distinguished guests including Sh. Bharat Kakade, President & Managing Trustee of BAIF Development Research Foundation; Dr. Sanjay Singh, Director General, Uttar Pradesh Council of Agricultural Research; and Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi.

In celebration of the "Foundation Week," several programmes were organized:

- 63000 earthen *Diyas* were lit by the institute's staff and their families, symbolizing the institute's successful journey in fodder research.
- A fodder-centric training-cum-input distribution programme was conducted to benefit local farmers.
- A vibrant "Fodder Mela" was organized on 8th November 2024 by the Institute along with its regional centers.
- A lecture series was initiated under the theme making India a *"Fodder Plus Nation"* inaugurated in presence of Dr. Meenesh Shah, Hon'ble Chairman and Managing Director of NDDB, Anand, as chief guest; with Prof. (Dr.) A.K. Singh, Vice-Chancellor, RLBCAU, Jhansi, and Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi, as Guests of Honour.

10.2 Swachhta Pakhwada

The institute celebrated 'Swachhta Pakhwada' from 16th to 31st December 2024 with the aim of promoting greater awareness about the importance of cleanliness and environmental stewardship, under the theme *"Swachhta Hi Sewa 2024"*.

10.3 हिंदी पखवाड़ा

हिंदी पखवाड़ा (14–30 सितम्बर, 2024) का समापन समारोह संस्थान में डॉ. चंद्रिका प्रसाद त्रिपाठी, मानस मर्मज्ञ एवं पूर्व शिक्षक, राजकीय इंटर कॉलेज, झाँसी के मुख्य आतिथ्य में तथा संस्थान के निदेशक डॉ. पंकज कौशल की अध्यक्षता में सम्पन्न हुआ।

हिंदी पखवाड़ा के अंतर्गत संस्थान में विभिन्न गतिविधियाँ आयोजित की गईं, जिनमें प्रारूप एवं टिप्पणी लेखन, निबंध लेखन, अनुवाद, भाषण प्रतियोगिता, हिंदी कार्यशाला, विभागीय निरीक्षण तथा पुरस्कार वितरण आदि प्रमुख रहे।

10.4 Plantation Drive

On 17th September 2024, institute organized a plantation drive under the campaign "एक पेड़ माँ के नाम" (One Tree for Mother), aligning with the national initiative launched by the Ministry of Agriculture and Farmers Welfare. This campaign aimed to promote environmental conservation and honor motherhood through tree planting.

10.5 तिरंगा रैली

राष्ट्र के आगामी 78वें स्वतंत्रता दिवस के उपलक्ष्य में भा.कृ. अनु.प.–भा.च. एवं चा.अनु.सं., झाँसी के मुख्यालय एवं उसके क्षेत्रीय शोध केन्द्रों पर तिरंगा रैली का आयोजन किया गया। इस अवसर पर राष्ट्रभक्ति के जय–घोषों के साथ महापुरुषों के बलिदानों को स्मरण किया गया और सभी ने देश की एकता एवं अखंडता के प्रति अपनी प्रतिबद्धता दोहराई।

10.6 Van Mahotsav

Institute celebrated *Van Mahotsav*- India's tree-planting festival-by organizing a tree plantation drive on 9th August 2024 to promote environmental conservation and green awareness.

10.7 World Intellectual Property Day

Institute celebrated *World Intellectual Property Day* on 26th April 2024 with great fervor and enthusiasm. Dr. Sanjeev Saxena, former ADG, IP&TM, graced the occasion as the Chief Guest and shared valuable insights on the significance of intellectual property in agricultural innovation.

10.8 21st Annual Review meeting of Network Project on Buffalo Improvement

Institute organized 21st Annual Review Meeting of the Network Project on Buffalo Improvement (NPBI) on 12-13 November, 2024 to review the progress of ongoing projects across participating centers for the year 2023-24. The meeting was chaired by Dr. Raghavendra Bhatta, DDG (Animal Science), ICAR, New Delhi. Distinguished attendees were Dr. T.K. Datta, Director, ICAR-Central Institute for Research on Buffaloes (CIRB), Hisar & Project Coordinator, NPBI; Dr. G.K. Gaur, ADG (Animal Production & Breeding); Dr. H.K. Narula, PS (Animal Breeding & Biotechnology) from ICAR Headquarters, New Delhi; and Dr. R.K. Sharma, NPBI. The inaugural session was graced by Dr. Pankaj Kaushal, Director, ICAR-IGFRI, Jhansi, along with Heads of Divisions of the institute.

