भाकृअनुप
ICAR

भा.च.चा.अ.सं.
IGFRI

INTERNATIONAL YEAR OF MILLETS, 2023

G20
भारत 2023 INDIA

ICAR-IGFRI

वार्षिक प्रतिवेदन
Annual Report
2023

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) Jhansi, Uttar Pradesh, is a distinguished institution in Asia, devoted to fundamental, strategic, applied, and adaptive research on both annual and perennial grasslands and fodder crops. For over six decades, IGFRI has achieved remarkable progress in developing tailored technologies for grassland enhancement and forage production, aimed at delivering green and sustainable fodder solutions to the farming community. The institute's success is rooted in its multidisciplinary approach, which integrates soil, plant, and animal research to address the critical shortage of green and dry fodder amid a growing livestock population and diminishing grassland areas. IGFRI operates through seven specialized divisions, encompassing crop improvement, crop production, grassland and silvipasture management, farm machinery and post-harvest technology, seed technology, plant-animal relationships, and social sciences. This work is further supported by three regional stations located in different agro-climatic zones.

During the reporting year, the lucerne variety IGFR-DL-2 (AWCL-2) was identified for release in the North West Zone by the Variety Identification Committee (VIC) during the NGM Rabi 2023-24 session. This variety yields 85-90 tons of green fodder per hectare, 10-15 tons of dry matter per hectare, 2.5-3.0 tons of Crude Protein Yield (CPY) per hectare, and 0.1-0.15 tons of seeds per hectare. It boasts a crude protein content of 16-18%. Additionally, the lucerne variety IGFR-DL-5 (IGFRI-Dharwad Lucerne-5) was identified for release in Zones 8 and 3 of Karnataka State by the 41st State Seeds Sub-Committee (SSSC). This variety yields 90-110 tons of green fodder per hectare, 15-20 tons of dry matter per hectare, and has a crude protein content of 15-20%.

The institute maintains approximately 10,980 forage accessions of over 70 genera in a midterm storage (MTS) module. To strengthen the fodder seed chain and ensure the availability of quality seeds to end users, the institute supplied 18.34 tonnes of breeder seeds of various fodder crops for further multiplication and 7.52 tonnes of TFL seeds directly to the farming community. Additionally, >10 lakhs rooted slips of perennial grasses were supplied to vaious stakeholders. To have regular and increased supply of quality fodder seeds, institute has made concerted efforts in licensing of some varieties with industry involving AgrInnovate. To ensure every Indian state becomes fodder surplus, IGFRI organized workshops with the animal husbandry departments of 27 states and have successfully developed state-specific 'Fodder Plans' for these states. Publications in high rated journals have become the regular feature and hallmark of the institute and during the current year > 70 research articles published in > 6 NAAS rated journals.

The institute has provided technical guidance for developing grasslands in Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Gujarat, Maharashtra, Karnataka, and Jammu and Kashmir, in collaboration with state and union territory governments and NGOs. Two consultancy projects with big business houses of the country were executed during the year for grassland development and increased green biomass production for Compressed Bio Gas (CBG). IGFRI has extensively showcased forage and livestock technologies in states like Meghalaya, Assam, West Bengal, Punjab, Himachal Pradesh, Jharkhand, Maharashtra, Karnataka, Rajasthan, Uttar Pradesh, Madhya Pradesh, and Jammu and Kashmir, as well as across the country through various outreach programs such as Farmers First, TSP, SCSP and NEH.

Throughout the year, the institute successfully organized six sponsored training programs focusing on various aspects of fodder production, conservation, and utilization. These programs targeted women farmers from different districts and veterinarians and agricultural officers from Tamil Nadu, generating a revenue of Rs. 16,00,000. Additionally, a 21-day Faculty Development Programme emphasized the role of science and technology in sustainable agriculture and allied sectors, benefiting numerous participants. The institute also conducted institutional trainings on improved forage and livestock techniques, biosafety for handling hazardous chemicals and biological agents, and intellectual property rights for farmers. These programs served diverse groups, including farmers, students, and government employees, enhancing their knowledge and skills in modern agricultural practices. The institute welcomed numerous stakeholders, such as farmers, government employees, students, and NGO representatives, for exposure visits. These visits facilitated interactions with experts and provided practical insights into advanced agricultural techniques. Notable visits included those from various schools, government departments, and agricultural universities, contributing to knowledge exchange and capacity building. The HRD team played a pivotal role in supporting students' academic endeavors by facilitating dissertations, internships, and RAWE (Rural Agricultural Work Experience) programs for 14 MSc students, three MSc (Biotech) students for one-month training,

and one BSc student for RAWE. These initiatives aimed to enhance the students' practical skills and research capabilities. The institute signed > 10 Memoranda of Understanding (MoUs) with various organizations to promote entrepreneurship development, academic collaboration, and research activities. Notable MoUs included partnerships with the ABI Unit ICAR-IGFRI Jhansi, ICARDA, APAHD, Galgotias University, M/s Harda Narmadeshwar Bamboo Initiative, and CSIR-IHBT Palampur, fostering collaborative efforts in research and technology dissemination. Academic collaborations were further strengthened, with 38 ICAR-IGFRI scientists engaged in teaching courses at RLBCAU Jhansi. M.Sc. in Seed Science and Technology and certificate course on MOOC Platform was also envisaged with RLBCAU and these programs were approved by BoM of RLBCAU. Capacity building and skill improvement programs were a priority, with 18 scientists, six technical officers, and seven administrative, finance, and account officers received specialized training organized by various national institutes and agencies. The institute also celebrated International Women's Day, Vigilance Awareness Week, Swachhta Pakhwada, World Soil Day, World Water Day, Constitution Day, and International Yoga Day, as well as national days like Republic Day and Independence Day, with great enthusiasm.

IGFRI is a recipient of the Sardar Patel Outstanding ICAR Institution 2015 Award, sharing its significant achievements and contributions to the farming community to improve livestock productivity and farmer's income. We believe that strong collaboration is the key to success, and in this direction institute is working with international organizations namely CIAT-Bioversity International ICRISAT and ICARDA for fodder crop improvement and popularization of thorn less cactus.

The year 2023 was celebrated as International Year of the Millets and IGFRI has actively demonstrated the importance of millets at various platforms and promoted use of millets in daily diets. Various initiatives to highlight the importance of millets, millet-based food items, particularly Bajra, were served during significant events, engaging school programs, awareness and training sessions, webinars, and input distribution sessions, all of which contributed to widespread participation and engagement across different sectors.

Rangelands, which cover over half (54%) of the world's land surface, are our largest ecosystem, yet they are also the most endangered and least protected. Recognizing this, year 2026 has been declared as 'International Year of Rangelands & Pastoralists (IYRP)' by UN. To draw attention from all stakeholders and in preparation to celebrate the year, a three days' workshop (December 22-24, 2023) was organized at IGFRI in collaboration with SEVA. A draft grassland policy document was also developed and submitted to council. During the year many externally funded projects (Rs >10 Cr) namely from NLM, DAHD and SERB were received by the scientists of the institute.

During the year, institute in collaboration with RMSI, Jhansi successfully organized an International conference (December 1-3, 2023) wherein > 300 delegates have participated and shared their research finding etc. Also, institute hosted the ICAR west Zone sports event (December 16-19, 2023) where > 700 sports personnel have participated from 25 ICAR institutes.

Our research and development efforts are guided and supported by the Indian Council of Agricultural Research (ICAR) and the Ministry of Agriculture and Farmers Welfare, Government of India. I am deeply grateful to the advisory committees, including the Research Advisory Council and the Quinquennial Review Team, for their proactive role in regularly guiding the institute. I also extend my heartfelt gratitude to the Ministers of Agriculture and Farmers Welfare, the Director General of ICAR, the Deputy Director General (Crop Science), and the Assistant Director General (Food and Fodder Crops) for their guidance, encouragement, and positive attitude towards the development of the institute on both scientific and administrative fronts. I take this opportunity to express my appreciation to the entire IGFRI Team/Family, including the Project Coordinator (FCU), Heads of Divisions, Officers-in-Charge of Regional Stations, and the scientific, technical, administrative, supporting, and contractual staff, for their unwavering commitment to the institute's growth and their dedication to upholding the reputation of this ISO 9001:2015 certified institute. Their continuous hard work, reliability, and cooperation have been instrumental in achieving our targets. I also acknowledge the sincere efforts of the editorial committee in compiling this Annual Report, documenting the institute's activities and achievements promptly.

As a special note, I humbly submit that I as a Director of this prestigious institute was overwhelmed working each of you for the last three years (2021 to 2023) and grateful to each and every one of you extending unconditional and untiring supports bringing this institute to the next higher level. Convey my best wishes to the new leadership and each of you.

All the best!

(Amaresh Chandra)

कार्यकारी सारांश

कार्यक्रम 1 : चारा फसलों की गणवत्ता, बहुकटाई, अजैविक दबाव प्रबन्धन एवं जैव-फोर्टिफिकेशन, परम्परात, अपोमिक्सिस और नये प्रजनन उपकरणों का उपयोग करते हुए अनुवंशिक सुधार।

- लूसर्न किस्म IGFR&DL–2 (AWCL–2) को भारत के उत्तर–पश्चिम क्षेत्र के लिए जारी करने के लिए पहचाना गया और IGFR&DL–5 (IGFRI–धारवाड़ लूसर्न–5) को कर्नाटक के जोन 8 और जोन 3 के लिए राज्य रिलीज के लिए पहचाना गया। लूसर्न (वार्षिक) की एक प्रविष्टि AWL–6 को केन्द्रीय क्षेत्र में AVT–1 के लिए प्रमोट किया गया। लूसर्न (वार्षिक) की एक नई प्रविष्टि–IGFRI-DL–1 ने रबी 2023–24 में योगदान दिया।
- धारवाड़ में फॉल आर्मीवर्म का मौसमी प्रकोप दोनों खरीफ एवं रबी में देखा गया, और खरीफ के दौरान प्रकोप अधिक था। अगस्त के अंतिम सप्ताह के दौरान सर्वाधिक प्रकोप (55%) देखा गया और दिसंबर के अंतिम सप्ताह में दूसरा सर्वाधिक (25%) प्रकोप देखा गया। सभी पर्यावरण–मित्री दृष्टिकोणों में Metarhizium (Nomuraea) anisopleae दोनों स्प्रे दौरों के दौरान अधिक प्रभावी पायी गयी। कीटनाशक स्प्रे में, Emamectin Benzoate 5 WG / 0-5 g/L दोनों स्प्रे दौरों के दौरान अधिक प्रभावी पायी गयी ।
- खरीफ 2023 के दौरान चारा घासों की कुल 548 प्रविष्टियों का संग्रह और मूल्यांकन किया गया और पैनिकम प्रजाति की 45 प्रविष्टियों को USDA से प्राप्त कर उनका चरित्रांकन किया गया।
- बर्सीम की लगभग 222, लोबिया जर्मप्लाज्म की 230 और दीनानाथ घास की 57 प्रविष्टियां को ICAR-NBPGR में दीर्घकालिक संरक्षण के लिए भेजा गया ।
- चारा फसलों की कुल 10,896 प्रविष्टियों को आईसीएआर–आईजीएफआरआई, झाँसी के एमटीएस मॉड्यूल में संरक्षित किया जा रहा है और बीएन हाइब्रिड, गिनी घास और मार्वल घास की 19 किस्मों को एनएजीएस में फील्ड जीन बैंक के रूप में संरक्षित किया जा रहा है।
- दीनानाथ की किस्म, JHD–19–4 (बुंदेल दीनानाथ–3) को सीवीआरसी द्वारा 25 सितंबर 2023 को अधिसूचना संख्या S-O-4222(E) के साथ जारी करने के लिए अधिसूचित किया गया।
- आईजीएफआरआई और आईएआरआई के सहयोग से एक चारा मक्का हाइब्रिड (AFH–7) को एनजीएम खरीफ 2023 के दौरान प्रजातीय पहचान समिति द्वारा उत्तर–पश्चिम क्षेत्र में जारी करने के लिए पहचाना गया।
- एक नए प्रकार का ज्वार जीनोटाइप, जिसमें कई गाइनोशियम, तीन–परागकण, प्रत्येक पैनिकल में प्रति सेसाइल स्पाइकलेट जुड़वां और त्रिपल बीज होते हैं, की पहचान की गई और पंजीकरण के लिए प्रस्तुत किया गया।
- बाजरे में कम लिग्निनय उच्च पत्ती तना अनुपात एवं देर से फूल आनाय अधिक टिलरिंग, पौधे की अधिक ऊँचाई, उच्च पुनर्जनन क्षमता के लिए नए आनुवंशिक सामग्रियों की पहचान की गई।
- मक्का की देशी किस्मों (96) का कृषि–मॉर्फोलॉजिकल, चारा गुणवत्ता और सूक्ष्म पोषक तत्वों के लक्षणों के लिए मूल्यांकन किया गया, जिसमें मुख्य रूप से क्रूड प्रोटीन, आयरन और जिंक शामिल हैं।
- मक्का में दोहरे उद्देश्य वाली जनसंख्या विकसित करनेय बाजरे (मिश्रित) में बहु कटाई के लिएय ज्वार में उच्च बायोमास और बहु–पर्णीय रोग प्रतिरोधी जनसंख्या को विकसित करने के प्रयास किए गए।
- चारे के लिए उच्च बायोमास, बहुविध कटाई, प्रारंभिक परिपक्वता, गुणवत्ता, प्रतिरोध और तनाव (स्ट्रेस) के लिए लोबिया, मक्का, बाजरा, ज्वार और जई की क्रॉस और इनब्रेड की विभिन्न पीढ़ियों को उन्नत किया गया।
- बाजरे की 257 जीनोटाइप की एसोसिएशन पैनल का हरा चारा उत्पादन और गुणवत्ता लक्षणों के लिए मूल्यांकन किया गया।
- उच्च उपज देने वाली 24 बहुविध कटाई वाली बाजरे की खुले परागण किस्मों को क्रोस किया गया ताकि श्रेष्ठ पुनः संयोजक (recombinants) पहचाने जा सकें। 13 बहुविध ज्वार लाइनों ने 5 के पैमाने पर उच्च पुनर्जनन क्षमता दिखाई।
- सूखा सहन करने वाली ज्वार लाइनों का फील्ड परिस्थितियों में मूल्यांकन किया गया।
- 1905 जई लाइनों से विविधता का प्रतिनिधित्व करने वाली 227 (11%) जीनोटाइप की एक कोर सेट विकसित की गई। लक्षण–विशिष्ट लाइनों का भी चयन किया गया, जिसमें 07 लाइन्स को पत्तियों की संख्या के

लिए, 12 लाइन्स को पत्तियों की लंबाई के लिए, 29 लाइन्स को पत्तियों की मोटाई के लिए, 13 लाइन्स को तने की मोटाई के लिए, 15 लाइन्स को प्रारंभिक और देर से परिपक्वता के लिए, 31 लाइन्स को पौधे की ऊँचाई के लिए, 33 लाइन्स को बीज की मोटाई के लिए, 08 लाइन्स को पैनिकल लंबाई के लिए और 18 लाइन्स को स्पाइकलेट्स की संख्या के लिए चयनित किया गया।

- लवणता और क्षारीयता प्रतिबल (stress) के लिए 105 जई लाइनों की स्क्रीनिंग के परिणामस्वरूप भविष्य के अध्ययन के लिए 21 लाइनों की पहचान की गई।
- कम फॉस्फोरस परिस्थितियों में उच्च फॉस्फोरस उपयोग क्षमता (PUE) वाली लोबिया जीनोटाइप की पहचान की गई।
- बाजरे में ब्लास्ट प्रतिरोध के लिए पहचाने गए 14 एसएनपी में से दो को रोग प्रतिरोध प्रोटीन और फॉस्फेटिडाइलिनोसिटोल या फॉस्फेटिडाइलकोलाइन ट्रांसफर प्रोटीन के कार्य से संबंधित पाया गया।
- गिनी घास में अपोमेइओसिस (MSP1), पार्थेनोजेनेसिस/एंब्रायोजेनेसिस (BBM1) और स्वायत्त एंडोस्पर्म विकास (FIS1) के जीन के साथ अभिव्यक्ति अध्ययन से पता चला कि सेक्सुअल लाइन की तुलना में पूर्व–मेयोसिस, मेयोसिस और पोस्ट–मेयोसिस चरणों में अभिव्यक्ति का पैटर्न विभिन्न प्लोइडी में भिन्न था।
- लोबिया में फूल आने के समय (FT) जीन के लिए पूरे जीनोम की पहचान करते समय लोबिया जीनोम में 13 थ्ज जीन पाए गए।
- मक्का, बाजरा, लोबिया, बीएन, जई और ज्वार जैसी चारा फसलों में स्टेशन परीक्षण किए गए।
- खरीफ 2023 में अखिल भारतीय परीक्षण के लिए 13 प्रविष्टियाँ प्रस्तुत की गईं, जिसमे एकल एवं बहु कटाई के वाली मक्का (03), बाजरा (06), ज्वार (01) और लोबिया (03) विष्टियाँ थीं।
- AICRP-FC, झाँसी, IARI, नई दिल्ली, ICRISAT और IIMR, हैदराबाद के 20 परीक्षण मुख्य रूप से मक्का (08), बाजरा (04), जई (06), ज्वार (02) में आयोजित किए गए।
- जई की किस्मों JHO–822, JHO–851, JHO–99–1, JHO–99–2, JHO–2000–4, JHO–10–1, JHO–09–1, JHO–12–2 और JHO–15–1 में नाभिक बीज उत्पादन (57 किग्रा) किया गया। चारा लोबिया 3 किस्मों BL–1 (8 किग्रा), BL–2 (7 किग्रा) और BL–4 (7 किग्रा) में भी नाभिक बीज उत्पादन किया 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।

- अर्ध–शुष्क क्षेत्र के लिए सिल्विपास्चर प्रणाली में पुर्नस्थापन पारिस्थितिकी के अंतर्गत, हरा चारा उत्पादन (GFY) गिनी घास (39.58 टन/हेक्टेयर) में सबसे अधिक पाया गया, इसके बाद धवलू घास (26.03) और स्आइलोसांथेस सीब्राना (9.18) में प्राप्त हुआ। पेड़/झाड़ियों में, सर्वाधिक हरा चारा उत्पादन सुबबूल (13.29 टन/हेक्टेयर) में प्राप्त हुआ, इसके बाद पाकड़ (5.86), देसी बबूल (4.17) और सहतूत (3.91 टन/हेक्टेयर) में था। सुबबूल एवं पाकड़ आधारित सिल्विपास्चर प्रणाली में जलौनी भेड़ के चराई के दौरान, 1% शरीर वजन के अनुपात में पूरक राशन देने से दोनों प्रणालियों में दैनिक शरीर वजन में लगभग 50 ग्राम की वृद्धि दर्ज की गयी।
- तीन–स्तरीय सिल्विपास्चर प्रणाली में झाड़ियों और पेड़ों की कटाई–छटाई प्रबंधन के अंतर्गत, 70% तीव्रता पर छटाई करने से 50% तीव्रता (2.71 और 3.23 टन/हेक्टेयर) की तुलना में अधिक टॉप फीड (3.57 टन/हेक्टेयर) और जलाऊ लकड़ी (4.25 टन/हेक्टेयर) प्राप्त हुई । झाड़ी प्रजातियों में, बेर में सबसे अधिक टॉप फीड और जलाऊ लकड़ी प्राप्त हुई, इसके बाद देसी बेर एवं घोट (हार्डविकिया बिनाटा के सहयोग में) का स्थान रहा। तीन–स्तरीय सिल्विपास्चर प्रणाली में जलौनी भेड़ और बुन्देलखण्डी बकरियों को चारा वृद्धि मास एवं बाद के महीनो में चराई की, जिसमें बकरियों में औसत दैनिक शरीर भार वृद्धि लगभग 64 ग्राम और भेड़ों के लिए 62 ग्राम पाई गई।
- अंजन वृक्ष आधारित सिल्विपास्चर प्रणालियों में छंटाई प्रबंधन के अंतर्गत, अंजन वृक्ष की शाखाओं की 60% छंटाई से 30 और 45% कैनोपी छंटाई की तुलना में काफी अधिक टॉप फीड (4.10 टन/हेक्टेयर) और जलाऊ लकड़ी (6.09 टन/हेक्टेयर) प्राप्त हुई । अंजन की शाखाओं की 60% छंटाई से चारागाह में चारा उत्पादन (9.94 टन/हेक्टेयर) भी 30 और 45% छंटाई की तुलना में अधिक पाया गया । अंजन की शाखाओं की हल्की छंटाई (30%) से 45 एवं 60% की तुलना में 0–15, 15–30 और 30–60 सेमी मिट्टी की गहराई अधिक मृदा नमी प्राप्त हुई।
- फल और चारा सुरक्षा के लिए मिट्टी और पेड़ प्रबंधन प्रथाओं के साथ उन्नत हॉर्टिपास्चर प्रणाली में