10.9 *Parthenium* Awareness Week

Institute successfully organized 18th *Parthenium* Awareness Week from August 16 to 22, 2024, with the primary objective of educating people about the adverse effects of *Parthenium*. During the event, the Director emphasized that *Parthenium* is not only a threat to crop production but also a nuisance in residential areas, parks, roadsides, and railway tracks. He urged for its eradication through active public participation.

10.10 World Soil Day

The World Soil Day was organized on 5th December, 2024 on the theme "Caring for Soils: Measure, Monitor, Manage". The program was attended by 25 farmers from different villages of Jhansi. Participants were informed about the role of soil and soil health management. Farmers were also provided with the Soil Health Card and leaf color chart and acquainted with their utility.

Chapter 11

Awards and Recognitions

Professional Society Awards

- Dr. D.R. Palsaniya received **Dr. K.G. Tejwani Award** for excellence in agroforestry research and development for the year 2023 on 18 June, 2024 by Indian Society of Agroforestry, Jhansi.

- Dr. Purushottam Sharma was awarded as **Fellow** of the National Academy of Dairy Science of India on 09 April, 2024 at DUVASU, Mathura .

Academic Awards

- Dr. Shashikumara P received **INSA Visiting Scientist Fellowship-2024** by Indian National Science Academy, New Delhi.
- Dr. Avijit Ghosh received **INSA Visiting Scientist Fellowship-2024** by Indian National Science Academy, New Delhi.

Conference Awards

- Dr Sultan Singh received **Best Oral Presentation Award** in 20th Biennial International Conference of ANSI on "Sustainable animal nutrition for global health and production: Innovations and Directions" held at Madras Veterinary College, Chennai during 23-25 January, 2024.

- Dr. Subhash Chand received **Young Scientist Award** in 2nd International Agriculture Conference on "Natural farming innovation: enhancing soil health and seed quality with AI and drones for greener agricultural future" during 3-5 November, 2024 (Hybrid mode).
- Dr. Subhash Chand received **Young Scientist Award** in 1st International Conference on "Innovations to achieve climate-resilient smart agriculture for ensuring global food and nutritional security", jointly organised by ICAR-IISR, Lucknow, AEETDS, Lucknow, and UPCAR, Lucknow during 18-19 November, 2024.
- Dr. Surinder Paul received **Young Scientist Award** in Agricultural Biotechnology by Indian Society of Agriculture Sciences & Technology Research (ISASTR), Noida, India during the International Conference (CITAAS-2024) held at Guru Kashi University, Bathinda during 29-31 August, 2024.
- Dr. Mahendra Prasad received **Best Poster Award** in National Conference on "Novel strategies for mitigating biotic and abiotic stresses for agricultural and environmental sustainability" held at ICAR-National Institute of Biotic Stress Management, Raipur during 28-29 February, 2024.
- Dr. Shashikumara P. received **Best Poster Award** in national conference on "Novel strategies for mitigating biotic and abiotic stresses for agricultural and environmental

sustainability" held at ICAR-National Institute of Biotic Stress Management, Raipur during 28-29 February, 2024.

- Dr. Sonu Kumar Mahawer received **Best Oral Presentation Award** in IPS North-Eastern Zonal Meet and AAAS National Conference on "Advances in innovative technologies and plant health management strategies in climate resilient agriculture (AITPRA)" by the Indian Phytopathological Society, Agartala during 26-27 September, 2024.
- Dr. Surinder Paul received **Academic Merit Award** for paper presentation in 76th Annual meeting of the "Society on plant health for food Security: Threats and Promises" held at ICAR-Indian Institute of Sugarcane Research, Lucknow during 01-03 February, 2024
- Dr. Pushpendra Koli received **Best Oral Presentation Award** in the National Conference on "Advances in innovative technologies and plant health management strategies in climate resilient agriculture" by the Indian Phytopathological Society, Agartala during 26-27 September, 2024.

Best Ph.D. Thesis Award

- Dr. Pushpendra Koli received **Best Ph.D. Thesis Award** in the National Conference on "Advances in Innovative Technologies and Plant Health Management Strategies in Climate Resilient Agriculture" of Indian Phytopathological Society, Agartala during 26-27 September, 2024.

Sports Award

- Dr. Vinod Kumar, Dr. Tejveer Singh, Dr. S R Kantwa, Dr. Ratnakar Patel and Dr. Sultan Singh achieved 2nd position (Silver medal) in ICAR Inter-Zonal Sports Meet held at ICAR-CAZRI, Jodhpur from 14-17 October, 2024.

Institute Foundation Day Awards

- **Best Division Award:** Plant Animal Relationship Division.
- Dr. Shashikumara P. received **Best Worker Award** (Scientific category).

Other Awards

- Dr. Vinod Kumar- **Incentive award for the year 2023-24** for having brought Externally Funded Competitive Adhoc Project worth Rs. 125.79 lakhs during 2023-24 from University of Agricultural Sciences, Dharwad during the Foundation day of the University held on 01 October, 2024.
- Dr. B.G. Shivakumar, received **Excellent Reviewer Award** of the *Indian Journal of Agricultural Research*, ARCC, Karnal.

Chapter 12

Administration and Accounts

Budget

	Budget allocated (Rs. in Lakhs)	Expenditure (Rs. in Lakhs)
ICAR-IGFRI*	5306.50	5306.06
AICRP (FC&U)*	1346.71	1346.68
Total	6653.21	6652.74

*Including salary & pension

Staff strength as on 31.12.2024

Cadre	Sanctioned	In position	Vacant
Research Management	01	01	-
Scientist	121	66	55
Technical	80	56	24
Administrative	73	36	37
Multi Tasking Staff	55	31	24
Total	330	190	140

Departmental promotion in respect of scientific, technical, administrative and multi tasking staff during the period 01.01.2024 to 31.12.2024

S. No.	Name of officer	Nature of promotion	Date of office order
1.	Dr. Ravi Prakash Saini, Scientist (Agricultural Biotechnology)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/-pre revised)	15.01.2024 w.e.f. 02.07.2022
2.	Dr. Maharishi Tomar Scientist (Plant Biochemistry)		15.01.2024 w.e.f. 01.07.2020
3.	Dr. Avijit Ghosh Scientist (Soil Science)		03.04.2024 w.e.f. 24.04.2024
4.	Dr. Brijesh Kumar Mehta Scientist (Genetics & Plant Breeding)		03.04.2024 w.e.f. 04.01.2023
5.	Dr. Keerthi M.C. Scientist (Agril. Entomology) (Transferred)		03.04.2024 w.e.f. 12.09.2022
6.	Dr. Neeraj Kumar Scientist (Genetics & Plant Breeding) (Transferred)		03.04.2024 w.e.f. 25.10.2021
7.	Dr. Prabha Singh Scientist (Plant Physiology)		03.04.2024 w.e.f. 25.10.2021
8.	Dr. Shashikumara P. Scientist (Genetics & Plant Breeding)		03.04.2024 w.e.f. 04.01.2023

9.	Dr. Seva Nayak Dheeravathu Scientist (Plant Physiology) (Transferred)	Research Level-12 (7^{th} CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/-pre revised) To be designated as Sr. Scientist	03.04.2024 w.e.f. 01.01.2023
10.	Dr. Tejveer Singh Sr. Scientist (Genetics &Plant Breeding)	Research Level-13A (7^{th} CPC) in the pay matrix (Pay Band Rs. 37400-67000 + RGP 9000/-pre revised)	03.04.2024 w.e.f. 24.04.2022
11.	Dr. Mukesh Choudhary Sr. Scientist (Agronomy)		03.04.2024 w.e.f. 15.12.2022