उत्पादकता बनाए रखने के अंतर्गत, प्राकृतिक खेती को बढ़ावा देने के लिए आँवला आधारित हॉर्टिपास्चर प्रणाली में विघटन उत्प्रेरक का मूल्यांकन किया गया। अमरूद आधारित हॉर्टिपास्चर प्रणाली में, उच्च सांद्रता वाले सूक्ष्म पोषक तत्वों ($ZnSO_4$ + बोरैक्स) के पर्णीय अनुप्रयोग ने अमरुद की ललित और श्वेता किस्मो में क्रमशः अधिक फल लगे (61.4 और 59.6%) और अधिक फल उत्पादन (53.4 और 49.2 किग्रा/पेड़) के साथ–साथ भौतिक–रासायनिक संरचना में सुधार देखा गया। अन्तःस्थान में 3.1 से 3.6 टन सूखा चारा प्रति हेक्टेयर प्राप्त हुआ ।

- विभिन्न कृषि–जलवायु क्षेत्रों में सहतूत एवं अरडू के विभिन्न जनन द्रव्यों का मूल्यांकन करने पर पता चला कि झांसी में एक साल की फील्ड प्लांटिंग के बाद शहतूत के 73 जनन द्रव्यों में 33.33–100% और श्रीनगर में समशीतोष्ण परिस्थितियों में मूल्यांकित 20 जनन द्रव्यों में 10–70% जीवितता पाई गई। शहतूत की जस्ट किस्म में अधिक ऊँचाई और अधिक व्यास दर्ज किया गया । अरडू में, झाँसी और अविकानगर में 57 पेड़ों के बीजों से क्रमशः 0–15% और 0–61% अंकुरण दर दर्ज की गई।
- अर्ध–शुष्क क्षेत्र में बेल से अधिक उत्पादकता और चारा सुरक्षा के लिए पुनर्जीवित कैनोपी संरचना के अंतर्गत, बेल सीवी. CISHB–2 के केंद्रीय नेता प्रणाली (27.97 टन/हेक्टेयर) और खुले केंद्र प्रणाली (26.78 टन/हेक्टेयर) के बाद अकेले चरागाह प्रणाली (30.19 टन/हेक्टेयर) में सर्वाधिक घास उत्पादन (ताजे वजन) दर्ज किया गया। अनट्रेंड बेल पेड़ के नीचे उगाई गई घास में सबसे कम उत्पादन (19.75 टन/हेक्टेयर) दर्ज किया। केन्द्रीय नेता प्रणाली के साथ प्रशिक्षित बेल पेड़ों ने अधिक फल उत्पादन (41.91) किया, इसके बाद खुले केंद्र (41.65) और संशोधित केंद्रीय नेता (38.47), और अनट्रेंड प्रणाली (30 किग्रा/पेड़) में सबसे कम फल उत्पादन उत्पादन दर्ज किया गया।
- भू–स्थानिक प्रौद्योगिकी का उपयोग करके घास भूमि मूल्यांकन प्रणाली के विकास के अंतर्गत, छतरपुर जिले में सर्वेक्षण द्वारा भारत के लैंडसैट 8 तकनीक का उपयोग करके घासभूमि का आधार मानचित्र और विषयगत परतें उत्पन्न की गईं। एक बहु–मापदंड निर्णय विश्लेषण पद्धति (TOPSIS) ने संकेत दिया कि बामिथा, बारी और दौरिया क्षेत्रों में घासभूमि की स्वास्थ्य स्थिति बेहतर थी।

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

- सीवेज जल सिंचाई के परिणाम स्वरुप क्रोमियम, कैडमियम एवं शीशा जैसे तत्वों का अवशेष सुरक्षित स्तर के अंतर्गत पाया गया, लेकिन निकिल की मात्रा सुरक्षित सीमा से अधिक पाई गई। कानपुर और भोपाल में पशु दूध और रक्त के नमूनों में क्रोमियम, कैडमियम एवं शीशा का अवशिष्ट स्तर अधिकतम अनुमेय सीमा से अधिक पाया गया। मिट्टी–चारा–पशु श्रृंखला में भारी धातु संचय को कम करने के लिए कम धातु–संचय चारा फसलों और सीवेज जल के पतले अनुपात (1:3 सीवेज जल से भूजल) का संयोजन अपनाने की सिफारिश की जाती है।
- संकर बाजरा नेपिएर में 75% RDF के साथ 50% उपलब्ध मिट्टी की नमी पर ड्रिप सिंचाई ने किसान प्रथा की तुलना में 13% अधिक हरा चारा उपज दर्ज की गयी। इससे सिंचाई जल की 20–55% बचत भी हुई।
- प्राकृतिक सिलिकॉन स्रोतों और फास्फोरस घोलक माइक्रोब (PSM) का उपयोग करके मूल मिट्टी फॉस्फोरस का घुलन किया गया। मिट्टी को फास्फोरुस घोलक माइक्रोब और धान के पुआल (RS) की क्रमिक खुराकों के साथ विभिन्न जल–तापीय परिदृश्यों में उपचारित किया गया। 10 टन/हेक्टेयर पर धान के पुआल का अनुप्रयोग 2.7–3.6% अकार्बनिक फास्फोरस को घोल सकता है, जिससे फास्फोरस उपलब्धता में 3.3 से 5–4 गुना वृद्धि होती है। सिलिकॉन सांद्रता और मिट्टी के पीएच में परिवर्तन मिट्टी के वातावरण को प्रभावित करने वाले सबसे महत्वपूर्ण कारक थे। कुल मिलाकर, वार्षिक धान के पुआल (10 टन/हेक्टेयर). फास्फोरस घोलक माइक्रोब अनुप्रयोग विभिन्न नमी उपलब्धता में नम उष्णकटिबंधीय इन्सेप्टिसोल्स में फास्फोरस उपलब्धता को बनाए रख सकता है।
- चारा झाड़ी–आधारित एली फसल सिस्टम में सिंचित परिस्थितियों में, संकर बाजरा नेपियर के साथ सहजन में सबसे अधिक हरा चारा, शुष्क चारा एवं और कच्चे प्रोटीन का उत्पादन दर्ज किया गया। वर्षा आधारित चारा झाड़ी–आधारित एली क्रॉपिंग सिस्टम में, मोरिंगा के साथ चराई वाली गिनी एवं सिग्नल घास ने हरा चारा, सूखा चारा और अधिक कच्चा प्रोटीन उत्पादन दर्ज किया गया जो कि सेस्बानिया और सुबबूल आधारित प्रणालियों की तुलना में बेहतर पाया गया। वर्षा आधारित परिस्थितियों में, सहजन चारा झाड़ियाँ, सेस्बानिया और सुबबुल की तुलना में श्रेष्ठ पाई गईं।

- धान के पुआल से बने न्यूट्रिजेल पर्यावरणीय परिदृश्य के आधार पर पोषक तत्व जारी करते हैं। न्यूट्रिजेल के माध्यम से 50% NPK, 25% NPK खनिज उर्वरक के माध्यम से देने पर चारा ज्वार और जई फसलों की जैवमास उत्पादन, पोषक तत्व अवशोषण और पोषक तत्व उपयोग दक्षता को सुधार सकता है, एवं फसल उत्पादन को बिना कम किए खनिज उर्वरक की 25% और पानी की 17–22% बचत कर सकता है

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

- पीले, लाल और गहरे लाल बीज कोट रंग वाले बरसीम बीजों को विभिन्न तापमानों पर पॉलीथीन बैग में भंडारण करने से उनके अंकुरण और विद्युत चालकता पर प्रभाव पड़ता है, जो समय के साथ घटता जाता है। गहरे रंग के बीजों में उच्च जैव रासायनिक सामग्री लेकिन पीले बीजों की तुलना में कम एंटीऑक्सीडेंट गतिविधि पाई गई।
- एक मशीन बनाई गई जो स्टेनलेस स्टील से बनायीं गयी है (1100x400x1000 मिमीय क्षमताः 150 लीटर/ घंटा तक) जो न्यूनतम नुकसान सुनिश्चित करते हुए धुएं को पानी के साथ कुशलता से मिश्रित करती है । यह देखा गया कि 100% सांद्रता (धुँआ पानी बिना पतला किए) के साथ धुएं का पानी दीनानाथ एवं लम्पा घास के अंकुरण को रोकता है, जबकि 1% सांद्रता के धुएं का पानी मानक की तुलना में बीज अंकुरण को बढ़ाती हैद्य इस प्रकार धुआं पानी की सांद्रता बीज अंकुरण पर पड़ने वाले प्रभाव को उजागर करती है।
- पांच समशीतोष्ण चारा फसलों जैसे *Trifolium pratense, Bromus unioloides, Dactylis glomerata, Festuca arundinacea* और *Lolium multiflorum* में बीज मानकों का विकास किया गया और पांच नई समशीतोष्ण चारा फसलों जैसे *timothy, red fescue, white clover, sainfoin* और persian clover में बीज मानक विकशित करने की पहल की गई।
- 206 विविध बरसीम लाइनों के अंकुरण प्रतिशत के आधार पर NIR स्पेक्ट्रा उत्पन्न किया गया। प्रिंसिपल कंपोनेंट एनालिसिस (PCA) का उपयोग करके स्पेक्ट्रल विविधता का पता लगाया गया। इसके अतिरिक्त, मल्टीवेरिएट पार्शियल लीस्ट स्क्वेर्स (MPLS) ने सटीक स्पेक्ट्रोस्कोपिक डेटा विघटन के लिए संदर्भ मानों का उपयोग किया गया ।
- चारा लोबिया की किस्मों (कोहिनूर, BL–1, BL–2, BL–4 और EC–4216) को शाकीय से परिपक्वता चरण तक परिवेश और ऊंचे (परिवेश से 2°C अधिक) तापमानों पर ओपन–टॉप चौम्बर्स में जाँचा गया। कोहिनूर और BL–1 किस्में तापमान तनाव के प्रति EC–4216, BL–2 और BL–4 की तुलना में अधिक सहनशील पाई गईं।
- विभिन्न स्थानों से एकत्र किये गए सिराट्रो और ब्रिकयेरिया के नमूनों की भौतिक शुद्धता विश्लेषण और बीज गुणवत्ता मूल्यांकन किया गया एवं दोनों मापदंडो के लिए औसत डेटा निकाला गया। इन दोनों फसलों में बीज गुणवत्ता परीक्षण के लिए प्रोटोकॉल विकसित किए गए।

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

- भेड़ एवं बकरियों द्वारा चरागाह में चराई तीव्रता का अध्ययन किया गया और पाया गया कि दिन के अधिकांश समय, जिसमें सुबह, दोपहर और शाम शामिल हैं, भेड़ें घास पसंद करती हैं। जबकि बकरियां विभिन्न प्रकार के पौधों की प्रजातियों को पसंद करती हैं, जिसमें सुबह और दोपहर में घास और शाम को कांटेदार झाड़ियाँ और झाड़ियाँ शामिल हैं। बारिश के मौसम में, दोनों प्रजातियों में, चराई का समय और चराई का सेवन परिवेश के तापमान और आर्द्रता के साथ नकारात्मक रूप से सहसंबंधित था।
- लौंग से निकाले गए आवश्यक तेल ने आलू डेक्सट्रोज एगर माध्यम में 250 µL/mL या उससे अधिक की सांद्रता पर फफूंद (*Aspergillus parasiticus* और *Aspergillus flavus*) की वृद्धि को रोक दिया। तेल में A- flavus की तुलना में A- parasiticus में अधिक वृद्धि अवरोध देखा गया।
- सहिमा जीनोटाइप IG02–695–1 और नेपियर बाजरा संकर के साइलेज को भेड़ों को खिलाने पर दोनों में शुष्क पदार्थ, कार्बनिक पदार्थ की पचाकता एवं नत्रजन सेवन समान पाए गए। सेलूलोज पाचकता नेपियर बाजार संकर में अधिक थी। नत्रजन प्रतिधारण (%) बीएनएच के लिए अधिक (49.44) और बीएस1 के लिए सबसे कम (39.23%) था।
- उपचार समूहों के तहत प्राकृतिक चरागाहों ने 5.44–9.013 टन शुष्क घास/हेक्टेयर उपज दी। पोषक तत्वों की पाचकता तुलनीय थी, सिवाय एनडीएफ के जो स्टॉकिंग दरों SR3 (65.96) esa SR1 (72.58) की तुलना में कम थी। जानवरों ने सभी स्टॉकिंग दरों में

नवम्बर तक शरीर का वजन बढ़ाया; SR1 में सबसे अधिक वृद्धि देखी गई।

- जालौनी मेमनों को टीएमआर साइलेज खिलाने पर डीएम, एनडीएफ और सीपी पाचनशक्ति (64.67, 60.78 और 65.80%) नियंत्रण समूह (62.02, 56.72 और 63.38%) की तुलना में बेहतर थी। रुमेन लिकर NH3N (mg/dl) और TVFA (mmol/L) भी उपचारित समूह में नियंत्रण समूह (22.59 और 66.33) की तुलना में अधिक थे। दैनिक वजन बढ़ाव (80.75g) साइलाज खिलाए गए जानवरों में नियंत्रण (74.2g) की तुलना में बेहतर था।
- गांवों में सर्वेक्षण से पता चला कि बुन्देलखण्डी बकरी का झुंड आकार 3 से 86 तक था। झुंड में वयस्क/वर्षीय मादा (62%) प्रमुख थीं। प्रजनन बकरे केवल 9.8% थे। औसत शरीर का वजन जन्म पर, 3, 6 महीने और 12 महीने पर क्रमशः 2.35±0.07, 9.41±0.27, 13.82±0.28 और 20.00±0.37 किग्रा था। 90 दिनों में औसत दूध उत्पादन 41.99±3.07 लीटर था और दुग्ध अवधि 90.71±6.63 दिन थी।
- वर्ष 2023 में भदावरी भैंसों की औसत दुग्ध अवधि, दुग्ध उत्पादन, मानक दुग्ध उत्पादन और शिखर उत्पादन क्रमशः 1657.40±65.6 किग्रा, 352.8±14.4 दिन, 1496.98± 549.9 किग्रा और 8.08±0.13 किग्रा था। औसत दूध वसा, एसएनएफ, प्रोटीन और लैक्टोज क्रमशः 8.23±0.17, 9.78±0.13, 3.54±0.04 और 5.32±0.07: थे। प्रथम ब्यांत के समय की औसत आयु 49.17±4.5 महीने पाई गई। वर्ष के दौरान गर्भाधान दर 62.24% थी।
- छोटे और हल्के घास के बीजों की पेलेट बनाने के लिए एक अर्ध–स्वचालित पेलेटिंग मशीन का निर्माण किया गया। मशीन का प्रदर्शन दीनानाथ घास के बीजों के लिए मूल्यांकन किया गया। 5 किग्रा मिट्टी, 100 ग्राम फुल्के/फुज्जिकृत बीजों को पेलेट में बदलने में 8–10 मिनट का समय लगा। मशीन की क्षमता 60 किग्रा/घंटा थी। पेलेट में सच्चे बीजों के वजन के बढ़ने के साथ अंकुरित बीजों की संख्या बढ़ी, जबकि खाली पेलेट में घट गई। प्रति हेक्टेयर अनुकूल पौध संख्या के लिए आवश्यक पेलेट की संख्या 100 ग्राम सच्चे बीजों के लिए 31,949 और 200 ग्राम सच्चे बीजों के लिए 17,259 थी।
- चारा बीज कोटिंग और उपचार के लिए एक मशीन विकसित की गई। मशीन में बीज दर नियंत्रण के लिए एक स्लाइडर गेट, 200˜ मोटर के साथ एक रासायनिक मिक्सर और 137 लीटर वॉल्यूम के लिए एक स्टेनलेस स्टील कोटिंग चेंबर है। यह प्रति बैच 15–20 किग्रा बीजों का उपचार कर सकती है, जिसकी दक्षता 97% है। इस मशीन से 91% श्रम बचाता है और 10 रु./किग्रा की लागत आती है। इसे विभिन्न चारा बीजों के साथ–साथ अनाज/सब्जी के बीजों के उपचार के लिए पाउडर या ग्रैन्युलर और तरल रासायनिक एजेंट/पॉलिमर के साथ उपयोग किया जा सकता है एवं ऑपरेटर के लिए पूर्ण सुरक्षित है।
- कृषि कार्यों जैसे जुताई/निराई, बुआई, परिवहन आदि के लिए चार ट्रैक्शन पहियों वाली सौर ऊर्जा संचालित बहुउद्देश्यीय मशीन डिजाइन की गई है। एक 250 W DC मोटर इस मशीन के पिछले पहियों को शक्ति प्रदान करती है। इस मशीन की चार्जिंग के लिए एक सौर चार्जिंग स्टेशन स्थापित किया गया, जिसमें एक सौर पैनल (अधिकतम दक्षता के लिए 40° कोण पर झुका हुआ), सौर प्रबंधन इकाई, बॉक्स, बैटरी और कनेक्टर शामिल हैं।
- एक ट्रैक्टर–चालित फ्रंट माउंटेड फॉरेज हार्वेस्टर के प्रोटोटाइप का परीक्षण किया गया। मशीन को चारा फसलों की कटाई, गाँठों को बाँधने और साइलाज तैयारी के लिए उपयुक्त पाया गया। सिमरधा गांव, झांसी में एक रीपर बाइंडर मशीन का अग्रिम पंक्ति प्रदर्शन किया गया।

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

- झाँसी के 10 किसानों के खेतों पर किए गए संशोधनों के साथ प्रभावी आईएफएस मॉडलों के मूल्यांकन ने चारे की कमी के मुद्दों में 40–50% की कमी और पशु उत्पादकता में 18–30% की वृद्धि दर्ज की गयी। छोटे और मध्यम–बड़े किसानों के यहाँ भी सकारात्मक परिणाम देखे गए, जिसमें 2–3 लाख रुपये की आशाजनक वापसी और आय में वृद्धि (1.6–2.0 गुना) हुई।
- एससीएसपी कार्यक्रम के तहत कुल 24 प्रशिक्षण सत्र, चारा प्रौद्योगिकियों पर 984 प्रदर्शन, पशु प्रौद्योगिकियों पर 281 प्रदर्शन, और अन्य कृषि प्रौद्योगिकियों पर 832 प्रदर्शन छह राज्यों में कृषि विज्ञान के सहयोग से किये गए ।
- झाँसी जिले में एससीएसपी हस्तक्षेप के प्रभाव विश्लेषण से पता चला कि तकनीकी हस्तक्षेप ने फार्म आय में 45–51% और एससी किसानों द्वारा कृषि एवं घरेलू संपत्ति 23–27% की वृद्धि दर्ज की गयी।

- NIAP–नेटवर्क परियोजना के तहत चारे की किस्मों का आर्थिक प्रभाव मूल्यांकन से पता चला कि IGFRI–727 (*C. ciliaris*), JHO–822 (ओट) और बुंदेल दीनानाथ–2 (*Pennisetum pedicellatum*) आर्थिक प्रभाव क्रमशः 7. 17, 29.59 और 3.14 करोड़ रुपये लगभग था।
- ट्राइबल सब प्लान के तहत 1036 चारा प्रौद्योगिकी प्रदर्शनों (FTDs) का संचालन किया गया और छह राज्यों में 27 जागरूकता शिविर सह प्रशिक्षण कार्यक्रम आयोजित किए गए। प्रभाव विश्लेषण ने चारा फसलों की उत्पादकता में 25–30% और दूध उत्पादन में 15–25% की महत्वपूर्ण वृद्धि दिखाई।
- उत्तर पूर्व क्षेत्र कार्यक्रम के तहत केन्द्रीय कृषि विश्वविद्यालय, इम्फाल ने छह प्रशिक्षण कार्यक्रम आयोजित किए, जिससे 206 प्रशिक्षार्थियों को लाभ हुआ, साथ ही 75 फसल प्रदर्शन और सामान वितरण किए गया। असम कृषि विश्वविद्यालय, जोरहाट द्वारा वर्षभर चारा उत्पादन और संरक्षण पर 13 प्रशिक्षण सत्र आयोजित किए गए, जिससे 430 कृषकों को लाभ हुआ और नौ पशु स्वास्थ्य शिविर आयोजित किए गए, जिससे 550 किसानों को लाभ हुआ। आईसीएआर–एनआरसी मिथुन, मेडजिफेमा ने साइलेज प्रशिक्षण आयोजित किया और 102 लाभार्थियों को बेबी कॉर्न और स्वीट कॉर्न (प्रत्येक 30 किग्रा.) के बीज वितरित किए।
- फार्मर फर्स्ट कार्यक्रम के तहत, तकनीकी हस्तक्षेपों को पांच मॉड्यूल्स (फसल–आधारित, पशुधन, बागवानी, आईएफएस और किसान क्षमता निर्माण) में लागू किया गया। हरे चने (IPM 2–3), मूंगफली (TG 37A) और गेहूं (Raj–4079) जैसी उन्नत फसल किस्मों के शुरुवात से क्रमशः 2.12, 3.00 और 2.54 का उच्च लाभ–लगत अनुपात प्राप्त हुआ। उन्नत सब्जी किस्मों ने स्थानीय किस्मों की तुलना में प्रति रुपये निवेश पर 40% अधिक सकल रिटर्न दिया। प्रभाव मूल्यांकन से पता चला कि प्रौद्योगिकी अपनाने से घरेलू मासिक उपभोग व्यय में उल्लेखनीय वृद्धि हुई (38,880 रुपये तक)।
- कृषि तकनीकि सुचना केंद्र के द्वारा कुल 37 साप्ताहिक ऑनलाइन बैठकें और वैज्ञानिक–किसान संवाद सत्र आयोजित किए गए। 'अंतर्राष्ट्रीय बाजरा वर्ष' के उत्सव के दौरान आयोजित प्रदर्शनी सह किसान मेला में 300 किसानों ने सम्मिलित होकर लाभ प्राप्त किया।
- कृषि व्यवसाय इन्कुबेतैओन सेण्टर केंद्र ने व्यावसायिक बकरी पालन, संकर नेपिएर उत्पादन और उपयोग, और हरे चारे को साइलाज में बदलने पर तीन उद्यमिता विकास प्रशिक्षण कार्यक्रम आयोजित किए, जिससे 38 प्रशिक्षुओं को लाभ हुआ। एक कार्यशाला चारा बीज प्रौद्योगिकी हस्तांतरण पर आलमदार सीड्स प्राइवेट लिमिटेड के साथ आयोजित की गई और आईजीएफआरआई ने एक एफपीओ और एक किसान के साथ अनुबंध के लिए 200.0 किग्रा बरसीम बीज प्रदान किए। एकसीड डिजिटल, झाँसी ने एबीआईआईग्रो 2.0 – एग्री–स्टार्टअप्स के लिए प्रशिक्षण कार्यक्रम का सफलतापूर्वक समापन किया। एबीआईसी ने स्टार्ट–अप्स के लिए इनक्यूबेशन सुविधा भी प्रदान की और बुन्देलखण्ड एग्री–स्टार्टअप शिखर सम्मेलन में भाग लिया।

Executive Summary

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

- Lucerne variety IGFR-DL-2 (AWCL-2) was identified for release in NW zone of India and IGFR-DL-5 (IGFRI-Dharwad Lucerne-5) for state release *i.e*. Zone 8 and Zone3 of Karnataka. One entry AWL-6 of Lucerne (Annual) promoted to AVT-1 in central zone. One new entry of Lucerne (Annual) - IGFRI-DL-1 contributed for *rabi* 2023-24.
- Seasonal incidence of fall armyworm at Dharwad was noticed in both *kharif* and *rabi* and was more during *kharif*. Highest incidence of 55% was noticed during last week of August and second peak of 25% during last week of December. Among all the eco-friendly approaches *Metarhizium (Nomuraea) anisopleae* was found to be more effective during both rounds of spray. Among insecticides, emamectin benzoate 5 WG @ 0.5g/lwas found more effective during both rounds of spray.
- A total of 548 accessions of forage grasses were collected and evaluated during *kharif* 2023 and 45 accessions of *Panicum* species procured from USDA were characterized.
- About 222 accessions of berseem, 230 cowpea germplasm and 57 accessions of dinanath grass were sent to ICAR-NBPGR for long term conservation.
- A total of 10,896 accessions of forage crops are being maintained in the MTS module at ICAR-IGFRI, Jhansi and 19 varieties of BN hybrid, guinea grass and marvel grass are maintained as Field Gene Bank in NAGS.
- Dinanath variety, JHD-19-4 (Bundel Dinanath-3) was notified for release by CVRC with notification no. S.O. 4222(E), dated 25th Sep 2023.
- One fodder maize hybrid (AFH-7) of IGFRI and IARI collaboration was identified for release in north west zone by varietal identification committee during NGM *kharif* 2023.
- A novel sorghum genotype with multiple gynoecium three-stamens, twin and triplet seeds per sessile spikelet per panicle was identified and submitted for registration.
- Novel genetic materials were identified in pearl millet for low lignin; high leaf to stem ratio and late flowering; high tillering, higher plant height, higher regrowth potential.
- Maize landraces (96) were evaluated for agro-morphological, forage quality and micronutrients traits mainly crude protein, iron and zinc.
- Dual purpose population in maize was developed; composites in pearl millet for multicut; population for high biomass and multi-foliar disease resistance in sorghum were also developed.
- Different generations of crosses and inbreds meant for high biomass, multicut, early maturity, quality, resistance and stress were advanced in cowpea, maize, bajra, sorghum and oats.
- Pearl millet association panel of 257 genotypes was evaluated for green forage yield and quality traits.
- Twenty four high-yielding multicut pearl millet open pollinated varieties were crossed to identify superior recombinants. 13 multicut sorghum lines showed high regeneration potential on the scale 5.
- Drought tolerant sorghum lines were evaluated in field conditions.
- A core set of 227 (~11%) genotypes representing diversity from 1905 oat lines was developed. Trait specific lines were also selected which includes 07 lines for leaf number; 12 lines for leaf length; 29 for leaf thickness; 13 for stem girth; 15 for early and late maturity; 31 for plant height; 33 for seed thickness; 08 for panicle length and 18 for number of spikelet's.
- Screening of 105 oat lines for salinity and alkalinity stress led to identification of 21 lines for future studies.
- High PUE cowpea genotypes were identified under low-P regimes
- From 14 SNPs identified for blast resistance in pearl millet, two were identified as associated with the disease resistance protein and to the function of phosphatidylinositol or phosphatidylcholine transfer protein.
- Expression study with the genes of apomeiosis (MSP1), parthenogenesis/embryogenesis (BBM1) and autonomous endosperm development (FIS1) in guinea grass showed that pattern of expression

was differing in ploidies at pre-meiotic, meiotic and post meiotic stages as compared to sexual line.

- Genome wide identification for flowering time (FT) gene in cowpea revealed 13 FT genes in cowpea genome.
- Station trials conducted in forage crops *viz*., maize, bajra, cowpea, BN, oat, and sorghum.
- Thirteen entries were submitted for all India testing in *kharif* 2023 meant for single cut, multicut in maize (03), bajra (06), sorghum (01) and cowpea (03 entries).
- Twenty trials mainly from AICRP-FC, Jhansi, IARI, New Delhi, ICRISAT and IIMR, Hyderabad were conducted in maize (08), bajra (04), oat (06), sorghum (02) trials.
- Nucleus seed production (57 kg) was carried out in oat varieties, 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; three forage cowpea varieties *viz*., BL-1 (8), BL-2 (7) and BL-4 (7 kg).

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

- Under restoration ecology in silvipasture system for semiarid region, green forage yield (GFY) was maximum in *Megathyrsus maximus* (39.58 t ha^{-1}) followed by *Chrysopogon fulvus* (26.03) and *Stylosanthes seabrana* (9.18).Among tree/shrubs maximum GFY was obtained from *Leucaena leucocephala* (13.29 t ha^{-1}) followed by *F. infectoria* (5.86), *A. nilotica* (4.17) and *M. alba* (3.91 t ha^{-1}). Jalauni sheep grazing on *L. leucocephala* and *F. infectoria* based silvipasture system during growing season along with supplementation of concentrate @ 1% body weight could support a daily body weight gain of around 50 g under both the systems.
- Under lopping management in three tier silvipasture system, lopping of shrubs and trees at 70% intensity resulted in higher top feed (3.57 t ha^{-1}) and fire wood (4.25t ha^{-1}) as compared to 50% intensity (2.71 and 3.23 t ha^{-1}). Among shrub species, *Ziziphus mauritiana* recorded maximum top feed and fire wood followed by *Ziziphus* and *Acacia catechu* (in association with *Hardwickia binata*. Jalauni sheep and Bundelkhandi goats grazed in three-tier silvipasture system for growing season as well as post growing season showed average daily gain of around 64 g for goats and 62 g for sheep.
- Under pruning management in *H. binata* based silvipasture systems, 60% pruning of *H. binata* branches resulted in significantly higher top feed (4.10 t ha^{-1}) and fire wood yields (6.09 t ha^{-1}) as compared to 30 and 45% canopy pruning. Pasture yield (9.94 t ha^{-1}) significantly increased with 60% pruning of *H. binata* branches than 30 and 45% pruning. Light pruning of *H. binata* branches (30%) resulted in maximum moisture content followed by 45 and 60% pruning at 0-15, 15-30 and 30-60 cm soil depths.
- Under sustaining productivity in grown-up hortipastoral system for fruit and forage security with soil and tree management practices, evaluation of decomposer accelerator to promote natural farming in aonla-based hortipasture system was undertaken. In guava based hortipastoral system, foliar application of higher concentration of micronutrients ($ZnSO_4$ + Borax) recorded higher fruit set (61.4 and 59.6%) and fruit yield (53.4 and 49.2 kg/tree) as well as physico-chemical composition in Lalit and Shweta, respectively. The understorey pasture (*C. ciliaris* + *S. hamata*) production ranged from 3.1-3.6 t DM/ha.
- Evaluation of *Morus* species and *Ailanthus excelsa* germplasm under various agro-climatic zones revealed, 73 *Morus* germplasm had 33.33-100% survival after one year of field planting in Jhansi while 10-70% survival among 20 germplasms evaluated at temperate conditions in Srinagar and maximum height and diameter was observed for variety Zust. In case of *A. excelsa* seeds from 57 plus trees recorded 0-15% and 0-61% seedling emergence at Jhansi and Avikanagar, respectively.
- Under recuperated canopy architecture for higher bael (*Aegle marmelos*) productivity and forage security in semi-arid region, the highest grass yield (fresh weight) was recorded in sole pasture system (30.19 t ha^{-1}) followed by central leader (27.97 t ha^{-1}) and open centre system (26.78 t ha^{-1}) of bael *cv*. CISHB-2. Grass grown under untrained bael tree recorded the lowest yield (19.75 t ha^{-1}). Bael tree trained with central leader system produced higher fruit yield (41.91) followed by open centre (41.65) and modified central leader (38.47), and the lowest yield in untrained system (30 kg/tree).

- Under development of grassland assessment system using geospatial technology, the generation of base map and thematic layers of grasslands in the Chatarpur district was done using survey of India using Landsat 8 Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) a multi-criteria decision analysis method, indicated that Bamitha, Bari and Dauriya regions had better grassland health.

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

- Sewage water irrigation resulted in accumulation of Cr, Cd and Pb in safe, but Ni exceeded safe limit. Residue levels of Cr, Cd and Pb in animal milk and blood samples were found higher than the maximum permissible limit in Kanpur and Bhopal. Adoption of a combination of low metal-accumulating fodder crops and a sewage water dilution ratio (1:3 sewage water to groundwater) is recommended to minimize heavy metal accumulation in the soil- fodder-animal continuum.
- Drip irrigation at 50% available soil moisture in BN hybrid with 75% RDF recorded 13% higher GFY over farmer practice. It also saved 20–55% of irrigation water.
- Under solubilization of native soil phosphorus using natural sources of silicon and P solubilizing microbe (PSM), soils were treated with PSM (*Burkholderia cepacia*) and graded doses of rice straw (RS) under varying hydrothermal scenarios (temperature and soil moisture suctions). Application of RS at 10 t ha^{-1} could solubilize 2.7-3.6% of inorganic P enhancing P availability by 3.35-4 times over control, respectively. Silicon concentrations and changes in soil pH were the most significant factors to influence soil environment to mobilize soil P. Overall, annual RS (10 t ha^{-1}) + PSM application under varying moisture availability could sustain P availability in humid tropical Inceptisols.
- Among the fodder shrub-based alley cropping systems under irrigated conditions, moringa with BN hybrid recorded the highest GFY, DFY and crude protein yield (CPY). Among the rainfed fodder shrub-based alley cropping systems, moringa with grazing guinea signal grass recorded higher green fodder, dry fodder and crude protein yield as compared to sesbania and subabul based systems. The fodder shrubs moringa was found superior to sesbania and subabul under rainfed conditions.
- Nutrigels developed from rice straw are biodegradable and release nutrients based on the environmental scenario. Application of 50% NPK through Nutrigel + 25% NPK through mineral fertilizer could improve biomass yield, nutrient uptake and nutrient use efficiency of fodder sorghum and oat crops, and saved 25% mineral fertilizer and 17-22% water without reducing crop yield.

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

- Storing berseem seeds with yellow, red, and dark red seed coat color in polythene bags at varying temperatures affect their germination and electrical conductivity which decline over time. Dark-colored seeds exhibited higher biochemical content but lower antioxidant activity compared to yellow seeds.
- A machine was built with stainless steel (1100×400×1000 mm; Capacity: Up to 150 l/h) to efficiently mix smoke with water, ensuring minimal loss. It was observed that 100% concentration (smoke water without dilution) inhibits germination of *Pennisetum pedecellatum* and *Heteropogon* sp, whereas 1% concentration enhances it compared to control, highlight the impact of smoke water concentration on their seed germination.
- Development of seed standards in five temperate forage crops namely *Trifolium pratense*, *Bromus unioloides, Dactylis glomerata, Festuca arundinacea* and *Lolium multiflorum* was completed and five new temperate forages namely timothy, red fescue, white clover, sainfoin and persian clover were initiated.
- NIR spectra of 206 diverse berseem lines was generated on the basis of their germination percentage. Principal Component Analysis (PCA) was then employed to uncover spectral variance. Additionally, multivariate partial least squares (MPLS) utilized reference values for accurate spectroscopic data decomposition.
- Forage cowpea varieties (Kohinoor, BL-1, BL-2, BL-4 and EC-4216) were investigated under ambient as well as elevated (2°C higher than ambient) temperatures at vegetative to maturity stage in open-top chambers. Kohinoor and BL-1 varieties were found relatively tolerant to temperature stress than EC-4216, BL-2 and BL-4.

- Physical purity analysis and seed quality evaluation of Siratro and *Brachiaria* were conducted by collecting samples from diverse locations. Average data was worked out and potocols were developed for seed quality testing in these two crops.

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

- The majority of the day, including the morning, afternoon, and evening, sheep preferred grasses. While goats favoured a greater diversity of plant species, including grasses in the morning as well as afternoon, and thorny bushes followed by shrubs in the evening. Moreover, grazing time and grazing intake were negatively correlated with the ambient temperature and humidity during the rainy season in both species.
- Essential oil extracted from *Curcuma longa* inhibit the growth of *Aspergillus parasiticus* and *Aspergillus flavus* in potato dextrose agar medium at a concentration of 250 µl/ml and more. Oil has more growth inhibition in *A. flavus* than *A. parasiticus*.
- The DM, OM digestibility and N intake were similar between Sehima genotype IG02-695-1 and NBH silage fed to sheep. Cellulose digestibility tended to be higher for BN hybrid. N retention (%) was higher for BNH (49.44) and lowest for BS1 (39.23%).
- Natural pastures yielded 5.44- 9.013t DM/ha herbage under treatment groups. Nutrients digestibility was comparable except NDF was lower in stocking rates SR_3 (65.96) than SR_1 (72.58%). Animals gained body weight in all stocking rates up to November; being highest in SR_1.
- Jalauni lambs fed TMR silage had better DM, NDF and CP digestibility (64.67, 60.78 and 65.80%) than control (62.02, 56.72 and 63.38%). Rumen liqour NH3N(mg/dl) and TVFA (mmol/L) were also higher (31.36 and 80.83) in treated group than in control group (22.59 and 66.33). Daily body weight gain (80.75g) was improved in silage fed animals than in control (74.2g).
- Field survey in villages revealed that Bundelkhandi goat flock-size ranged from 3 to 86. The flock was predominated by adult/yearling females (62%). Breeding bucks were available 9.8% only. Average body weights at birth, 3, 6 and 12 months were 2.35±0.07, 9.41±0.27, 13.82±0.28 and 20.00±0.37 kg, respectively). Average milk yield at 90 days was 41.99±3.07 litres with lactation length of 90.71±6.63 days.
- During the year 2023 average lactation milk yield, lactation length, standard lactation milk yield and peak yield of Bhadawari buffaloes were 1657.40±65.6 kg, 352.8±14.4 days, 1496.98±549.9 kg and 8.08±0.13 kg, respectively. Average milk fat, SNF, protein and lactose were recorded as 8.23±0.17, 9.78±0.13, 3.54±0.04 and 5.32±0.07 %, respectively. Average age at first calving was recorded as 49.17±4.5 months. Conception rate was 62.24% during the year.
- A prototype of semi-automatic pelleting machine was fabricated for making pellets of small and lighter grass seeds. Performance of the machine was evaluated for Dinanath grass seeds. About 8-10 minutes was required to convert 5 kg soil + 100 g fluffy seeds into pellets. Machine had a capacity of 60 kg/h. Number of seeds germinated increased with increase in weight of true seeds in pellets, whereas decreased in blank pellets. Number of pellets required for optimum population per ha was 31,949 for 100 g true seeds and 17259 for 200 g true seeds.
- A forage seed coating machine was developed for seed coating and treatment. Machine has a slider gate for seed rate control, a chemical mixer with 200 W motor, and a stainless-steel coating chamber for 137 l volume. It can treat 15-20 kg seeds/batch, with 97% efficiency. It saves 91% labor and costs 10 Rs/kg. It can be used for treatment of different fodder seeds as well as grain/vegetable seeds with powder or granular and liquid chemical agents/polymers, and ensures the safety of operator.
- A solar powered self-propelled multipurpose machine for agricultural operations was designed with four traction wheels for transportation and traction force during weeding/tilling operations. A 250 W DC motor powered the rear wheel. A solar charging station was installed at CR farm, consisting of a solar panel (tilted at 40° angle for maximum efficiency), solar management unit, box, battery and connecters.

- A prototype feasibility testing was conducted on a tractor-operated front mounted forage harvester. The machine was found suitable for harvesting forage crops, binding knots, and for silage preparation. A frontline demonstration of a reaper binder machine was conducted in Simardha village, Jhansi.

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

- Assessment of promising IFS models with modifications at 10 farmers' fields in Jhansi showed significant reduction (40-50%) in fodder deficit issues and increase in animal productivity by 18-30%. Positive outcomes observed in small and medium-large farmers, with a promising return of 2-3 lacs rupees and income enhancement (1.6-2.0 times).
- Under SCSP programme, a total of 24 trainings, 984 demonstrations on fodder technologies, 281 demonstrations on animal technologies, and 832 demonstrations on other agricultural technologies were conducted in collaboration with KVKs in six states.
- Impact analysis of SCSP intervention in Jhansi district revealed that the technological interventions accentuated farm income by 45-51% and farm and domestic asset possession by SC farmers by 23-27%.
- Economic impact assessment under the NIAP-network project for IGFRI-727 (*C. ciliaris*), JHO-822 (oat) and Bundel Dinanath-2 (*Pennisetum pedicellatum*) varieties revealed the estimated economic impact as Rs. 7.17, 29.59 and 3.14 crores, respectively.
- Under TSP, 1036 Fodder Technology Demonstrations (FTDs) were conducted and 27 awareness camps cum training programs were organized in six states. Impact analysis indicated a significant 25-30% increase in the productivity of forage crops and 15-25% increase in milk yield, showcasing the positive outcomes.
- Under NEH, Central Agricultural University, Imphal organized six training programs, benefiting 206 individuals, along with 75 crop demonstrations and input distributions. Thirteen trainings on round-the-year fodder production and preservation were conducted by AAU, Jorhat benefiting 430 individuals and nine animal health camps were organized, benefiting 550 farmers. The ICAR-NRC Mithun, Medziphema conducted silage training and distributed seeds of baby corn and sweet corn (30 kg each) to 102 beneficiaries.
- Under Farmer First program, technological interventions were implemented across five modules: field crop-based, livestock, horticulture, IFS, and farmer capacity building. Introduction of improved crop varieties like green gram (IPM 2-3), groundnut (TG 37A), and wheat (Raj-4079) resulted higher BC ratios of 2.12, 3.00 and 2.54, respectively. Improved vegetable varieties resulted 40% higher gross return/rupee invested compared to local cultivars. Impact assessment revealed that technology adoption led to a significant increase in households' monthly consumption expenditure (up to Rs. 38,880).
- Under ATIC, a total of 37 weekly online meetings and Scientist-Farmers interface sessions were organized. The Exhibition cum Farmers Fair held during 'International Year of Millets' celebration benefitted 300 farmers.
- Under ABIC, the centre organized three Entrepreneurship Development Programme trainings on commercial goat farming, BN hybrid production and utilization, and converting green fodder to silage benefitting 38 trainees. A workshop on fodder seed technology transfer was held with Alamdar Seeds Pvt. Ltd. and IGFRI provided 200.0 kg berseem seeds for a contract with one FPO and a farmer. Exceed Digital, Jhansi, successfully completed the ABIIGROW 2.0 - Mentoring of Training Program for Agri-Startups. ABIC also provided incubation facility for start-ups and participated in the Bundelkhand Agri-Startup Summit.