S. No.	Probation period	Probation period confirmation	Date of office order
	Scientist		
1.	Dr. Amit Kumar Patil Scientist (Farm Machinary & Power)	01.07.2020	15.04.2024
	Technical Staff		
1.	Dr. Anjaly M.V., T-6	27.07.2024	28.11.2024
	Multi Tasking Staff		
1.	Sh. Shripat S/o Banshi, Multi Tasking Staff (Cleaner)	11.11.2022	31.05.2024
2.	Sh. Gulab Singh S/o Shriram, Multi Tasking Staff (Peon)	11.11.2022	31.05.2024
3.	Sh. Ningappa V. Bailur S/o Varappa Bailur, Multi Tasking Staff (Peon)	11.11.2022	31.05.2024
4.	Sh. Omprakash S/o Gopal Dhanka, Multi Tasking Staff (Peon)	12.11.2022	31.05.2024
5.	Sh. Asharam S/o Raghuwar, Multi Tasking Staff (Mali)	11.11.2022	31.05.2024
6.	Sh. Keshav S/o Ram Lal, Multi Tasking Staff (Peon)	11.11.2022	31.05.2024
7.	Sh. Maruti R. Belamaddi S/o Ramappa Belamaddi, Multi Tasking Staff (Lab Attd.)	11.11.2022	31.05.2024
8.	Sh. Rudrappa S. Nagneur S/o Shankarappa, Multi Tasking Staff (Peon)	11.11.2022	31.05.2024
9.	Sh. Khuman S/o Kamta, Multi Tasking Staff (Peon)	11.11.2022	31.05.2024
10.	Sh. Panchu S/o Hardas, Multi Tasting Staff (Peon)	11.11.2022	31.05.2024
11.	Sh. Ratiram S/o Radhakashan, Multi Tasking Staff (Peon)	12.11.2022	31.05.2024
12.	Sh. Shiyojiram S/o Ranbaj, Multi Tasking Staff (Peon)	12.11.2022	31.05.2024
13.	Sh. Kapil S/o Jagannath, Multi Tasking Staff (Mali)	28.11.2022	31.05.2024
14.	Sh. Moti Lal S/o Govind Das, Multi Tasking Staff (Lab Attd.)	18.03.2023	31.05.2024
15.	Sh. Dhani Ram S/o Param, Multi Tasking Staff (Workshop Staff)	18.03.2023	31.05.2024
16.	Sh. Madan S/o Laxmi Narayan, Multi Tasking Staff (Peon)	18.03.2023	31.05.2024

S. No.	Technical	Nature of promotion category	Date of office order
1.	Smt. Seema Khatri, CTO	One advance	18.03.2024
2.	Sh. Pradeep Kumar Tyagi, CTO	increment in same grade T-9	18.03.2024
3.	Sh. Harish Kumar Agrawal, CTO	01.01.2022	18.03.2024
4.	Sh. Atul Kumar Saxena, CTO		18.03.2024
5.	Sh. Kailash Prakash Rao, CTO	One advance increment in same grade T-9 24.02.2023	18.03.2024
6.	Sh. D.K. Singh, Ex-CTO (Retired)	T-7/8 to T-9	18.03.2024
7.	Sh. R.B. Bhondele, Ex-CTO	01.01.2022	18.03.2024
8.	Sh. Ram Asre, CTO		18.03.2024
9.	Sh. Deepak Choudhary, STA	T-3 to T-4 27.08.2023	17.09.2024
10.	Sh. Uttam Singh Verma, STA	T-3 to T-4 27.04.2024	23.09.2024
11.	Sh. Arun Prajapati, STA	T-3 to T-4 07.08.2023	23.09.2024
12.	Sh. Syed Julfikar Ali, TO	T-4 to T-5 01.01.2024	23.09.2024
13.	Sh. M.K. Tripathi, TO	T-4 to T-5 21.07.2024	23.09.2024
14.	Sh. Shailendra Sinha, ACTO	T-6 to T-7/8 19.08.2024	25.11.2024
15.	Sh. Devendra Pratap, STO	T-5 to T-6 09.06.2024	25.11.2024
16.	Sh. V.D. Chhavada, CTO	One advance increment in same grade T-9 01.01.2023	25.11.2024
17.	Sh. Ashok Kumar Singh, ACTO	T-6 to T-7/8 24.03.2024	25.11.2024
S. No.	**Administrative**	**Nature of promotion category**	**Date of office order**
1.	Smt. Shobhita Nair	Assistant to AAO	09.07.2024
2.	Sh. Amit Kumar Singh	Assistant to AAO	02.09.2024

Chapter 13

Distinguished Visitors

Dr. N.P. Singh
Vice Chancellor, BUAT
Banda, Uttar Pradesh

Sh. G.P. Sharma
Joint Secretary (Finance)
New Delhi

Dr. R.C. Bhattacharya
Director, ICAR-National Institute of Plant Biotechnology, New Delhi