Chapter 1

ICAR-IGFRI : An Introduction

To address the forage needs of a nation with the largest livestock population globally and to conduct systematic scientific research on grasslands, fodder production, and their utilization, the Government of India established the prestigious 'Indian Grassland and Fodder Research Institute' (IGFRI) on 1 November 1962, in Jhansi, a biodiversity hotspot for grasses. On 1 April 1966, the institute became associated with the Indian Council of Agricultural Research (ICAR). Furthermore, the All India Coordinated Research Project on Forage Crops and Utilization was initiated in 1972, with IGFRI as its headquarters. This project facilitates multi-location testing of forage varieties and technologies across different agro-climatic zones through 22 coordinating centres at various State Agricultural Universities under the National Agricultural Research System. IGFRI 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 relationships, with the latter two being particularly unique. Additionally, the institute includes PME, HRD, ATIC, ITMU, AKMU, and ABIC units and facilities such as a library, central research farm, dairy, central instrumentation lab, and MTS. The institute also operates three regional stations in Dharwad (Karnataka), Avikanagar (Rajasthan), and Srinagar (Jammu & Kashmir) to conduct focused forage research in humid tropic, semi-arid to arid, and temperate climatic conditions, respectively, along with a grassland centre in Palampur (Himachal Pradesh). ICAR-IGFRI has successfully served the nation for six decades, entering its 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 engages in both basic and applied research on cultivated and range species across various aspects, 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 nutrient management. IGFRI undertakes numerous research projects at institutional, inter-institutional, and externally funded national and international collaborative levels to address the persistent issues of fodder shortage and quality forage deficiency. Additionally, the institute's outreach programs 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, Schedule 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.

In the reporting year, ICAR-IGFRI, Jhansi, maintained a total of 10,896 accessions of forage crops in the MTS module. These accessions included cereal fodder (3,437 accessions), cultivated legumes (3,233 accessions), range legumes (746 accessions), and range grasses (3,480 accessions). Additionally, 19 varieties of BN hybrid, guinea grass, and Marvel grass were preserved in the Field Gene Bank. In Programme 1, focusing on the genetic enhancement of forage crops with an emphasis on quality, multicut, stress tolerance, and biofortification, significant advancements were made. The variety Dinanath Grass (JHD-19-4, Bundel Dinanath-3) was released by the certifying agency CVRC, with notification no. S.O. 4222(E) dated 25th September 2023. During *kharif* 2023, a total of 548 accessions of forage grasses were grown, including *Cenchrus species* (102 accessions), *Bothriochloa species* (52 accessions), *Heteropogon contortus* (154 accessions), and *Dichanthium annulatum* (240

accessions). Additionally, 45 accessions of *Panicum* species procured from USDA, comprising *Panicum antidotale* (33 accessions), *P. coloratum* (6 accessions), *P. hallii* (1 accession), and *P. virgatum* (5 accessions), were characterized for 17 morpho-agronomical traits. Furthermore, 96 maize landraces, along with four checks, were evaluated in an augmented design for 13 agro-morphological traits, 5 forage quality traits, and 4 micronutrient traits. The genotypes IC309150 (58.62 t ha^{-1}), IC419460 (59.28 t ha^{-1}), and IC629314 (58.16 t ha^{-1}) recorded significantly higher green fodder yield (GFY) compared to J-1006 and KDFM-1. Genotypes IC591245 (61.76%) and IC419459 (64.92%) exhibited high dry matter digestibility (DMD), IC565877 (15.80%) and IC591240 (15.98%) showed high crude protein content, IC396851 (313.00 ppm) and IC447236 (237.40 ppm) demonstrated high iron (Fe) content, and IC394361 (56.95 ppm) and IC396851 (52.66 ppm) showed high zinc (Zn) content. These values were significantly higher compared to the checks (Mean DMD: 57.40%, CP: 8.75%, Fe: 137.54 ppm, Zn: 27.33 ppm).

A fodder maize hybrid (AFH-7), developed collaboratively by ICAR-IARI, New Delhi, and ICAR-IGFRI, Jhansi, was identified for release in the North West Zone by the varietal identification committee during the NGM *Kharif* 2023. Station trials involving eleven S1 recurrent populations and one composite population, along with three checks (African Tall, J-1006, and CoHM-8), revealed that four populations and one composite population exhibited over 5% superiority compared to the best check. During *Kharif* 2023, three fodder maize entries were contributed to the AICRP on FCU, and four AICRP coordinated trials on fodder maize were conducted, in addition to four trials from IARI, New Delhi. Four entries of high biomass pearl millet genotypes were submitted to the multicut initial varietal trial 2023, and two entries were submitted to the single-cut initial varietal trial 2023 under the AICRP on forage crops and utilization. Additionally, two AICRP trials on fodder pearl millet were conducted during *Kharif* 2022, and two summer pearl millet multicut trials were undertaken in the summer season of 2023.A total of 200 fodder sorghum accessions were sown during *Kharif* 2023. This included material procured from NBPGR and IIMR, Hyderabad, 22 released varieties, 5 trait-specific lines, and four checks. These were evaluated for fodder and morphological traits. Moreover, eight new materials were sown for seed multiplication and station trials.

A total of 66 entries were evaluated for morphological traits across six AICRP-FC trials. The maintenance of advanced breeding material and nucleus seed production involved the multiplication of nine advanced breeding materials for All India testing. Nucleus seed production was carried out for several forage cowpea varieties, and 230 cowpea germplasm were multiplied for evaluation and conservation in the national gene bank. Evaluation of cowpea germplasm for green fodder yield (GFY) identified several superior genotypes compared to the checks. Generation advancement of crosses included the development of F2 populations from selected genotypes. Station trials identified entries with significant superiority over checks for further trials. A framework linkage map of the Bajra-Napier Hybrid was constructed using an interspecific immortalized F2 mapping population, identifying 138 polymorphic SSR markers. A total of 33 QTLs for biomass-related traits were detected, providing a pathway for further genetic enhancement of this crop species. Additionally, Lucerne varieties IGFR-DL-2 and IGFR-DL-5 were identified for release in different zones, demonstrating high forage yield and nutritional quality. The genetic improvement of temperate forage crops included the evaluation of accessions of sainfoin and orchard grass, revealing significant variations in biometric fodder traits.

The Lucerne variety IGFR-DL-2 (AWCL-2) was identified for release in the North West Zone by the Variety Identification Committee (VIC) during the NGM *Rabi* 2023-24 session. This variety yields 85-90 tons of green fodder per hectare, 10-15 tons of dry matter per hectare, 2.5-3.0 tons of Crude Protein Yield (CPY) per hectare, and 0.1-0.15 tons of seeds per hectare. It boasts a crude protein content of 16-18%, in-vitro dry matter digestibility (IVDMD) of 58-62%, 35-40% acid detergent fiber (ADF), and 55-60% neutral detergent fiber (NDF). Similarly, the Lucerne variety IGFR-DL-5 (IGFRI-Dharwad Lucerne-5) was identified for release in Zones 8 and 3 of Karnataka State by the 41st State Seeds Sub-Committee (SSSC). This variety yields 90-110 tons of green fodder per hectare, 15-20 tons of dry matter per hectare, and has a crude protein content of 15-20% with an IVDMD of 65-68%. It also features lower ADF (25-30%) and NDF (35-40%), indicating

better digestibility and voluntary intake by animals, and is moderately resistant to rust and aphids. Several varieties have been identified for various zones and breeding institutes. For Berseem, PC-114 from PAU Ludhiana is recommended for the North-west zone, while Berseem JHB 20-1 from IGFRI Jhansi and JB 08-17 from JNKVV Jabalpur are recommended for the Central zone. Fodder oats varieties identified include JO 13-513 (dual) from JNKVV Jabalpur, HFO-1014 (dual) and HFO-917 (dual) from CCS HAU Hisar, all recommended for the North-west and North-east zones. OL-1931 (dual) from PAU Ludhiana is recommended for the North-east zone. SKO-224 (SC) from SKUAST Srinagar is recommended for the North-west and hill zones, while HFO-915 (MC) from CCS HAU Hisar and OL-1949 (MC) from PAU Ludhiana are recommended for the hill zone. For perennial lucerne varieties, LLC-7 from PAU Ludhiana, BAIF Lucerne-5 from BAIF Urulikanchan, and AWCL-2 from SRRS-IGFRI Dharwad are recommended for the North-west zone. The Lathyrus variety KL-5 from BCKV Kalyani is recommended for Lathyrus growing areas of India.

In the reporting year, Programme 2 focused on the diversification and sustainable intensification of fodder production in different land use systems, including the assessment and rejuvenation of grasslands and other resources to improve productivity and livelihood options. Work on restoration ecology in a silvipasture system for semiarid regions revealed maximum green forage biomass production in *Megathyrsus maximum* (39.58 t ha^{-1}), followed by *Chrysopogon fulvus* (26.03 t ha^{-1}) and *Stylosanthes seabrana* (9.18 t ha^{-1}). Among tree and shrub species, *Leucaena leucocephala* achieved the highest green fodder production (13.29 t ha^{-1}), followed by *F. infectoria* (5.86 t ha^{-1}), *A. nilotica* (4.17 t ha^{-1}), and *M. alba* (3.91 t ha^{-1}). Jalauni sheep grazing on *L. leucocephala* and *F. infectoria* during the growing season, supplemented with concentrate at 1% body weight, exhibited a daily weight gain of approximately 50 g. In a three-tier silvipasture system, lopping shrubs and trees at 70% intensity resulted in higher top feed (3.57 t ha^{-1}) and firewood yields (4.25 t ha^{-1}) compared to 50% lopping intensity (2.71 and 3.23 t ha^{-1}, respectively). Among shrub species, *Ziziphus mauritiana* recorded the maximum top feed and firewood yield, followed by *Ziziphus* and *Acacia catechu* in association with *Hardwickia binata*. Grazing trials with Jalauni sheep and Bundelkhandi goats in this system indicated average daily gains of around 64 g for goats and 62 g for sheep. Pruning *Hardwickia binata* branches by 60% significantly increased top feed (4.10 t ha^{-1}) and firewood yields (6.09 t ha^{-1}) compared to 30% and 45% pruning. Pasture yield (9.94 t ha^{-1}) also improved with 60% pruning. Light pruning of *H. binata* branches (30%) resulted in the highest soil moisture content at depths of 0-15 cm, 15-30 cm, and 30-60 cm. In aonla-based hortipasture systems, the use of decomposer accelerators was evaluated to promote natural farming. Additionally, the application of micronutrients, specifically $ZnSO_4$ and Borax, in guava-based systems improved fruit set (61.44% in Lalit and 59.6% in Shweta) and fruit yield (53.37 kg/tree in Lalit and 49.2 kg/tree in Shweta), alongside enhanced physico-chemical properties. Understory pasture production (*Cenchrus ciliaris* + *Stylosanthes hamata*) ranged from 3.1 to 3.6 t dry matter/ha. Seventy-three Morus species germplasm collections had a survival rate of 33.33-100% after one year of field planting. Twenty Morus germplasm are being evaluated under temperate conditions in Srinagar, with a survival rate of 10-70% and maximum growth observed in variety Zust. Seeds from 57 plus trees of *Ailanthus excelsa* recorded 0-15% seedling emergence at Jhansi and 0-61% at Avikanagar. In a study on bael (*Aegle marmelos*), the highest grass yield (fresh weight) was recorded in a sole pasture system (30.19 t ha^{-1}), followed by central leader (27.97 t ha^{-1}) and open center systems (26.78 t ha^{-1}). Grass grown under untrained bael trees yielded the lowest (17.12 t ha^{-1} for cv. NB-9 and 19.75 t ha^{-1} for cv. CISHB-2). Bael trees trained with the central leader system produced the highest fruit yield (41.91 kg/tree), followed by open center (41.65 kg/tree) and modified central leader systems (38.47 kg/tree), with the lowest yield from untrained trees (30 kg/tree). A base map and thematic layers of grasslands in Chatarpur district were generated using Landsat 8 and the Survey of India. Utilizing the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a multi-criteria decision analysis method, indicated that the Bamitha, Bari, and Dauriya regions exhibit better grassland health. This comprehensive programme addresses various aspects of fodder production, optimizing forage yield and quality through innovative silvipasture

systems, sustainable management practices, and advanced genetic evaluations.

In Programme 3, focused on climate-resilient sustainable fodder production, several significant findings emerged. Sewage water irrigation led to safe accumulation levels of chromium (Cr), cadmium (Cd), and lead (Pb), but nickel (Ni) exceeded safe limits. Cr, Cd, and Pb residues in animal milk and blood in Kanpur and Bhopal were higher than permissible limits. To reduce heavy metal accumulation, low metal-accumulating fodder crops and a sewage water dilution ratio of 1:3 (sewage to groundwater) are recommended. Drip irrigation at 50% available soil moisture in the BN hybrid with 75% recommended fertilizer dose (RDF) increased green fodder yield by 13% and saved 20-55% of irrigation water. Using phosphorus-solubilizing microbes (PSM; *Burkholderia cepacia*) and rice straw (RS) at 10 t ha^{-1} under varied hydrothermal scenarios enhanced phosphorus availability by 3.35-4 times. Silicon concentrations and soil pH changes were key factors in mobilizing soil phosphorus. In irrigated alley cropping systems, moringa with bajra napier hybrid achieved the highest green fodder, dry fodder, and crude protein yields. Under rainfed conditions, moringa with grazing guinea signal grass outperformed sesbania and subabul. Nutrigels from rice straw, combined with 50% NPK from Nutrigel and 25% NPK from mineral fertilizer, improved biomass yield, nutrient uptake, and nutrient use efficiency in fodder sorghum and oat crops, saving 25% of mineral fertilizer and 17-22% of water without reducing crop yield.

In Programme 4, focused on enhancing quality forage seed production and strengthening the national forage seed network, several key advancements were made. Storing berseem seeds with different seed coat colours (yellow, red, dark red) in polythene bags at varying temperatures impacted germination and electrical conductivity, both declining over time. Dark-coloured seeds had higher biochemical content but lower antioxidant activity, with Fusarium sp. possibly contributing to deterioration. A stainless steel machine (1100 × 4 00 × 1000 mm; capacity: 150 liters/hr) was developed to mix smoke with water efficiently. It was found that 100% smoke water inhibited germination of *Pennisetum pedecellatum* and *Heteropogon sp*., while 1% concentration enhanced germination. Seed standards were developed for five temperate forage crops: *Trifolium pretense*, *Bromus unioloides*, *Dactylis glomerata*, *Festuca arundinacea*, and *Lolium multiflorum*, with new research initiated on timothy, red fescue, white clover, sainfoin, and Persian clover. NIR spectra of 206 diverse berseem lines were generated based on germination percentage, with PCA and MPLS used for analysis. Forage cowpea varieties (Kohinoor, BL-1, BL-2, BL-4, EC-4216) were tested under ambient and elevated temperatures (2°C higher). Kohinoor and BL-1 showed greater tolerance to temperature stress. Physical purity and seed quality evaluations of Siratro and Brachiaria were conducted, with protocols developed for seed quality testing in these crops.

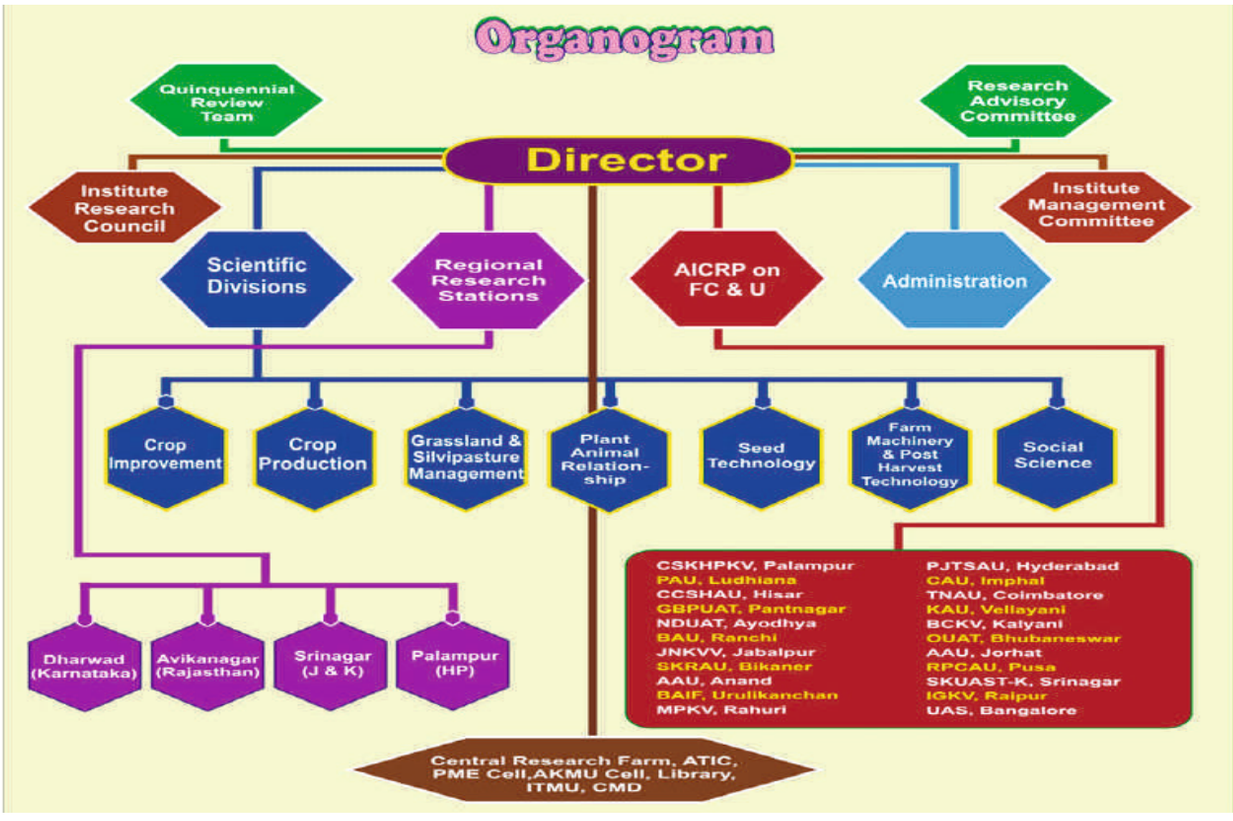
In Programme 5, focusing on the nutritional evaluation and post-harvest management of forage resources for sustainable crop-livestock production, several advancements were made. A study on grazing intensity revealed that goats exhibited higher grazing time, rumination, bite rate, and intake compared to sheep, with significant diurnal variations in grazing behaviours for both species. In another study, essential oil from Curcuma longa was found to inhibit the growth of *Aspergillus parasiticus* and *Aspergillus flavus* at a concentration of 250 ppm, with greater inhibition observed in *Aspergillus flavus*. A semi-automatic pelleting machine was developed for Deenanath grass seeds, capable of converting 5 kg of soil and 100 g of seeds into pellets in 8-10 minutes, with a capacity of 60 kg/h. The optimal seed population per hectare required 31,949 pellets for 100 g of true seeds. Additionally, a seed coating machine was created, featuring a chemical mixer and a 137-litre stainless-steel coating chamber, capable of treating 15-20 kg of seeds per batch with 97% efficiency. This machine saves 91% labour and costs 10 Rs/kg, suitable for treating various types of seeds with chemical agents. A solar-powered, self-propelled multipurpose machine was designed for agricultural operations, equipped with a 250W DC motor and a solar charging station for maximum efficiency. Furthermore, a tractor-operated front-mounted forage harvester was tested for silage preparation. A demonstration of a reaper binder machine was conducted, and a Technology and Machinery Fair was organized at IGFRI Jhansi to showcase scientific innovations for cost and energy savings in agriculture.

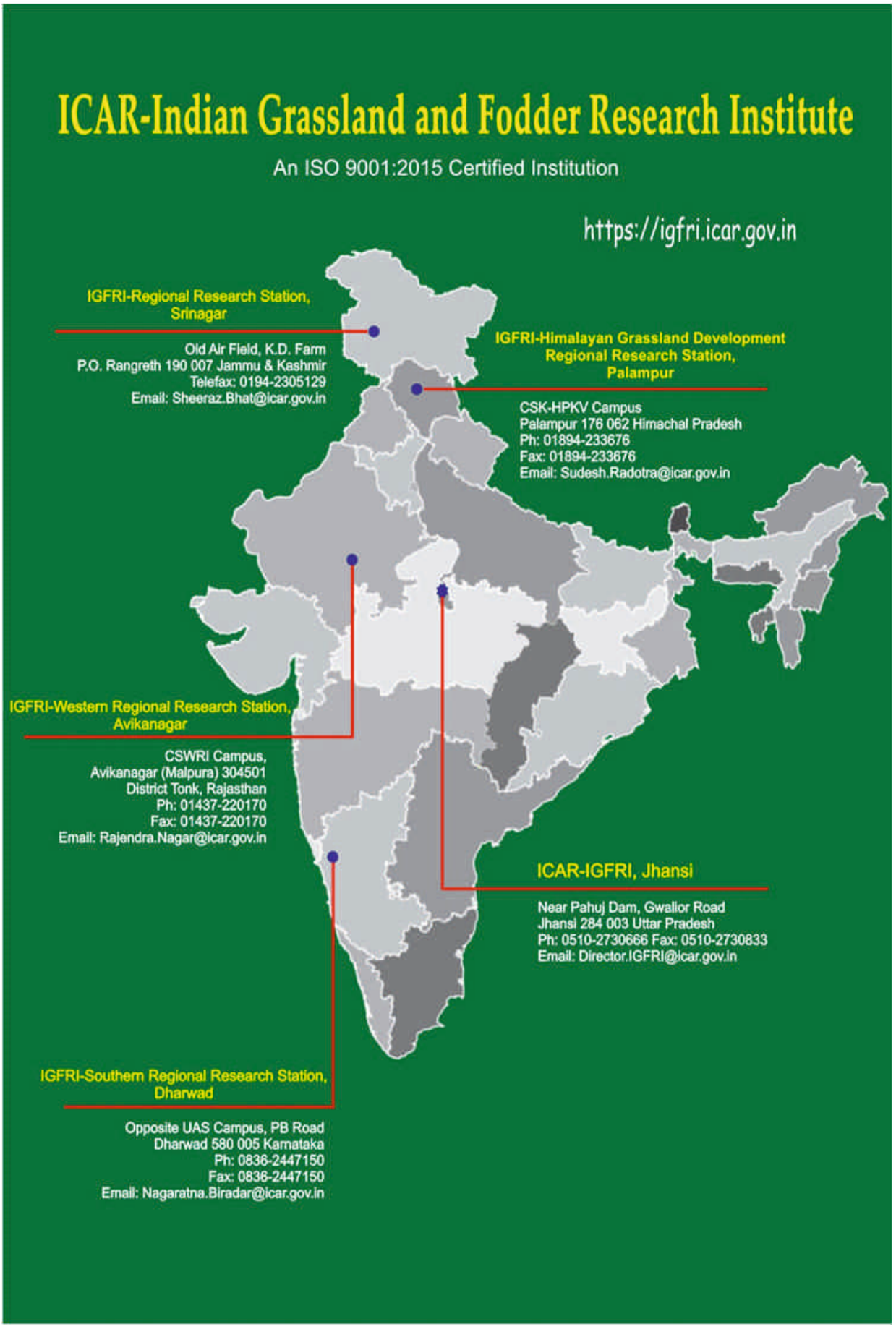
Programme 6 focused on social, economic, policy, and translational research and capacity building with

several impactful initiatives. Assessment of Integrated Farming Systems (IFS) models in Jhansi showed a 40-50% reduction in fodder deficits and an 18-30% increase in animal productivity, enhancing income by 1.6-2.0 times for smallholder and medium-large farmers. Under the SCSP Programme, 24 trainings and over 2,000 demonstrations were conducted across six states, boosting farm income by 45-51% and asset possession by 23-27% in Jhansi. The NIAP-Network project estimated significant economic impacts for IGFRI-727, JHO-822, and Bundel Dinanath-2 at Rs. 7.17 crore, Rs. 29.59 crore, and Rs. 3.14 crore, respectively. The TSP organized 1,036 Field Testing Demonstrations and 27 training programs in six states, resulting in a 25-30% increase in forage crop productivity and a 15-25% increase in milk yield. NEH interventions in the Northeast benefited over 1,200 individuals through training programs, crop demonstrations, and animal health camps. The Farmer First program introduced higher-yielding crop varieties, significantly increasing household consumption expenditure. ATIC held 37 Zoom meetings and fairs, engaging hundreds of farmers. The Agri-Business Incubation project offered training on commercial goat farming, hybrid production, and silage, benefiting 38 trainees. It also facilitated seed technology transfer, celebrated World Intellectual Property Day, and provided startup incubation, reducing green fodder shortages from 58.5% to 21.25% with a high adoption rate of new technologies.

The institute is currently focussing research on the 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.

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Chapter 2

Weather and Crops

The Southwest monsoon set in over Kerala on 8th June against normal date of 1st June and covered the entire country by 2nd July a remarkable six days ahead of the usual date of 8th July). During the season there were 15 low pressure system formed in the Indian region . Out of these low pressure system one intensified into an extremely severe cyclonic storm (BIPORJOY) that formed over north east Arabian sea during 6th to 19th June. There were two monsoon depression during the season, one in August (1-3) and another on 30th September. Monthly rainfall over the country as whole was 91% long period average (LPA) in June, 113% in July, 64% in August and 113% of LPA in September. With the reduction in the rainfall and formation of the anti-cyclonic circulation in lower troposphere withdrawal of SW monsoon began on 25th September against the normal date of 17th September.

2.1 Rainfall pattern

In Jhansi, total rainfall of 846.2 mm was recorded during January-December, 2023 in 37 rainy days. The rainfall deficiency was found to be 6.8% from its long period average (LPA) of 908.8 mm. The seasonal rainfall during *rabi* (1-22 SMW) and *kharif* (26-52 SMW) season are illustrated in Fig. 2.1. In the *rabi* season, 50.9 mm of rainfall occurred in 6 rainy days and it was higher by 5.7% from its LPA. *Kharif* season received 795.3 mm rainfall, which was deficient by 7.6% from its LPA.

The monsoon was active during the *kharif* season *i.e.*, mid of June to September and the rainfall during 23- 39th SMW was 795.3 mm (Fig. 2.2). In the month of June (25th-26th SMW), two weeks received rainfall in the range of 92.2 to 115.4 mm and rainfall was higher by 193.6 and 226% from the normal values. In the month of July (27th-31st SMW), heavy amount of rainfall to the tune of 254.2 mm was recorded. Further, four weeks (32 and 35 SMW) of August received rainfall below it normal value. A heavy rainfall of 119.9 mm and 66 mm recorded in 36th and 37th SMW. Also, the monsoon was active up to mid of October (40th-42nd SMW). Rainfall during this period was 35.8 mm which was more than 211% from their LPA. Onwards rainfall did not occur till December.

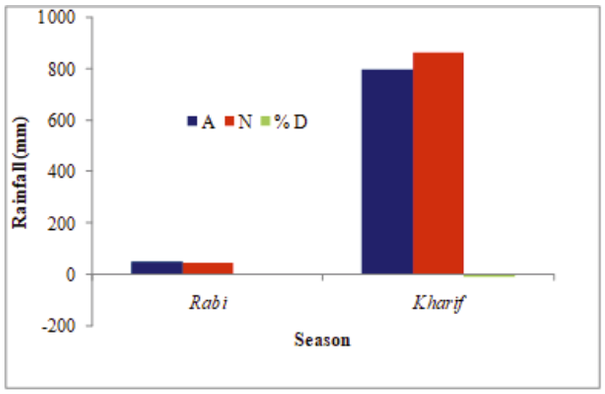

Fig. 2.1. Seasonal mean rainfall along with its departure from normal

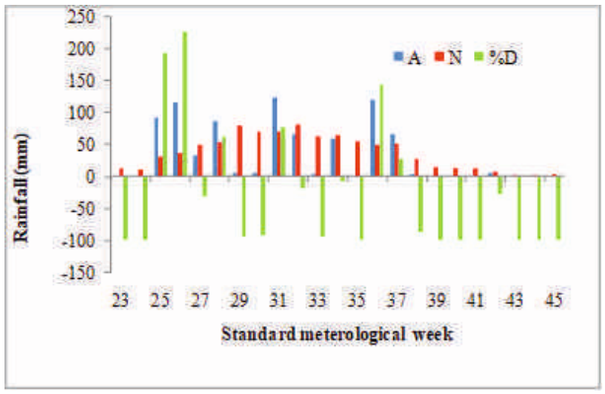

Fig. 2.2 Weekly rainfall distribution pattern and its departure during *kharif* season at Jhansi

2.2 Temperature

Mean annual maximum and minimum temperatures during 1st-22nd SMW were lower by 1.45 and 1.24°C from their corresponding normal values (Max T=33.3°C and MinT=16.6°C). Weekly anomaly for the period 1st-22nd SMW of maximum and minimum temperature is presented in Fig. 2.3. In *rabi* crop growing season (1st to 5th SMW), maximum temperatures were lower in four weeks from their corresponding normal temperature in the range of 0.55 (in 5th SMW) to 6.99°C (in 1st SMW). Further, in subsequent weeks (6th-9th SMW) the maximum temperatures were higher than their corresponding normal values in the range of 0.96 to 4.75°C. The minimum temperatures during these weeks (1st-10th SMW) fluctuated in the range of -2.61 (in 1st SMW) to 4.1°C (in 5th SMW). Both maximum and minimum temperatures were lower in the range of 0.33 to 6.1°C during 11th to 22nd SMW.

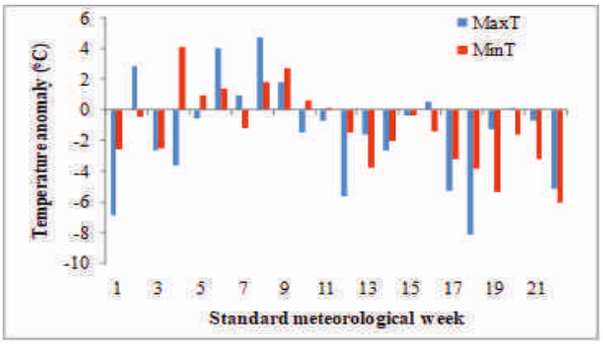

Fig. 2.3. Weekly anomaly pattern of maximum (Max T) and minimum (Min T) temperature during *rabi*

Mean maximum and minimum temperatures for the period 23rd-52nd SMW were slightly higher by 1.35 and 1.41°C, respectively from their corresponding normal value (Max T=30.5°C and Min T=17.1°C). In *kharif* season, maximum temperatures were in general higher in the range of 0.30 to 3.8°C from their normal values during 27th-42nd SMW. Further, ten weeks also (43rd-52nd SMW) experienced higher maximum temperature from their normal in the range of 0.58 to 4.0°C. Similarly minimum temperature was higher in the range of 0.22-5.9°C during 27th-52nd SMW (Fig. 2.4).

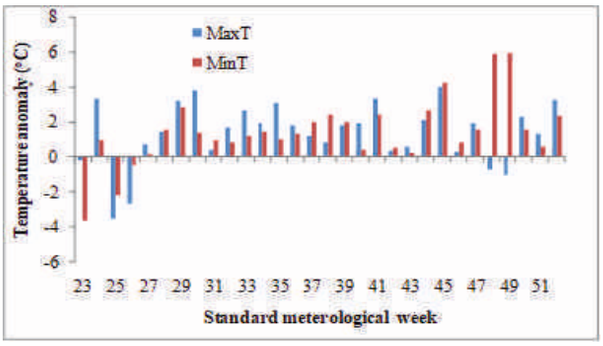

Fig. 2.4. Weekly anomaly pattern of maximum and minimum temperature during *kharif* season

2.3 Evaporation

Evaporation

Mean *rabi* season evaporation rate (5.1 mm/day) was lower by 20.1% than the normal (6.34 mm/day) evaporation rate (Fig. 2.5). Evaporation rate during 1st to 22nd SMW period experienced lower evaporation rate in the range of 1.3 to 10 mm/day against its normal range (1.69 to 12.5 mm/day). Mean evaporation rate during *kharif* was recorded to be 4.15 mm/day and it was slightly lower by 6.1% from its long period average (4.43 mm/day). Weekly evaporation rate/day during monsoon season (27th-37th SMW) fluctuated between 3.8 to 4.8 mm/day against their corresponding normal values (3.2 to 7.0 mm/day). In the post-monsoon (40th-48th SMW) season the evaporation rate oscillated in the range of 2.1 to 4.9 mm/day against its corresponding normal values (2.6-4.1 mm/day) Majority of weeks experienced lower evaporation rate in the range of 2.4 to 20.5% from their normal value.

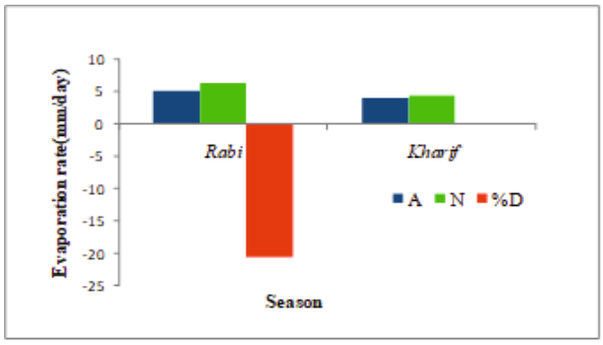

Fig. 2.5. Seasonal actual (A) and normal (N) evaporation along with percentage departure (%D) from its normal values

Relative humidity pattern

Mean morning relative humidity for both *rabi* (RH1) and *kharif* (RH1) was found to be 76.2 and 81.0%, respectively and both were deficient by 0.25 and 11.1% from their respective normal value (Fig. 2.6). Morning relative humidity during the period (1-12 SMW) and (13th-22nd SMW) fluctuated between 81-91.3% and 61-77 %, respectively. Similarly, morning relative humidity during the period 26th-39th SMW and 40th-52nd SMW ranged between 76th-90th and 73-91%. The morning relative humidity was found to be lower by 2-13.6% from their corresponding normal values during monsoon season (27th-39th SMW).

Mean afternoon relative humidity during *rabi* (RH2) and *kharif* (RH2) was found to be 40.9 and 60.2%, respectively and these were significantly higher by 27.1 and 20.2%, from their corresponding normal values. Afternoon relative humidity oscillated between 27-77% during 1st-22nd SMW. The afternoon relative humidity ranged between 62-80% and 42-71% for the period 26th-39th and 40th-52nd SMW, respectively.

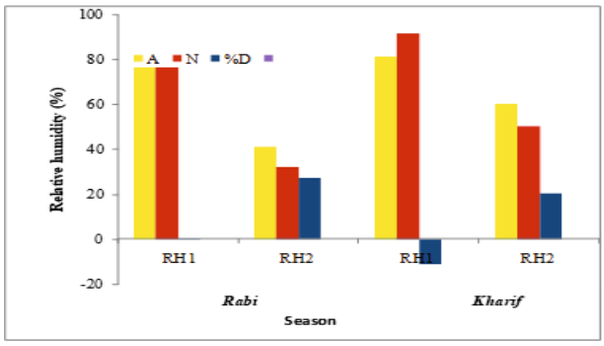

Fig. 2.6. Seasonal actual (A) and normal (N) relative humidity along with percentage departure (%D) from its normal values

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

A total of 548 accessions of forage grasses comprising *Cenchrus* species (102), *Bothriochloa* species (52), *Heteropogon contortus* (154) and *Dichanthium annulatum* (240) were grown during *kharif* 2023. Accurately, 45 accessions of *Panicum* species procured from USDA comprising *Panicum antidotale* (33), *P. coloratum* (6), *P. halli* (1) and *P. virgatum* (5) were characterized for 17 morpho-agronomical traits.

Biochemical evaluation

Significant variability was observed in the nutritional quality in the plant material collected from Banni grassland. Crude protein varied from 3.95 to 21.99%, neutral detergent fibre (NDF) ranged between 48.89 to 91.42%, acid detergent fibre (ADF) spanned between 23.24 to 52.47%, and acid detergent lignin (ADL) varied from 5.31 to 15.62%.

Maintenance of germplasm in the MTS

A total of 10,896 accessions of forage crops comprising cereal fodder (3,437), cultivated legumes (3,233), range legumes (746), and range grasses (3,480) are being maintained in the MTS module at ICAR-IGFRI, Jhansi. About 19 varieties of BN hybrid, guinea grass and Marvel grass were maintained in the Field Gene Bank.

Variety release

Dinanath Grass: JHD-19-4 (Bundel Dinanath-3); Certifying agency: CVRC, Notification No. S.O. 4222(E), date 25th September, 2023. Six accessions of *Dichanthium- Bothriochloa* complex under trail at AICRP on FC.

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

Evaluation of maize germplasm

A total of 96 maize landraces along with four checks were evaluated in augmented design for 13 agro-morphological, 5 forage quality, and 4 micronutrients traits. Genotypes IC309150 (58.62 t ha^{-1}), IC419460 (59.28 t ha^{-1}), and IC629314 (58.16 t ha^{-1}) recorded significantly higher green fodder yield (GFY) over J-1006 and KDFM-1. Genotypes IC591245 (61.76%) and IC419459 (64.92%) recorded high dry matter digestibility (DMD), IC565877 (15.80%) and IC591240 (15.98%) recorded high crude protein, IC396851 (313.00 ppm) and IC447236 (237.40 ppm) recorded high iron (Fe), and IC394361 (56.95 ppm) and IC396851 (52.66 ppm) recorded high Zinc (Zn), in comparison to checks (Mean DMD: 57.40%, CP: 8.75%, Fe: 137.54 ppm, Zn: 27.33 ppm).

Phenotypic recurrent selection

Second cycle of phenotypic recurrent selection (selfing followed by random mating) has been practiced in five crosses (*i.e.* AT × KDFM-1, AT × TSFM-15-5, J-1007 × KDFM-1, J-1007 × TSFM-15-5, AT × IG-02-04-02) to increase the frequency of superior alleles for fodder biomass.

Hybridization programme

The F1 plants of African Tall (AT) × Teosinte with tillering and branching trait were selfed as well as backcrossed with African Tall. The BC1F1 and F2 plants were phenotyped for teosinte traits, and BC2F1 and F3 seeds were generated. F1 has been generated between African Tall and PSSC-1 (sweet corn) to develop dual purpose population using marker-assisted selection approach. In addition, 190 hybrid combinations have been generated among 20 S6 inbreds in half diallel fashion. These hybrids along with checks (AT, J-1006 and CoHM-8) were evaluated for fodder yield and contributing traits at three locations *viz.*, Jhansi, New Delhi and Ranchi. Twenty hybrids, BM-5, BM-21, BM-41, BM-54, BM-56, BM-65, BM-66, BM-71, BM-91, BM-100, BM-103, BM-109, BM-110, BM-135, BM-144, BM-145, BM-184, BM-186, BM-188 and BM-194 with high GFY were identified for conducting station trials.

Identification of fodder maize variety by VIC

One fodder maize hybrid (AFH-7) developed by ICAR-IARI, New Delhi in collaboration with ICAR-

IGFRI, Jhansi was identified for release in North West Zone by varietal identification committee during NGM *Kharif* 2023.

Station trials conducted

Station trial of eleven S1 recurrent populations and one composite population was conducted along with three checks *viz.*, African Tall, J-1006 and CoHM-8. Four populations *viz.* AT × KDFM-1, J-1007 × AT, AT × IG-02-04-02, TSFM-15-5 × KDFM-1, and one composite population recorded >5% superiority over best check.

Contribution of fodder maize entries to AICRP and Co-ordinated trials conducted

Three fodder maize entries (JHFM-23-1, JSFM-23-2, and JHFM-23-3) were contributed to AICRP on FCU in *kharif* 2023. Four AICRP co-ordinated trials *viz.* IVTM, AVTM-1, AVTM-2, and AVTM-2 (seed) on fodder maize were conducted. In addition, four trials of IARI, New Delhi were also conducted.

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

(CRSCIGFRISIL20200101)

Evaluation of Pearl millet germplasm

A total of 257 genotypes from the pearl millet association panel were assessed using an alpha lattice design with two replications. The evaluation focused on green forage yield (GFY) and its component traits, including SPAD value and canopy temperature (Fig. 3.1.1). Additionally, the panel was characterized for six forage quality traits: ADF, NDF, lignin content, cellulose content, and crude protein. During the summer 2023, fifteen high-yielding multicut genotypes were evaluated for their performance in a multicut system (three cuts at 50 DAS, 80 DAS, and 110 DAS, respectively). These genotypes were compared with five released cultivars. Notably, genotypes IGBV 128 (0.61 kg plant^{-1}), IGBV9 (0.59 kg plant^{-1}), IGBV13 (0.54 kg plant^{-1}), and IGBV26 (0.48 kg plant^{-1}) exhibited significantly higher average GFY per plant across the three cuts compared to the best-performing checks, Siratej (0.43 kg plant^{-1}) and Nutrifast (0.43 kg plant^{-1}).