Dr. P.L. Gautam
Former Vice Chancellor
GBPUAT, Pantnagar, Uttrakhand

Dr. O.P. Chaturvedi
Former Director, CAFRI
Jhansi, Uttar Pradesh

Dr. Bharat Kakade
President, BAIF
Pune, Maharashtra

Dr. R. Bhatta
DDG (Animal Science)
ICAR , Krishi Bhawan, New Delhi

Dr. Meenesh Shah
Chairman and Managing Director (NDDB)
Anand, Gujarat

Dr. S.N. Shusil
Director, ICAR-National Bureau of Agricultural Important Resources, Bengaluru, Karnataka

Sh. Shyamveer Singh
MORAT
Cabinet Minister

Dr. D.K. Yadav
ADG (Seeds)
ICAR, New Delhi

Dr. K.H. Anantha
Consultant
ICRISAT, Hyderabad, Telangana

Dr. Jitendra Kumar
ADG (NASF)
ICAR, New Delhi

Dr. C.D. Mayee
Former Chairman, ASRB
New Delhi

Dr. Sanjay Singh
Director General, UPCAR
Lucknow, Uttar Pradesh

Sh. Gabriel D. Wangsu
Minister, Agri-Allied *etc.*,
Govt. of Arunachal Pradesh

Chapter 14

List of Personnel

DIRECTOR

Dr. Pankaj Kaushal	Director	w.e.f. 01.04.2024

SCIENTIFIC

Division of Crop Improvement

Dr. Shahid Ahmad	Principal Scientist (Plant Breeding) & Head	
Dr. K.K. Dwivedi	Principal Scientist (Biotechnology)	
Dr. N. Dixit	Principal Scientist (EB &PGR)	Retired on 31.03.2024
Dr. Tejveer Singh	Senior Scientist (Genetics)	
Dr. Maneet Rana	Scientist (Agricultural Biotechnology)	
Dr. Rajesh Kumar Singhal	Scientist (Plant Physiology)	
Dr. Brijesh Kumar Mehta	Scientist (Genetics & Plant Breeding)	
Dr. Shashikumara P.	Scientist (Genetics & Plant Breeding)	
Dr. Parichita Priyadarshini	Scientist (Agricultural Biotechnology)	
Dr. Subhash Chand	Scientist (Genetics & Plant Breeding)	
Dr. Tanmaya Kumar Sahu	Scientist (Bioinformatics)	Upto 30.01.2024

Division of Crop Production

Dr. D.R. Palsaniya	Principal Scientist (Agronomy) & Head	
Dr. J.B. Singh	Principal Scientist (Agricultural Meteorology)	
Dr. S.K. Rai	Principal Scientist (Agricultural Meteorology)	Expired on 06.10.2024
Dr. Sita Ram Kantwa	Principal Scientist (Agronomy)	
Dr. Srinivasan R.	Principal Scientist (Microbiology)	
Dr. Mukesh Choudhary	Senior Scientist (Agronomy)	
Dr. Mahendra Prasad	Senior Scientist (Soil Science)	
Dr. Sonu Kumar Mahawer	Scientist (Agricultural Chemicals)	
Dr. Gaurendra Gupta	Scientist (Agronomy)	

Division of Grassland and Silvipasture Management

Dr. A.K. Shukla	Principal Scientist (Fruit Science) & Head	
Dr. J.P. Singh	Principal Scientist (Geography)	
Dr. Shiv Nath Ram	Principal Scientist (Agronomy)	
Dr. Sunil Kumar	Principal Scientist (Horticulture)	
Dr. Amit Kumar Singh	Senior Scientist (Ag. Meteorology)	
Sh. Vikas Chandra Tyagi	Scientist (Economic Botany & PGR)	On study leave
Dr. Kamini	Scientist (Agroforestry)	
Dr. Avijit Ghosh	Scientist (Soil Science)	

Division of Plant Animal Relationship

Dr. Purushottam Sharma	Principal Scientist (LPM) & Head	
Dr. K.K. Singh	Principal Scientist (Animal Nutrition)	
Dr. M.M. Das	Principal Scientist (Animal Nutrition)	