Creation of new variability

S2/S3 family selection: Approximately 112 S2 and 56 S3 lines, developed through selfing in forage bajra germplasm, were evaluated for their multicut potential. Subsequently, around 25 families displaying superior multicut potential were chosen, and crosses were made among them. The resulting F1 generations were reevaluated for biomass and selected lines were further crossed to create composites. Two outstanding crosses, namely TSFB15-8-S2 × Giant bajra-S2 and TSFB 15-8-S2 × baif bajra 1-S2, were advanced through bulk pollination.

Elite x Elite crossing

During the summer 2023, twenty-four high-yielding multicut Open-Pollinated Varieties (OPVs) were crossed, resulting in the development of 68 progenies aimed at identifying superior recombinants. From this pool, nine progenies were selected for further improvement through phenotypic recurrent selection, representing a selection intensity of 13.23%.

Novel genetic materials identified

The following genetic materials were identified, namely, ICBbmr07 for low lignin (3.17% lignin), IGBV100 for high leaf to stem ratio (2.2 at 50 DAS) and late flowering (82 days DFF), ICFPM 01 for high tillering, ICMFV 2308 and ICMFV 2401 for late flowering, IGBV9 for higher plant height (362 cm), ICMV 88908, IP 18389 and IP 17720 for higher regrowth potential.

Mapping of blast resistance in pearl millet

The F2 population, generated by crossing blast-susceptible parent ICMB99666 with blast-resistant parent ICMR 356, underwent BSR-Seq analysis, leading to the identification of fourteen significant single-nucleotide polymorphisms (SNPs). These SNPs are situated on chromosomes 2, 3, 4, 5, 6 and 7. Notably, two SNPs, namely LOC117847124 on chromosome 4 (associated with the disease resistance protein RGA2-like) and LOC117836075 on chromosome 3 (linked to the function of phosphatidylinositol or phosphatidylcholine transfer protein SFH8) are putative SNPs associated with blast resistance.

Development of high biomass pearl millet genotypes

Four entries (JHMCB-23-1, JHMCB-23-2, JHMCB-23-3, and JHMCB-23-4) had been submitted to multicut initial varietal trial 2023 and two entries (JHPM-23-1 and JHPM-23-2) were submitted to single cut initial varietal trial 2023 to AICRP on forage crops and utilization.

Trials conducted in Pearl millet

Two AICRP Trials IVPTM and AVPTM-2 on fodder pearl millet were conducted during *kharif* 2022. Two trails on summer pearl millet multicut (multi-cut forage pearl millet hybrid trial and multi-cut pearl millet forage OPVs trial) from ICRISAT were conducted in summer season 2023.

Fig.3.1.1 Field view of forage pearl millet breeding programme

3.1.4 Genetic improvement of sorghum for high biomass, forage quality, and resistance to foliar diseases

(CRSCIGFRISIL20160103)

Evaluation of sorghum germplasm

A total of 200 fodder sorghum were sown including material procured from NBPGR (112), IIMR, Hyderabad (70), 22 released varieties, 5 trait specific lines, with four checks (MP Chari, PC6, PC615 and CSV 33MF) were evaluated for fodder and morphological traits during *Kharif*-2023. Eight new materials (STS-1 to STS-8) were sown for seed multiplication and for station trials.

A novel sorghum genotype EC-484238 having twin and triple seeds in their panicle was reconfirmed in the field and pot conditions during 2023 summer and *kharif* (Fig. 3.1.2). This novel sorghum genotype with multiple gynoecium three- stamens, twin and triplet seeds per sessile spikelet per panicle was submitted for registration purpose.

\Multifoliar disease resistance twin and triple seed (MG) genotypes were successfully crossed (MG X IGS-90) and (IGS-90 X MG). Two F2 population having high biomass and multi-foliar disease resistance (IGS-1x IGS-114; MP-Chari x IGS-167) were sown for generation advancement and selection within population (Fig. 3.1.2 a). All the selected 13 multicut sorghum lines showed high regeneration potential on the scale 5. Three previously identified drought tolerance sorghum lines were evaluated in field conditions with 3 checks (MP Chari, PC6 and PC615) under control, moderate, and high-water stress. The morphological and fodder traits were evaluated and stay green was found crucial trait for drought tolerance in sorghum. One sorghum entry was submitted for AICRP-fodder sorghum trials. Two fodder sorghum AICRP trials (AVTHC (15 lines) and IVTHC (20 lines)) were conducted and morphological, dry matter, and fodder traits were observed.

Fig. 3.1.2 a. Population of high biomass and multi-foliar disease resistance crosses

Fig. 3.1.2 b. Sorghum genotype (EC-484238) showing twin and triple seeds

3.1.5 Breeding oat for improved productivity and quality

(CRSCIGFRISIL20150103)

Characterization of global oat germplasm collections: A total of 1905 lines were evaluated for 11morphological descriptors. Trait specific lines were also selected which included 07 lines for leaf number, 12 lines for leaf length, 29 for leaf thickness, 13 for stem girth, 15 for early and late maturity, 31 for plant height, 33 for seed thickness, 08 for panicle length, and 18 for number of spikelets.

Station trial: 03 station trials were conducted; in single cut, 16 lines along with one check JHO-99- 2 were tested. 04 lines performed (45.0-52.5 t ha^{-1}) better than check (40.8 t ha^{-1}) in terms of green fodder yield (GFY).

Trait variability among oat core set genotypes

Trait	NLPP	LL	LB	INL	SG	PL	NSPP	FPP	FLL	FLB	GFY
Mean	4.39	40.99	1.81	17.87	0.89	32.13	59.49	2.10	27.46	1.7	4.83
Minimum	2.67	16.00	0.70	5.17	0.20	8.00	9.67	1.00	9.67	0.50	0.20
Maximum	7	66.73	9.53	35.8	9.07	54.67	191	4.0	47.93	7	16
Range	4.33	50.73	8.83	30.63	8.87	46.67	181.33	3.00	38.27	6.50	15.80

NLPP: Number of leaves/ plant; LL: Leaf length; LB: Leaf breadth; INL: Inter node length; SG: Stem girth; NSPP: No. of spikelet's/ plant; PL: Panicle length; FPP: Florets/panicle; FLL: Flag LL; FLB: Flag LB; GFY: Green fodder yield

In dual purpose trial, 20 lines were evaluated, 05 lines performed better (15.0-18.0 t ha^{-1}) than check (10.6 t ha^{-1}) for GFY; in multi cut trial, 03 lines were selected out of 09 lines.

Screening for abiotic stresses: 105 lines including varieties, wild types, and germplasm lines were screened for salinity, alkalinity, and combined stress. 100 seeds of each line were subjected to control (T1), moderate salinity (T2), high salinity (T3), moderate alkalinity (T4), high alkalinity (T5), combined moderate (T4+T2=T6) and combined high (T3+T5=T7). Germination data (2-5 days) and seedling data (5-8 days) were recorded. The lines showed the diversity under stresses which leads to identification of 21 germplasm lines consisting of 10 tolerant, 9 moderate, and 2 susceptible for further evaluation. The selected 21 germplasm were tested for root architecture evaluation in hydroponic system in polyhouse using Hogland solution. Root being more sensitive to stress leads (Fig. 3.1.3) to more than 70% reduction in susceptible, 55-70% in moderate, and 40 to 50% in tolerant lines. Under stress, lateral root formation and vascular bundle formation (Fig 3.1.4) were inhibited and out of 21, based on root structure architecture (RSA) 11 lines (04 tolerant, 05 moderate, and 02 susceptible) were screened.

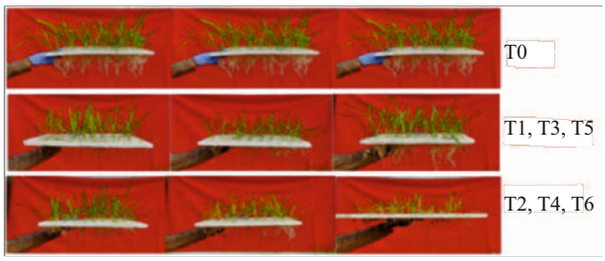

Fig. 3.1.3. comparison of oat seedlings under control and high combined stress

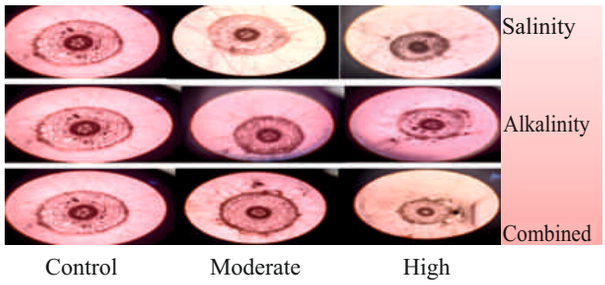

Fig. 3.1.4. Comparison of root anatomy under control and stress condition

AICRP-FC trials: A total of 66 entries were evaluated for 5 morphological traits in 06 trials, namely, IVTO-SC (15 entries); AVTO-SC-1 (14 entries); AVTO-SC-2 (06 entries); AVTO-MC-2 (04 entries); IVTO-D (11 entries) and IVTO-MC (16 entries)

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 (57 kg) 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.

3.1.6 Developing Erect type and Multicut fodder cowpea with enhanced nutritional quality

(CRSCIGFRISIL20210103)

Multiplication of cowpea germplasm

A total of 230 cowpea germplasm were multiplied for evaluation and conservation in national gene bank.

Evaluation of cowpea germplasm

A total of 230 cowpea genotypes were evaluated for GFY along with three checks *viz.*, BL-1, BL-2, and BL-4 in Augmented design. Fourteen genotypes were found superior over all the three checks. Nine selected high yielding cowpea genotypes along with two checks (BL-1 and BL-2) were analyzed for forage quality for second year. Genotypes IC20696 and IC240885-2 recorded low lignin content (<6.0%), while EC724773 (21.74%) recorded high crude protein (CP) content over checks (Lignin: 6.55%, CP: 18.57%).

Generation advancement of crosses (Pedigree selection)

F2 populations were developed from eight crosses between nine selected genotypes of four groups *viz.,* high biomass (EC100094, BL-1 and BL-2) × multicut (EC240891, IC402125, and EC724773), high biomass (BL-1 and EC100094) × high biomass (BL-2), high biomass (BL-1) × erect habit (Erect selection),

multicut (EC724773) × erect (CS-88) and high biomass (BL-1) × high crude protein (EC724773).

Station trials

A station trial comprising 23 cowpea entries along with three checks (BL-1, BL-2 and BL-4) was conducted. Entries CST-3, CST-7, CST-9, CST-14, and CST-17 having >10% superiority over the checks were selected for multi-location trials under AICRP. A multicut station trial consisting of 11 entries and two checks (BL-1 and BL-2) was also conducted. Entries CMST-1, CMST-4, CMST-6, CMST-8 and CMST-11 recorded 17.36-31.72% superiority in three cuts over the checks.

Contribution of cowpea entries to AICRP-FCU

Three entries of cowpea (BL-23-1, BL-23-1 and BL-23-1) were submitted to AICRP on FCU for conducting IVT in *kharif* 2023.

Multiplication of promising cowpea genotypes and nucleus seed production

Seed multiplication of three high biomass cowpea genotypes was carried out for conducting multi-location trials. Nucleus seed of three forage cowpea varieties *viz.* BL-1 (8 kg), BL-2 (7 kg) and BL-4 (7 kg) was produced.

3.1.7 Identification and characterization of cowpea genotypes for phosphorus use efficiency

(CRSCIGFRISIL20220102)

A field experiment was conducted to evaluate the morpho-physiological characteristics of a diverse cowpea core set (consisting of 250 genotypes) for phosphorus use efficiency (PUE). The experiments were carried out under low-P (11.3 kg P ha^{-1}) and sufficient-P regimes (20.2 kg P ha^{-1} + 17.6 kg P ha^{-1}) in augmented block design with three checks (BL-1, BL-2 and BL-4). Fresh and dry biomass significantly declined in low P condition, which adversely affected overall growth. Higher biomass accumulation and early plant vigour were observed under sufficient P regime as compared to low P regime. There were no significant changes in plant height and SPAD value due to the P application. The average percent reduction in dry fodder yield of cowpea genotypes was 36.8% under a low-P regime compared to a sufficient-P regime. The tolerant genotypes exhibited lesser reductions in the number of branches, stem diameter, and fresh as well as dry biomass when compared to sensitive accessions under low P regimes, as opposed to sufficient-P regimes. Genotypes IC202781, IC209151 and EC240663 performed well in terms of early plant vigour, biomass, and stem diameter under low P regime, while genotypes EC107192 and IC284554 had poor performance.

3.1.8 Identification and characterization of genes involved in expression of apomixis component-traits in Polyploidy series of guinea grass (*Megathyrsus maximus*)

(CRSCIGFRISIL20210101)

An expression study was conducted with the genes of apomeiosis (MSP1), parthenogenesis/ embryogenesis (BBM1), and autonomous endosperm development (FIS1) in guinea grass lines of varying ploidies (3x, 4x, 5x, 6x, 7x, 8x, 9x and 11x) and one obligate sexual plant SRP75 at three development *viz*., pre-meiotic, meiotic, and post-meiotic stages by Real time PCR analysis. Expression showed that pattern of expression was differing in ploidies at pre-meiotic, meiotic and post meiotic stages as compare to sexual line. The results showed that the ploidies with different level of apomictic frequencies were the expression of all the genes but the expression was different at different developmental stages as compared to sexual plant.

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

(CRSCIGFRISIL20230102)

The flowering time (FT) gene members were identified in cowpea by bioinformatic analyses. Genome wide identification revealed a total of 13 FT genes in cowpea genome. Expression analysis of these genes in early flowering cowpea genotype during floral initiation revealed higher expression of few candidate FT genes that might have role in flower induction in cowpea.

3.1.10 Evaluation of berseem gene pool for herbicide tolerance

(CRSCIGFRISIL20200401)

Main objective of study was to search for herbicide tolerant or resistant lines of berseem against glyphosate. Three rounds of screening against glyphosate were done and five putative lines were made depicting moderate to high levels of tolerance against glyphosate. In order to reconfirm their tolerance, five lines were sown in three replications to screen them again for glyphosate tolerance.

3.1.11 Genetic improvement of barley for forage and grain yield

(CRSCIGFRISIL 20l20101)

In 2022-23, 74 advance lines were evaluated in field for fodder and grain yield in cut and uncut trials. A total of 19,, 22, 16 and 16 lines were evaluated in RBD for dual purpose, grain, forage/grain, and forage yield performance, respectively. Under the cut trail, GFY ranged from 14.09 to 21.12 t ha^{-1} at 55 DAS, and two lines had high CGFY (JHSBC-5, 20.55 t ha^{-1}; JHSBK-1, 21.12 t ha^{-1}). Six lines had both high CGFY (17.89 – 19.7 t ha^{-1}) and high grain yield (1.98 – 2.65 t ha^{-1}). Four lines had high spike yield (5.65 – 7.07 t ha^{-1}) when uncut. Eight lines of forage type had high biomass yield (11.04 – 14.80 t ha^{-1}). Altogether 59 lines of barley (including lines of UPCAR project) with six checks are under evaluation and multiplication in 2023-24. Seeds of 14 lines of barley are being tested under IBDSN 2023-24.

3.1.12 Genetic improvement of temperate forage crops

(CRSCIGFRISIL20211002)

About 18 accessions/collections of sainfoin (*Onobrychis viciifolia*) and 45 accessions/collections of orchard grass (*Dactylis glomerata)* were evaluated for the 2nd year. Significant variations in sainfoin were observed for plant height (103.5-136 cm), number of tillers per plant (14.2-30.3), green herbage yield (42.3-54.7 t ha^{-1}), and dry herbage yield (12.19-18.3 t ha^{-1}). In orchard grass also, significant variation was observed for different biometric fodder traits, including plant height (107.2-136.2 cm), number of tillers per plant (32.6-58.7), green herbage yield (31.9- 48.2 t ha^{-1}), and dry herbage yield (10.3-16.8 t ha^{-1}).

Nineteen varieties of berseem were evaluated under irrigated conditions. Results revealed significant variation for green fodder yield and dry matter yield from two cuts. Highest green fodder yield (38.3 t ha^{-1}) was observed for the variety JHB-17-1, while the lowest was observed for JHB-22-1 (120 t ha^{-1}). Highest dry matter fodder yield (5.8 t ha^{-1}) for JHB-17-1, while the lowest for BL-44 (2.17 t ha^{-1}) was observed.

More than 300 crosses were done between rye grass and tall fescue for the development of *Festololium* and between red clover and berseem. The material generated shall be tested using phenotypic and molecular markers for paternity analysis.

3.1.13 Genomics assisted breeding for zinc and iron bio-fortification in oat

(CRSCIGFRISIL20210102)

Identification of genomic regions associated with high Zn and Fe in oats using association mapping

Enrichment of association mapping panel

Diverse oat material comprising 389 accessions (oat core collection, different oat species, released varieties of oat and previously selected oat biofortified lines) were sown in *rabi*, 2021-22). These lines were evaluated for zinc and iron content. In addition to this, various agro-morphological and physiological traits were also recorded. Based on mean zinc and iron content, a diverse enriched association mapping panel of 196 individuals were formed.

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

The enriched oat association mapping panel was sown under two regimes *i.e.* Control and treatment (foliar spray of $ZnSO_4$ and $FeSO_4$) at three locations *viz*., ICAR-IGFRI, Jhansi, Uttar Pradesh; HRRS-IGFRI, Palampur, Himachal Pradesh and CCSHAU, Hisar, Haryana in *rabi* 2022-23 for phenotyping of Zn and Fe content along with various agro-morphological traits.

3.1.14. Genetic improvement of novel fertile Bajra-Napier hybrid for enhanced productivity and quality traits

(CRSCIGFRISIL20220101)

Construction of first-ever framework linkage map in fertile BN hybrid

A framework linkage map of Bajra-Napier hybrid was constructed using an interspecific immortalised F_2 mapping population (*Cenchrus americanus* x *Cenchrus purpureus*) using SSR markers. A total of 217 SSR markers were used to identify polymorphic primers between *Cenchrus americanus* x *Cenchrus purpureus*, the parental lines of the mapping population. Of the 217 SSR primer pairs, 138 (63.5%) primer pairs were found to be polymorphic and were further validated with 14 randomly selected F2 lines to confirm the polymorphism among the population. A total of 100 markers were selected after validation and assigned map positions at LOD 4.0 on seven linkage groups, spanning 858.08 cM distance of the Bajra Napier Hybrid genome with an average marker density of 9.75 cM. These markers exhibited a non-random distribution

varying in density from 5.02 cM/locus to 34.06 cM/locus on seven LGs. The SSR markers mapped on the present map included a total of 88 markers (Fig. 3.1.5).

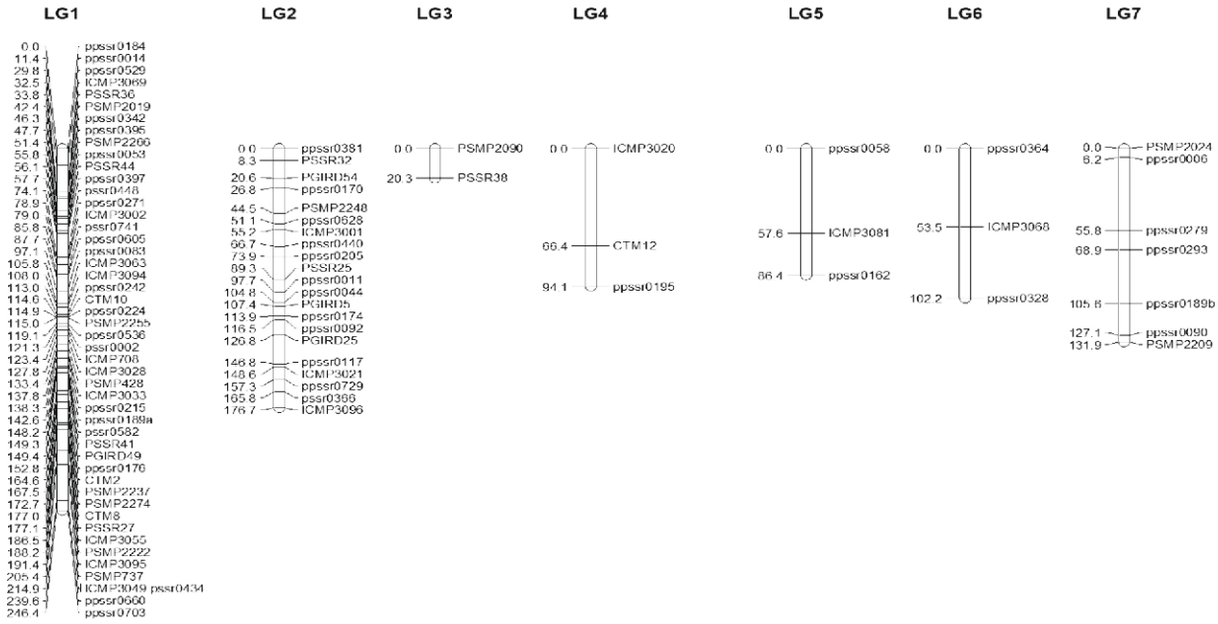

Fig. 3.1.5. Showing an interspecific linkage map of fertile Bajra Napier hybrid

Construction of QTL Map for biomass related traits

Further, the linkage map constructed was used for the identification of QTLs related to biomass related traits. Analysis of variance revealed significant differences for all the 22 measured traits between the *Cenchrus americanus* x *Cenchrus purpureus*. A total of 33 QTLs (LOD ≥ 3.0) were detected for biomass related traits. Of all the 22 measured traits, QTLs were detected for 13 traits only. Overall, 5 QTLs were detected for morphological traits, 4 for phenological traits, 5 for oxalate content and 19 for yield related traits. Fourteen QTLs were located on LG1 followed by eleven on LG2, one on each LG3 and LG4, 3 on LG5 and 2 on LG6. Phenotypic variation explained by QTLs ranged from 10.8 to 70.64%. The highest phenotypic variation (70.64 %) was explained by the QTL for spike length.

In conclusion, it is envisaged that the present linkage map, fortified with 88 SSR markers and 33 QTLs for biomass related traits would provide a means to breeders for further genetic enhancement of this crop species.

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-2 (AWCL-2) –This variety has been identified for release for North West Zone by the Variety Identification Committee (VIC) during NGM *rabi* 2023-24. It produces green fodder yield of 85-90 t ha^{-1} and dry matter yield of 10-15 t ha^{-1}. The Crude Protein Yield (CPY) of 2.5-3.0 t ha^{-1}and seed yield of 0.1-0.15 t ha^{-1} is recorded. It has crude protein content of 16-18% with *in-vitro* dry matter digestibility (IVDMD) of 58-62%. Besides, it is having acid detergent fibre (ADF) (35-40%) and neutral detergent fibre (NDF) (55-60%).

Lucerne variety IGFR-DL-5 (IGFRI-Dharwad Lucerne-5)

Identified for release for Zone-8 and Zone-3 of Karnataka State by 41st State Seeds Sub-Committee (SSSC) It produces green fodder yield of 90-110 t ha^{-1}and dry matter yield of 15-20 t ha^{-1}. It has crude protein content of 15-20% with IVDMD of 65-68%. Besides, it is having lower ADF (25-30%) and NDF (35-40%) which is desirable indicating digestibility and voluntary intake by animal. It is moderately resistant to rust and aphids.

F_4 progenies of six crosses *viz.*, Crau x A-2, RL-88 X Crau, A-2 x Crau, A-2 x Ohoho, A-2 x Vernal, Crau x DWR-1 were found to be superior for green fodder yield/plant at Dharwad, Avikanagar and Jhansi. Out of 45 progenies evaluated at different centres, 21 at Dharwad, 18 at Avikanagar and 20 lines at Jhansi were found to be superior in terms of GFY (g/plant).

Quality analysis revealed that 13 lines at Avikanagar and 22 lines evaluated at Dharwad centre had

substantial variation with respect to crude protein, NDF, ADF, cellulose and lignin content.

Sixteen accessions of lucerne (IC0325172, IC 0526300X, IC0298169, IC 0298170, IC 0298176, IC 0298183, IC 0298194, IC 0298212, IC 0298218, IC 0298232, IC 0298259, IC 0400411, IC 0400743, IC 0325173, IC 0561063, IC 0561068) were found to be superior and about eight accessions (Acc No 8, 37,38, 39, 70, 71, 142, 194) showed vigorous crown root character.

Among the polycrosses – polycross progenies with RL-88, A-2 and Alamdar-51 (DWR), polycross progeny with RL-88 (AVK) and polycross progeny with Krishna (Jhansi) were found to be superior.

Disease Severity Index of 12.4% (*kharif* 2023) was observed at flowering stage against common leaf spot of lucerne (*Pseudopeziza medicaginis*). Little leaf of lucerne caused by Phytoplasma recorded in *kharif* 2023 and 10% disease incidence was observed.

3.1.16. Studies on invasive pest *Spodoptera frugiperda* in fodder maize

(CRSCIGFRISIL2OI90902)

Seasonal incidence of maize armyworm and its relationship with weather parameters

Seasonal incidence of fall army worm at SRRS, Dharwad indicated that fall armyworm was noticed in both the season's *kharif* and *rabi* and the incidence was more during the *kharif* season. Highest incidence of 55% (Fig 3.1.6 a&b) was noticed during last week of August and second peak of incidence of 25% was noticed during last week of December. Correlation between seasonal incidence of maize fall army worm and weather parameters indicated that there was a significant negative relationship with the rainfall (-0.52**) and morning humidity (0.40*). Probably heavy rains washed the eggs and larva stages and acted as natural abiotic factor that reduced incidence.

Management of fall armyworm using entomo-pathogens

Among all the eco-friendly entomopathogens, *Metarhizium (Nomuraea) anisopleae* was found to be more effective and it was at par with standard check Azadiractin 10000 ppm @ 2ml /l. The highest GFY and dry matter yield (DMY) were recorded in *Metarhizium (Nomuraea) anisopleae* treated plots compared to untreated check.

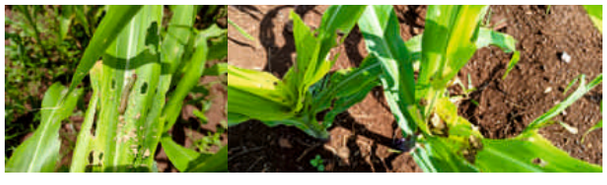

Fig. 3.1.6. a & b. Incidence of fall army worm *Spodoptera frugiperda* in maize

Management of fall armyworm using insecticides

Emamectin benzoate 5 WG @ 0.5g/l was found to be more effective and the incidence was 9.33% as compared to 30.33% in the untreated check after 15 days of first round of spray and 6.66% as compared to 17.33% in untreated check after 15 days of second rounds of spray. Emamectin benzoate 5 WG @ 0.5g/l was at par with standard check *Clorantraniliprole* 18.5% SC 0.3 @ ml/l and superior over all other insecticides resulting in higher GFY and DMY.

Management of fall armyworm using ecofriendly approaches

Combination of *M. rileyi* @ 2 g/l followed by Azadirachtin @ 3000 ppm @ 5 ml/l was found to be effective combination over other combinations and recorded higher GFY and DMY.

Effect of intercropping on FAW incidence

Among the different intercropping systems, maize intercropped with field bean recorded the lowest green fodder yield, dry fodder yield, net returns and benefit:cost (B:C) ratio. The highest yields and monetary returns were recorded with maize intercropped with cowpea in 3:1 ratio with 150% RDN. However, the highest fodder yield of maize was recorded with the sole maize. Fodder maize with bund planting of bajra napier hybrid or guinea grass too recorded yield at par with sole or maize intercropped with cowpea with 150% RDN. Among the intercropped leguminous fodder crops, sole cowpea recorded higher fodder yield, net returns and B:C ratio. The magnitude of intensity of maize fallworm *Spodoptera frugiperda* observed in descending order of sole maize < maize+soybean (3:1) < maize+dolichos (3:1) < maize with bund planting of bajra napier hybrid < maize+cowpea (3:1) (Fig.3.1.7).

Fig. 3.1.7. Maize+ cowpea intercrop (3:1) for reducing FAW incidence

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. Mulberry based silvipastoral systems for augmenting forage availability

(CRSCIGFRISIL20171001)

The interspaces of forest plantations offer scope for raising pasture in order to meet forage requirement of the farmers and pastorals. In a mulberry based silvopasture (Fig. 3.2.1) study at ICAR-IGFRI RRS Srinagar, maximum green fodder yield (73.42 t ha^{-1}), dry fodder yield (19.09 t ha^{-1}), and crude protein yield (0.33 t ha^{-1}) were observed for *Phalaris* + orchard grass + sainfoin + mulberry system, followed by *Phalaris* + sainfoin + mulberry. However, crude protein was found maximum (21.64%) under the sainfoin + mulberry system and minimum was observed in the control treatment (4.70%). *Phalaris* + orchard grass + sainfoin + mulberry system recorded 225.16% yield increase over control, 36.72% over *Phalaris* + mulberry, 72.38% over orchard grass + mulberry, and 64.69% over sainfoin + mulberry systems. The *Phalaris* + orchard grass + sainfoin + mulberry silvopasture system is therefore, recommended for large scale adoption in land-uses.

Fig.3.2.1. Mulberry based silvipastoral systems

3.2.2. Studies on temperate pasturelands for enhanced forage yield, quality and environmental sustainability

(CRSCIGFRISIL20202001)

Five pasture combinations were studied in a temperate pastureland, *viz.*, SG (50% *Festuca arundinacea* + 50% *Dactylis glomerata*), SGL1 (25% *Festuca arundinacea* + 25% *Dactylis glomerata* + 50% *Onobrychis viciifolia*), SGL2 (25% *Festuca arundinacea* + 25% *Dactylis glomerata* +50% *Trifolium pratense*), SGL12 (25% *Festuca arundinacea* + 25% *Dactylis glomerata* +25% *Onobrychis viciifolia* + 25% *Trifolium pratense*) and NG (Natural pasture) and F (uncultivated fallow). Soils of SL under SGL1, SGL2, and SG12 had ~18, 36, and 22% greater organic than SG, respectively. The SGL1, SGL2, and SG12 had ~15, 30, and 18% greater microbial biomass carbon than SG, respectively. The biomass production under SG, SGL1, SGL2, and SG12 was ~ 2.1, 2.5, 2.4, and 2.2 times greater than NG, respectively. However, biomass production under SGL1, SGL2, and SG12 was ~18, 12, and 6% higher than SG, respectively.

Status of pasturelands observed by pastoralists

Majority of the (75.36%) pastoralists reported that there was a decline in pasture land area with average decrease value of 27.59% over the period of 20 years, followed by no change among one fourth of the pastoralists (20.29%), while only 4.35% reported that there was increase in pasture land area with average increase value of 47.14%. Similarly in the production of grasses, majority of the (75.36%) pastoralists reported that there was decrease in grass production with average decrease value of 43.29% over the period of 20 years, followed by no change among 12.56% pastoralists, and only 7.25% reported that there was increase in production of grasses with average increase value of 31.5% over the period of 20 years. Nearly half of the pastoralists (43.96%) reported that there was increase in the accessibility to pasture land with average increase value of 29%, followed by no change among 32.85%, and remaining 23.19% of the pastoralists reported reduction in the accessibility to pasture land with average decrease value of 27.17%.

3.2.3. Study of restoration ecology in silvipasture system for semiarid region

(CRSCIGFRISIL20200301)

During the year 2023, green forage production was higher in *Megathyrsus maximum* (39.58 t ha^{-1}) followed by *Chrysopogon fulvus* (26.03 t ha^{-1}) and *Stylosanthes seabrana* (9.18 t ha^{-1}) with different tree/shrub combinations of silvipastoral system. Crown lopping (30%) was imposed on tree species (Fig. 3.2.2a) (once a year) and pollarding (twice a year) on shrub species for obtaining top feed and maximum top feed production was obtained from *Leucaena leucocephala* (13.29 t ha^{-1}) followed by

Ficus infectoria (5.86 t ha^{-1}), *Acacia nilotica* (4.17 t ha^{-1}) and *Morus alba* (3.91 t ha^{-1}). The annual leaf litter production among trees/shrubs ranged from 3.38 to 4.02 t ha^{-1}. Jalauni sheep were allowed to graze (Fig. 3.2.2b) for 7-8 hours daily on *L. leucocephala* and *F. infectoria* based silvipasture in September-October. Total dry matter (DM) intake was higher (3.80%) in *L. leucocephala* based silvipasture system than *F. infectoria* based system (3.50%). Digestibility of DM, OM, CP and NDF were 59.92%, 64.31%, 54.21% and 54.66% in sheep grazed on *L. leucocephala* based silvipasture system and the corresponding values in sheep for the *F. infectoria* based system were 59.59%, 63.85%, 55.15% and 53.56%, respectively. Thus, grazing along with supplementation of concentrate @ 1% body weight could support a daily body weight gain of around 50 g in sheep under both the systems.

Fig. 3.2.2 a & b

3.2.4. Sustainable forage production through lopping management in three tier silvipasture systems

(CRSCIGFRISIL20220301)

In three tier silvipasture system, lopping of shrubs and tree at 70% intensity produced higher top feed (3.57 t ha^{-1}) and fire wood (4.25 t ha^{-1}) as compared to 50% lopping intensity (2.71 and 3.23 t ha^{-1}). Among shrub species, *Ziziphus mauritiana* recorded maximum top feed (3.56 t ha^{-1}) and fire wood (4.11 t ha^{-1}) followed by *Z. xylopyrus* (3.35 and 3.94 t ha^{-1}) and *Acacia catechu* (2.51 and 3.17 t ha^{-1}) in association with *Hardwickia binata*, respectively. Planting of *H. binata* and shrub species in alternate row at 6x6 m spacing recorded significantly higher understorey pasture yield of *C. ciliaris* (9.76 t ha^{-1}) as compared to 6x4 m (8.47 t ha^{-1}) and 4x4 m spacing (6.74 t ha^{-1}). *Z. mauritiana* recorded maximum carbon stock (24.20 t ha^{-1}) followed by *A. catechu* and *Z. xylopyrus* in association with *H. binata.*

Twenty numbers of growing Jalauni sheep and Bundelkhandi goats were allowed to graze in this system (Fig. 3.2.3) for growing season (August-October) as well as post growing season (November-January). Nutrient utilization study on goats and sheep indicated that along with 1% concentrate supplementation, DM intake was 3.73% in goats and 3.35% in sheep. Digestibility of DM, OM, CP and NDF were 60.60%, 64.84, 62% and 58.35% in goats and 59.30%, 64.39%, 60.64% and 57.28% in sheep, respectively. Average daily gain was around 64 g in goats and 62 g in sheep from grazing and browsing during growing season in three-tier silvipasture system.

Fig.3.2.3 Mixed herd grazing in three-tier silvipasture system

3.2.5. Pruning management for optimizing forage and wood productivity from *Hardwickia binata* based silvipasture systems

(CRSCIGFRISIL20230304)

In *H. binata* based silvipasture systems (Fig. 3.2.4a), 60% pruning of *H. binata* branches resulted in significantly higher top feed (4.10 t ha^{-1}) and fire wood yields (6.09 t ha^{-1}) as compared to 30% pruning (2.47 and 3.70 t ha^{-1}) and 45% canopy pruning (2.38 and 5.15 t ha^{-1}), respectively. Pasture yield (9.94 t ha^{-1}) also significantly increased with 60% pruning of *H. binata* branches than 30% pruning (7.74 t ha^{-1}) and 45% pruning (8.62 t ha^{-1}), respectively (Fig. 3.2.4b). However, in term of bole wood volume, 30% pruning of *H. binata* branches recorded significantly higher bole wood volume as compared to 45% pruning and 60% pruning. Among grasses, *Chrysopogon fulvus* recorded maximum pasture yield (9.50 t ha^{-1}) followed by *Cenchrus ciliaris* and *Megathyrsus maximus*. In total carbon stock of *H. binata* contributed above and below ground carbon stock were 21.19 and 5.95 t ha^{-1}, respectively. Soil moisture at 0-15 cm, 15-30 cm and 30-60 cm depths after monsoon (October and December) showed that *C. fulvus* recorded higher moisture content (7.65, 7.48 and 8.34%) as compared to *C. ciliaris* (7.14,7.15 and 8.05%) and *M. maximus* (6.66, 6.74 and 7.74%) at 0-15 cm, 15-30 cm and 30-60 cm soil depth. Similarly, light pruning of *H. binata* branches (30%) resulted in maximum moisture content followed by 45% pruning and 60% canopy pruning .

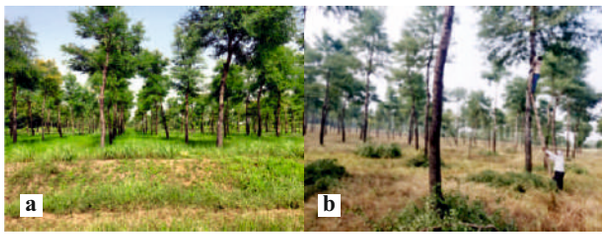

Fig. 3.2.4. (a) *Hardwickia binata* based silvipasture system (b) Pruning management in *H. binata* based silvipasture system

3.2.6. 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

Experiment on "Evaluation of decomposer accelerator to promote natural farming in aonla-based horti-pasture system" was started in July, 2023. The treatments were i). Livestock slurry-livestock urine 100 lt./ha + 100 kg dung/ha, ii). *Jeevamrit* @ 500 lt. /ha, iii). *Ghanjivamrit* @ 500 kg dry cow dung/ha using 50 litre *Jeevamrit*), iv). consortium (First year Pusa decomposer next year our self-developed), v). FYM 2 ton/ha,vi). RDF (30 kg N, 20 kg P and 20 kg K/ha to under storey pasture), and vii. Control with three aonla trees in each treatment, applied statistical design was RBD with three replications. The year 2023 was an initial year.

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

First year of experiment on "Improvement of ecosystem productivity in guava based horti-pastoral system with foliar application of micronutrients" at five levels *i.e.* T_1- Boron (Borax) (0.25%) + Zn SO_4 (0.5%), T_2- Boron (0.25%) + $ZnSO_4$ (0.75%), T_3- Boron (0.5%) + $ZnSO_4$ (0.5%) T_4- Boron (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 fruit trees of 15 years old guava *cv.* Lalit and Shweta. The fruit set and fruit retention per cent was increased due to application of borax and zinc sulphate (Fig. 3.2.5). The higher fruit set was recorded in response to higher concentration of micronutrients application $ZnSO_4$ + Borax (61.44% in Lalit and 59.6% in Shweta). Micronutrient application significantly influenced the fruit yield as compared to control and it was the highest (53.37 and 49.2 kg/tree in Lalit and Shweta respectively). The understorey dry matter yield of pasture (*C. ciliaris* + *S. hamata*) ranged from 3.1 to 3.6 t ha^{-1} and was not influenced by foliar application of micronutrients and tree cultivars.

Fig. 3.2.5. Guava fruit production with foliar application of micronutrients

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

(CRSCIGFRISIL20200302)

The highest grass (*M. maximus)* dry matter yield was recorded in sole pasture system (9.07 t ha^{-1}) followed by central leader (7.45 t ha^{-1}) and open centre system (8.04 t ha^{-1}) of bael *cv.* CISHB-2. Grass grown under untrained bael tree recorded the lowest dry matter .

Bael tree trained with central leader system produced higher fruit yield (41.91kg/tree) followed by open centre system (41.65 kg/tree) and modified central leader system (38.47 kg/tree) and lowest yield in (30.22 and 30.81 kg/tree, respectively). The highest yield efficiency (63 and 57.55 and) and productivity efficiency (0.227 and 0.186 kg/cm^2 TCSA) were recorded in tree trained under open centre system and modified leader system. Untrained tree recorded least efficiency.

3.2.8. Development of grassland assessment system using geospatial technology

(CRSCIGFRISIL20210301)

The generation of base map and thematic layers of the Chhatarpur (MP) district of grasslands and spread was done using survey of India *i.e.* region of Central Highland physiographic zone of India. For the present study Landsat 8 Operational Land Imager (OLI) data acquired from USGS Earth Explorer Study showed that Bamitha, Bari and Dauriya regions have better grassland health (Fig. 3.2.6).

3.2.9. Improved pasture management for sustaining soil-plant-animal productivity

(CRSCIGFRISIL20230302)

The whole area was rejuvenated by removal of

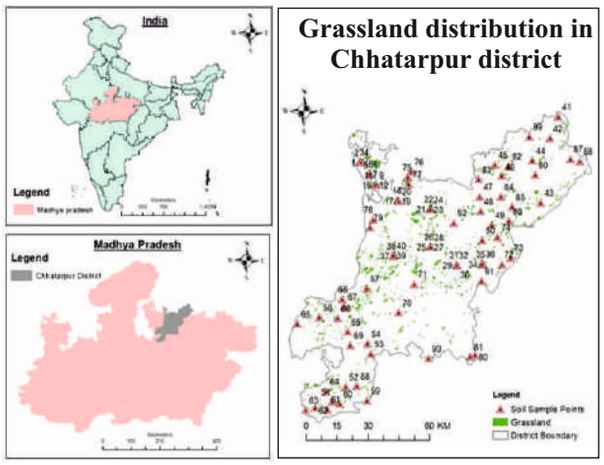

Fig. 3.2.6. Base map of Chhatarpur dustrict

unwanted bushes and through application of nano urea using drone and reseeding of *Cenchrus* and *Chrysopogon.* The intervention led to improved green biomass production in all treatments. Low, medium, and heavy intensity grazing resulted in 7.68, 6.82, and 5.94 t ha^{-1} green biomass production.