Dr. Sultan Singh	Principal Scientist (Animal Nutrition)	
Dr. P.N. Dwivedi	Principal Scientist (Animal Nutrition)	
Dr. A.K. Singh	Senior Scientist (Plant Breeding)	
Dr. Deepak Upadhyay	Scientist (LPM)	Upto 24.07.2024
Dr. Pushpendra Koli	Scientist (Agricultural Chemicals)	
Dr. Anup Kumar	Scientist (Agricultural Chemicals)	
Dr. Pooja Tamboli	Scientist (LPM)	

Division of Seed Technology

Dr. Awnindra Kumar Singh	Principal Scientist (Plant Breeding) & Head	
Dr. Swami Sunil Ramling	Scientist (Seed Science & Technology)	
Dr. Maharishi Tomar	Scientist (Plant Biochemistry)	
Dr. Ravi Prakash Saini	Scientist (Agricultural Biotechnology)	
Dr. Prabha Singh	Scientist (Plant Physiology)	
Dr. Surendra Kumar Meena	Scientist (Plant Physiology)	

Division of Farm Machinery and Post Harvest Technology

Dr. Sanjay Kumar	Principal Scientist (APE) & Head	
Dr. P.K. Pathak	Principal Scientist (ASPE)	
Er. Bholuram Gurjar	Scientist (Farm Machinery & Power)	On study leave
Sh. Amit Kumar Patil	Scientist (Farm Machinery & Power)	
Dr. Satpute Ajay Narayanrao	Scientist (Land & Water Management Engineering)	

Division of Social Science

Dr. Sadhna Pandey	Principal Scientist (Home Science) & Head	
Dr. M. Suman	Principal Scientist (Ag. Extension)	Retired on 31.08.2024
Dr. Bishwa Bhaskar Choudhary	Scientist (Agricultural Economics)	
Dr. Samir Barman	Scientist (Agricultural Statistics)	

AICRP (Forage Crops & Utilization)

Dr. V.K. Yadav	Principal Scientist (Genetics & Cytogenetics) & Project Coordinator	
Dr. R.K. Agrawal	Principal Scientist (Agronomy)	
Dr. R.V. Kumar	Principal Scientist (Plant Breeding)	

Regional Research Station, Avikanagar (Rajasthan)

Dr. R.P. Nagar	Principal Scientist (Seed Technology) & Officer-in-Charge	
Dr. Hari Singh Meena	Scientist (Agronomy)	

Regional Research Station, Dharwad (Karnataka)

Dr. K. Sridhar	Principal Scientist (Plant Breeding) & Officer-in-Charge	w.e.f. 17.01.2024
Dr. (Mrs.) N. Biradar	Principal Scientist (Agricultural Extension)	
Dr. B.G. Shivakumar	Principal Scientist (Agronomy)	
Dr. Vinod Kumar	Principal Scientist (Seed Technology)	
Dr. N.S. Kulkarni	Principal Scientist (Agricultural Entomology)	
Dr. (Mrs.) Edna Antony	Senior Scientist (Plant Physiology)	
Dr. (Mrs.) Ramyashree Devi G.S.	Scientist (Plant Pathology)	On study leave

Regional Research Station, Srinagar (J&K)

Dr. Sheeraj Saleem Bhat	Senior Scientist (Forestry) & Officer-in-Charge	
Dr. Suheel Ahmad Dand	Senior Scientist (Forestry)	
Sh. Nazim Hamid Mir	Scientist (Agronomy)	
Mrs. Atufa Regu	Scientist (Agricultural Extension)	

Centre for Indian Himalayan Grasslands, Palampur (H.P.)

Dr. S. Radotra	Principal Scientist (LPM) & Officer-in-Charge	
Dr. Surinder Paul	Scientist (Plant Biotechnology)	

TECHNICAL

Sh. P.K. Karpe	Chief Technical Officer	Retired on 31.12.2024
Sh. P.K. Tyagi	Chief Technical Officer	
Sh. A.K. Saxena	Chief Technical Officer	
Sh. Avinash Chandra	Chief Technical Officer	
Sh. V.D. Chhabra	Chief Technical Officer	
Sh. H.K. Agrawal	Chief Technical Officer	
Mrs. Seema Khatri	Chief Technical Officer	
Sh. Kailash Prakash Rao	Chief Technical Officer	
Sh. R.B. Bhondele	Chief Technical Officer	Retired on 31.03.2024
Sh. Ram Asre	Chief Technical Officer	
Sh. P.C. Gehlot	Assistant Chief Technical Officer	
Sh. Mohd. Irfan	Assistant Chief Technical Officer	
Sh. C.B. Tripathi	Assistant Chief Technical Officer	
Sh. S.M. Singh	Assistant Chief Technical Officer	
Sh. K.L. Meena	Senior Technical Officer	Retired on 29.12.2024
Sh. Ami Chand	Assistant Chief Technical Officer	Retired on 29.02.2024
Sh. N.K. Tripathi	Assistant Chief Technical Officer	Retired on 31.03.2024
Dr. H.C. Pandey	Assistant Chief Technical Officer	
Sh. Neeraj K. Dubey	Assistant Chief Technical Officer	
Sh. Kapil Kumar	Assistant Senior Technical Officer	Retired on 30.11.2024
Sh. Raj Kapoor Singh	Assistant Senior Technical Officer	
Sh. Shailendra Sinha	Senior Technical Officer	
Sh. Ashok K. Singh	Senior Technical Officer	Retired on 31.12.2024
Dr. Anjaly M.V.	Senior Technical Officer	
Sh. Dheeraj K. Dhingra	Senior Technical Officer	
Sh. Satya Naresh Singh	Technical Officer	
Sh. Rajesh K. Sharma	Technical Officer	
Sh. Harish Chandra	Technical Officer	
Sh. Ganga Sagar Yadav	Technical Officer	
Sh. Prem Swaroop	Technical Officer	
Sh. D.K. Niranjan	Technical Officer	
Sh. Haider Ali	Technical Officer	

Sh. S.V. Shinde	Technical Officer	
Sh. Pawan Kumar	Technical Officer	
Dr. R.S. Patel	Technical Officer	
Smt. Anita Srivastava	Technical Officer	Retired on 29.02.2024
Sh. Devendra Pratap	Senior Technical Officer	
Sh. Gopal Lal Meena	Technical Officer	
Sh. V.K. Gupta	Technical Officer	
Sh. Veeranna Rudrappa Kadakol	Technical Officer	
Sh. Syed Zulfikar Ali	Technical Officer (Driver)	
Sh. M.K. Tripathi	Technical Officer (Driver)	
Sh. Sudhir Ramteke	Technical Assistant	
Sh. Deepak Choudhary	Senior Technical Assistant	
Sh. Arun Prajapati	Senior Technical Assistant	
Sh. Uttam Singh Verma	Senior Technical Assistant	
Sh. Mathura Prasad	Senior Technician	
Sh. Dharam Singh Soni	Technician	w.e.f. 07.05.2024
Sh. Ajay Kumar	Technician	w.e.f. 30.04.2024
Sh. Suraj Kumar	Technician	w.e.f. 29.04.2024
Sh. Surendra Rajpoot	Technician	w.e.f. 06.05.2024
Ms. Shivani Prakash	Technician	w.e.f. 27.05.2024
Sh. Anand Raj	Technician	w.e.f. 06.05.2024
Sh. Rambhoo Kumar	Technician	w.e.f. 29.04.2024
Sh. Priyanshu Anand	Technician	w.e.f. 09.05.2024
Sh. Akhilesh Kumar	Technician	w.e.f. 29.04.2024
Sh. Ravi Shankar Kumar	Technician	w.e.f. 07.05.2024
Sh. Sundram Kumar	Technician	w.e.f. 07.05.2024
Sh. Mayank Rai	Technician	w.e.f. 15.05.2024
Sh. Arun Kumar	Technician	w.e.f. 22.04.2024
Sh. Nitesh Kumar Ravi	Technician	w.e.f. 06.05.2024

ADMINISTRATIVE

Sh. Firoz Khan	Chief Administrative Officer (SG)	Upto 12.06.2024
Sh. Kumar Vivek	Chief Administrative Officer	w.e.f. 10.06.2024
Sh. H.S. Yadav	Assistant Administrative Officer	Retired on 31.08.2024
Sh. Vijay K. Tiwari	Assistant Administrative Officer	
Sh. V.K. Paliwal	Assistant Administrative Officer	
Sh. Yashpal	Assistant Administrative Officer	
Sh. D.K. Namdev	Assistant Administrative Officer	
Sh. Sanjay Rajak	Assistant Administrative Officer	
Smt. Shobita Pillai	Assistant Administrative Officer	
Sh. Amit Kumar Singh	Assistant Administrative Officer	
Sh. R.S. Negi	Assistant Administrative Officer	
Sh. Pithani Satya Naveen	Assistant Finance Officer	w.e.f. 22.08.2024

Sh. Prem Chand	Principal Private Secretary	
Smt. Kumud Bhatia	Personal Secretary	
Sh. Jagdish Prasad	Personal Secretary	Retired on 31.05.2024
Sh. Kriparam	Personal Secretary	
Smt. Kirti Chaturvedi	Personal Secretary	
Sh. Faiyaz Khan	Assistant	Retired on 31.03.2024
Sh. R.K. Chhipa	Assistant	
Sh. Sanjay Kumar	Assistant	
Sh. Ajay Sehrawat	Assistant	Upto 02.12.2024
Sh. Siddhartha Pratap Singh	Assistant	w.e.f.. 09.09.2024
Sh. Shubham Yadav	Assistant	w.e.f.. 09.09.2024
Sh. Pranjal Panwar	Assistant	w.e.f.. 26.09.2024
Sh. Akash Prakash Verma	Assistant	w.e.f.. 27.09.2024
Sh. Satyam Agrawal	Assistant	w.e.f.. 03.10.2024
Sh. Sohail Khan	Assistant	w.e.f.. 11.10.2024
Sh. Shubham Tripathi	Assistant	w.e.f. 21.10.2024
Sh. Aneel Kumar	Senior Clerk (Deputation)	w.e.f. 21.06.2024
Ms. Neha	Senior Clerk	
Sh. Rajkumar	Senior Clerk	
Sh. Uma Shankar	Senior Clerk	
Sh. Jitendra Kushwaha	LDC	
Sh. Bharat Singh	LDC	
Ms. Priyanka Prajapati	LDC	
Sh. Prashant Saxena	LDC	
Sh. Yash Kapoor	LDC	Upto 31.05.2024
Ms. Sanjana Yadav	LDC	
Sh. Brij Bihari	LDC	
Smt. Girja	LDC	

भा.कृ.अनु.प.-भा.च.चा.अ.सं. समाचार पत्रों में/ICAR-IGFRI in Newspapers


ग्रासलैंड ने बनाई डफिंग मशीन, मिनटों में साफ कर रही बरसीम

छोटे-बड़े बीज को भी अलग करती है मशीन

चारे में आत्मनिर्भरता प्राप्त करने का लक्ष्य

अमर उजाला

जागरण

ग्रासलैण्ड ने बनाई आधुनिक मशीन, किसानों को मिलेगा फायदा

ग्रासलैण्ड का स्थापना दिवस सप्ताह समारोह सम्पन्न

जागरण 11 सितम्बर, 2024

चारा के उत्पादन को लेकर अरुणाचल सरकार व ग्रासलैण्ड के बीच होगा समझौता

उद्योग हकीकत

ग्रासलैंड स्थापना दिवस समारोह, निदेशक ने गिनाई संस्थान की उपलब्धियां

ग्रासलैण्ड संस्थान प्रबन्ध समिति की बैठक में हुए महत्वपूर्ण निर्णय

किसानों की आय वृद्धि को चारा उत्पादक एफपीओ पर हुई सहमति

दैनिक दर्शन पोस्ट 08 नवम्बर 2024

चारा अब बेचारा नहीं रहा, चारा उत्पादन की तकनीक हर जिले में पहुंचे यही प्रयास:पंकज कौशल

अमर उजाला

चारा विकास पर ग्रासलैंड में हुआ व्याख्यान

स्वदेश

चारा आत्मनिर्भरता को अग्रसर भारत विषय पर डेरी विकास बोर्ड के राष्ट्रीय अध्यक्ष का व्याख्यान

दैनिक भास्कर

आबादी बढ़ी पर कृषि कार्य करने वालों की संख्या

दैनिक भास्कर

राष्ट्रीय डेरी विकास बोर्ड के साथ एफपीओ बढ़ाएंगे किसानों की आय

स्वदेश

इण्डस्ट्री मीट एवं चारा तकनीकी प्रदर्शनी का आयोजन

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ग्राहक की भाषा समझे बिना व्यवसाय में उत्थान सम्भव नहीं

Swachh Bharat Abhiyan

स्वच्छ भारत

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