3.2.10. Canopy management for enhanced productivity and sustainability of neem based silvipastoral system in semi-arid tropics

(CRSCIGFRISIL20190802)

Canopy of neem trees was managed with four lopping intensities, namely, 50%, 75%, 100% lopping, and no lopping. Under various lopping intensities, mixed pastures of grasses and legumes (*Cenchrus setigerus* + *Stylosanthes seabrana* and *Cenchrus ciliaris* + *Stylosanthes seabrana*) were grown at WRRSIGFRI, Avikanagar, 2022–23. The highest plant height, number of tillers, and tussock diameter of *Cenchrus* spp. were observed with 100% lopping intensity. The neem-based silvipasture system provided significantly higher green fodder yield than open pasture. The 75% and 100% lopping intensities were statistically at par in terms of green fodder production from grass-legume pastures. The highest fodder yield of neem tree leaves (27 kg/tree) and dry fuel wood (20 kg/tree) were also obtained in 100% lopping intensity.

3.2.11. Evaluation of *Ailanthus excelsa* and *Morus* species germplasm for growth performance, fodder yield and nutritional traits under various agro-climatic zones

(CRSCIGFRISIL20200303)

Seventy three germplasms of *Morus* species (Fig. 3.2.7a) were evaluated and after one year of field planting survival varied from 33.33-100%. Twenty germplasm of *Morus* species being evaluated at RRS Srinagar, recorded 10-70% survival after 2 years; height among germplasm varied from 101.5 to 170.0 cm and collar diameter from 0.79 to 2.54 cm. In case of *Ailanthus excelsa* seeds (germplasm) from 57 plus trees were selected from Madhya Pradesh, Rajasthan and Uttar Pradesh and were sown in nursery at Jhansi (UP) and Avikanagar (Rajasthan) for raising plus tree progenies. Seedling emergence (Fig. 3.2.7b) was recorded at both the locations and seedling emergence varied from 0 to 15% at Jhansi and 0-61% at Avikanagar.

Fig.3.2.7 a. Field view of *Morus* spp. germplasm and b. *Ailanthus* seedling emergence

3.2.12. Assessment of water requirement for fodder based cropping systems in different parts of Uttar Pradesh

(CRSCIGFRISIL20220202)

Weekly weather data for three regions were collected for Varanasi, Lucknow and Jhansi from ICAR institutes and other sources. A meteorological database was created for Varanasi (2010-22), Lucknow (2012-22), and Jhansi (2010-22) for maximum Temperature (Tmax), minimum temperature (Tmin), relative Humidity (I and II), wind velocity, bright sun shine (Bss), and rainfall in appropriate format for computation of Potential Evapotranspiration (PET) following modified Penman method. The annual reference evapotranspiration (ET0) varied from 1374.9 to 1540.5 mm for Jhansi region. Further, the crop coefficient (Kc) of berseem was established cut-wise. The Kc value at each cutting stage has crosses the unit value (>1.0). The estimated crop coefficient (Kc) varied from 1.19 to 1.81 in different cuttings. The highest Kc coincided with second cutting followed by third and fourth cutting (Kc=1.58). Moreover, the average Kc value for the entire crop growth duration was estimated to be 1.54.

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

3.3.1 Assessment of long–term effect of sewage water irrigation on heavy metal accumulation in soil-fodder-animal continuum

(CRSCIGFRISIL20180201)

The soil, fodder, animal milk and blood samples were collected (Fig. 3.3.1) from long-term sewage water-irrigated peri-urban areas of Kanpur, Varanasi and Bhopal. Soil, fodder, milk, and blood samples of animals were analyzed for heavy metals, *viz.* chromium (Cr), nickel (Ni), cadmium (Cd), and lead (Pb) The heavy metal contents in the sewage water-irrigated soil were within the safe limit except for the sewage water-irrigated surface soil of Varanasi, while Ni content has crossed the maximum permissible limit (20 ppm) in the soil at all the locations. Irrespective of locations, heavy metals accumulation was higher in fodder bajra (Cr, Ni, and Pb, 8.36-13.17, 7.78-9.20, and 7.53-7.54 ppm, respectively), followed by fodder sorghum (Cr, Ni and Pb, 10.29-10.66, 5.21-5.36, and 5.62-6.60 ppm, respectively), berseem (Cr, Ni, and Pb, 9.46-9.51, 4.28-4.43, and 5.17-6.65 ppm, respectively) and fodder maize (Cr, Ni and Pb, 9, 4.13, and 5 ppm, respectively). Furthermore, the residue levels of Cd and Pb in animal milk (0.189-0.199 and 0.267-0.296 ppm Cd and Pb, respectively) and blood (0.088-0.257 and 0.520-2.486 ppm Cd and Pb, respectively) samples were found to be higher than the maximum permissible limit in Kanpur and Bhopal, except for Cr in blood samples in both locations, which was lower than the maximum permissible limit (1.0 ppm). Irrigation with sewage water increased fodder yield and the quality. At the same time, heavy metals (Cr and Pb) were significantly higher than the maximum permissible limit in fodder crops, animal milk, and blood. Therefore, based on this study, a combination of lesser heavy metal accumulating fodder crops (fodder oat, berseem, and fodder maize) and suitable dilution ratio of sewage water (1:3 ratio, sewage water: ground water) practices should be adopted for long term irrigation with sewage water to minimize heavy metal accumulation in the soil-fodder-animal continuum.

Fig. 3.3.1. Collection of soil, fodder, milk and blood samples

3.3.2 Development of decision support system for fodder crops with a special reference to climate change

(CRSCIGFRISIL20200201)

To validate the model, a field experiment was conducted during *rabi* season with three dates of sowing (D1: 21.11.2022, D2: 8.12.2022, D3: 22.12.2022) under four Nitrogen levels (0, 40, 80 and 120 kg N/ha with oat (JHO-2010-1). Detailed crop performance data on phonological events, yield and growth attributes were collected to evaluate the model.

Deviation of simulated anthesis date and maturity from observed was 4 to 6 days for D1 and D2 Sowings. Thus, predicted values were well, but greatest error in simulating anthesis and maturity date occurred during third date of sowing, which had a simulated anthesis date of 70 days after sowing compared with actual date of 88 days Bias (-0.024 to -0.34 t ha^{-1}) and root mean square of error (RMSE) (0.13 to 0.10 t ha^{-1}) statistics indicated that model is able to simulate grain yield and top weight reasonably well under different nitrogen levels and different date of sowings. Leaf area index (LAI) was simulated well for the first two date of sowing (deviation lies within the range of -13.0 to 4.5%). However, LAI simulated by the model was reduced by 38 to 55% than observed values for all the Nitrogen levels during third date of sowing. In this study, the CERES-Wheat model and DSSAT-CERES-Wheat model were proved to be useful decision-making tools for winter oat production in the Bundelkhand region of India.

3.3.3 Precision nitrogen management in forage crops

(CRSCIGFRISIL20190202)

A field experiment was conducted during summer and rainy season 2023 to test need-based N management approaches for multicut sorghum (CSV-33 MF). Total four cuts were taken. Applying 30, 40, and 50 kg N/ha after each cut (in addition to 30 kg N/ha as basal dose) recorded 54.5, 68.0, and 78.7% higher yield (Fig. 3.3.2) over control (No N). Furthermore, 40 kg N/ha when SPAD value 37-

41 produced 108 t/ha green and 21.1 t/ha dry fodder which was statistically at par with blanket application of 50 kg N/ha after each cut. Nitrogen scheduling at higher SPAD value (>45) added more N in soil but its effect on green fodder yield was not observed resulting in reduction of agronomic efficiency of applied nitrogenous fertilizer.

Fig. 3 3.2. Comparison of control and SPAD based fertilizer application treatment

3.3.4 Food-fodder based crop intensification and diversification with efficient soil water conservation approaches under rainfed condition

(CRSCIGFRISIL20170201)

Nine cropping systems and three moisture conservation practices were evaluated in the field condition. TSH+leucaena+ (Sorghum+ cowpea-Chickpea) cropping system (CS) recorded highest green fodder and dry matter yield (27.46 and 4.75 t ha^{-1}) in four cuts of TSH and lowest being with TSH+Gliricidia+ (Sorghum+ cowpea-Barley) CS (26.16 t ha^{-1} GFY). With respect to moisture conservation practices, integrated moisture management practices recorded significantly higher GFY and DMY of TSH over rainfed condition and limited irrigation treatments). Regarding system economics, the highest net returns and benefit cost ratio (Rs.48068/ha/yr and 1.58) was recorded in TSH+leucaena+ (Sorghum+ cowpea-barley) cropping system and the lowest being with TSH+Sesbania+ (Sorghum+ cowpea-chickpea) cropping system (Rs 33966/ha/yr and 1.39). Among moisture conservation practices, the highest net returns of Rs 49553/ha/yr and benefit cost ratio (1.63) was realized in limited irrigation + residue retention (RC2) followed by integrated moisture management practices (Rs 48940/ha/yr and 1.51) and rainfed condition (Rs 28090/ha/yr and 1.38). Integrated moisture management practices (Fig. 3.3.3) recorded 3.76% higher moisture content (V/V) in 0-15 cm soil profile, compared to limited irrigation + residue retention on 28th February, 2023, whereas, 10.14% higher soil moisture was observed in integrated moisture management practices over rainfed condition. Similar trend was also observed in 15-30 cm soil profile.

Fig. 3.3.3. TSH + Sesbania+ (Sorghum (F) + Cowpea (F)- Barley) in IMMP

3.3.5 Livestock based integrated farming systems for sustaining livelihood of Bundelkhand farmers

(CRSCIGFRISIL20190201)

The on-station irrigated IFS model (Fig. 3.3.4) comprising of groundnut-wheat cropping system in 0.3 ha, green gram – wheat in 0.25 ha, NB hybrid + cowpea – berseem round the year green fodder cropping system in 0.2 ha, guava + seasonal vegetable based agri-horticulture in 0.2 ha and two cow and one buffalo and water harvesting - cum - fish pond (20 m x 25 m x 2 m) in 0.05 ha was evaluated. The rainfed IFS model consisted of green gram - barley cropping system in 0.3 ha, fodder sorghum - oat in 0.15 ha, Subabul + TSH + *Stylosanthes* silvipasture system in 0.3 ha, ber + sesame - gram based agri-horticulture in 0.2 ha and one cow and five goats and rain water harvesting pond (20 m x 25 m x 2 m) in 0.05 ha. The irrigated model also have boundary plantation of subabul and spineless fodder cactus while rainfed model have caronda, spineless fodder cactus, subabul and moringa on the boundaries. During 2022-23, the irrigated IFS model produced excellent wheat yield (2320 kg), green fodder (17600 kg berseem, 3150 kg cowpea, and 4475 kg BN hybrid), vegetables (375 kg potato, 310 kg Palak, 950 kg cauliflower and cabbage, 60 kg radish, 40 kg onion, 20 kg garlic, 50 kg turmeric, 30 kg methi, 410 kg ladies finger, 755 kg bottle gourd, 75 kg pumpkin, 80 kg cucumber, 200 kg tomato, 175 kg brinjal, and 220 kg ridge gourd) and 25 kg fish. The rainfed IFS model produced 7300 kg fodder sorghum, 2250 kg green fodder from TSH, 1950 kg green fodder from subabul, 3500 kg green fodder from stylo, 1520 kg barley grain, 7125 kg fodder oat, and 130 kg gram.

Fig. 3.3.4. View of irrigated IFS model

3.3.6 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 green fodder yield of BN hybrid (Fig. 3.3.5) which was 30% higher than farmer practice (100% NPK and flood irrigation). Fertigation (75% NPK) at 50% ASM also recorded 13% higher yield of BN hybrid over farmer practice. To produce 1 kg dry matter, 473 litres of irrigation water was needed in flood irrigation whereas under drip irrigation it is lower and varies from 212 to 375 litres. Furthermore, under flood irrigation only 52.1 kg dry matter can be produced from 1 kg of nutrients applied whereas under fertigation treatments it was 58.8 to 149.3 kg DM/kg of nutrient (NPK) applied.

Fig. 3.3.5. Growth of BN hybrid under 75% ASM with 100% NPK

3.3.8. Effects of farming practices on fodder productivity and profitability of Pearl millet + Cowpea – Oat +Lucerne cropping system

(Project number????)

The experiment was conducted during rainy season in 2022-2023 at IGFRI-WRRS, Avikanagar. Different farming methods such as modern/ conventional farming, organic farming, integrated farming/integrated nutrient management, natural farming and improved natural farming were imposed on pearl millet+cowpea-oat + lucerne strip cropping in a randomized block design with four replications. The soil was sandy loam in texture with low carbon content 0.25% and low nitrogen (210 kg/ha), low in P (8 kg/ha) and medium in K. The inputs of natural farming such as *beejamrit, jeevamrit* and *ghanjeevamrit* were prepared. Among the farming methods, conventional farming and integrated farming were found at par and these methods resulted into significantly higher plant growth and fodder yield than organic and natural farming methods in pearl millet as well as cowpea. The system productivity of pearl millet + cowpea was reduced by 40% under natural farming as compared to conventional farming; this might be attributed to nitrogen deficiency observed in crop which severely affected plant growth. The green fodder yield of oat and lucerne reduced by 52% and 30% respectively in 1st cut under natural farming as compared to integrated nutrient management.

3.3.9. Solubilization of native soil phosphorus using natural sources of silicon and P solubilizing microbes

(CRSCIGFRISIL20230301)

To mobilize inorganic soil phosphorus (P), soils were treated with P solubilizing microbe (PSM; *Burkholderia cepacia*) and graded doses of rice straw (RS) under varying hydrothermal scenarios (temperature and soil moisture suctions), likely, S1 (25 ◦C and 0.033 MPa), S2 (35 ◦C and 0.033 MPa), S3 (25 ◦C and 0.1 MPa), and S4 (35 ◦C and 0.1 MPa). Six treatments were obtained, T0 (no PSMs and no RS), T1 (6 t RS ha^{-1} + PSMs), T2 (8 t RS ha^{-1} + PSMs), T3 (10 t RS ha^{-1} + PSMs), T4 (12 t RS ha^{-1} + PSMs), and T5 (PSM).

Temperature sensitivity of organic P mineralization was the highest for T3. Inorganic P solubilization rate under S1, S2 and S4 were ~62%, 86% and 54% greater than S3, respectively. T3 significantly reduced hysteresis by ~12-14% over control. Path analysis indicated silicon concentrations and changes in soil pH were the most significant factors to influence soil environment to mobilize soil P. T3 could solubilize ~2.7% and 3.6% of inorganic P under S1 and S2 enhancing P availability by 3.35, and 4 times over control, respectively. Overall,

annual rice straw (10 t ha^{-1}) + PSM application under varying moisture availability could sustain P availability in semi-arid tropical India.

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

(CRSCIGFRISIL20221101)

About 21 soil samples were collected from rhizosphere of the diverse forage crops and sufficient microbial diversity was observed in the soil samples. A total of 25 different bacterial isolates and 11 fungal isolates were isolated from above soil samples based on selective growth on different media, growth time (24 h to 72 h), and colony morphology (colour, growth pattern, and time) (Fig. 3.3.6).

Gram staining was done to categorize bacterial isolates in Gram positive and Gram negative as well as microscopic studies.

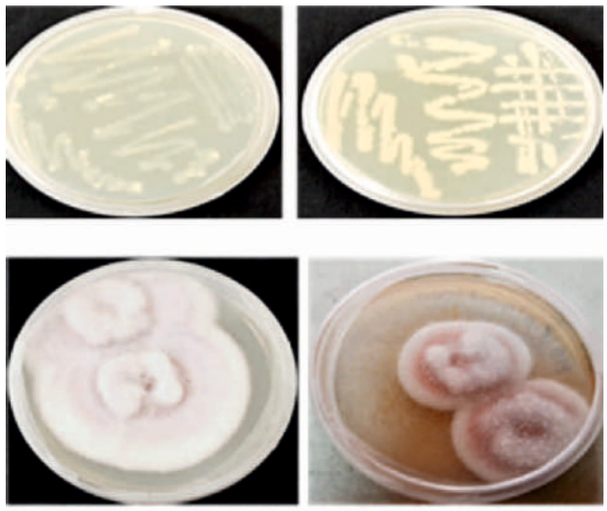

Fig. 3.3.6. Diverse bacterial and fungal isolates growth on PDA and LBA media plates

Mycelial growth for a week in PDA at 18 C at 150 rpm from 2 fungal isolates from the rhizospheric soil of fodder maize were filtered and used for DNA isolation and PCR amplification (Fig. 3.3.7).

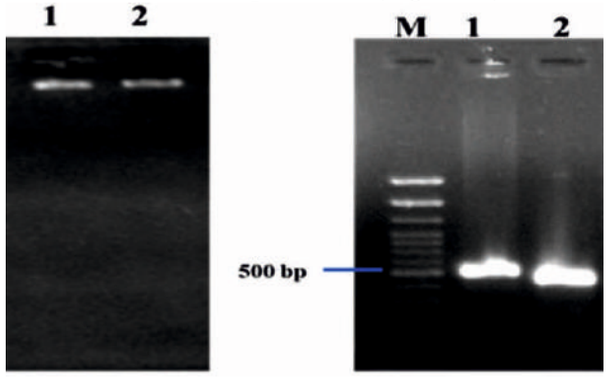

Fig. 3.3.7. Genomic DNA and ITS sequences amplification of two fungal isolates

3.3.11. Intensive fodder production through crop diversification and zinc fortification in Kashmir Himalaya

(CRSCIGFRISIL20221001)

The experimental investigations were carried out at ICAR-IGFRI, Regional Research Station, Srinagar. The experiment consisted of five cropping systems namely sole maize - sole oat, maize + cowpea - sole oat, sole maize - oat + berseem, maize + cowpea – oat + berseem and sole cowpea - sole berseem and three zinc levels viz. Zn @ 0 (control), Zn @ 5 kg/ha as basal soil application and Zn @ 5 kg/ha as basal soil application plus one foliar spray of $ZnSO_4$ @ 0.5%. Seeds at recommended rates were sown at 30 cm row spacing and intercrops were sown in between the main crop rows. Cropping systems significantly influenced plant height of both the crops. Sole maize in the maize – oat + berseem recorded highest plant height (257.00 cm) while as maize + cowpea-oat system recorded lowest plant height of maize (249.66 cm). LAI and leaf-stem ratio were not influenced by different cropping systems, however, zinc application significantly improved both LAI and leaf-stem ratio over control (no zinc). Among the different cropping systems, maize+ cowpea - oat + berseem recorded highest green fodder yield during *kharif* 2023 (50.93 t ha^{-1}) followed by maize + cowpea – oat (50.42 t ha^{-1}). Maize + cowpea - oat + berseem also recorded highest dry matter yield (12.87 t ha^{-1}) and was followed by maize + cowpea-oat (12.69 t ha^{-1}). Maize + cowpea - oat + berseem cropping systems also recorded the highest yearly fodder yield. Sole crops cowpea- berseem recorded the lowest annual fodder yield. Zn @ 5 kg/ha as basal soil application plus one foliar spray of $ZnSO_4$ @ 0.5% increased annual green fodder yield by 9.47 % and dry matter yield by 12.77 % over control.

Studies on natural farming practices in temperate forage crops

Dactylis glomerata (perennial) + (cowpea - oat) crops were under evaluation under this study. The data on initial soil health status, microbial composition of natural farming inputs (*Beejamrit, Jeevamrit* and *Ghanjeevamrit*) and data on growth and yield parameters of annual crops (*rabi*) has been recorded. The soil had high organic carbon, low plant available P and N, and medium plant available K. The conventional or modern farming resulted in the highest plant height (94.33 cm) while as natural farming recorded the lowest plant

height (73.66 cm). The treatment involving improved natural farming significantly improved plant height over natural farming treatment. Conventional or modern farming recorded the highest GFY (8.13 t ha^{-1}) and DMY (1.62 t ha^{-1}) followed by treatments integrated farming and improved natural farming.

3.3.12. Studies on fodder production potential of fodder shrub based alley cropping systems in peninsular India

(CRSCICFIISIL20200902)

Two experiments *viz.* fodder shrub based alley-cropping systems for irrigated conditions and fodder shrub based alley-cropping systems for rainfed conditions were carried out during 2023-24 to identify high yielding fodder shrub and fodder crop in alley cropping system.

Among the fodder shrub based alley cropping systems under irrigated conditions, moringa with bajra napier hybrid recorded the highest green fodder yield, dry fodder yield and crude protein yield (Fig. 3.3.8).

Among the rainfed fodder shrub based alley cropping systems, moringa with grazing guinea signal grass recorded higher green fodder, dry fodder and crude protein yield as compared to sesbania and subabul based systems (Fig. 3.3.9). The fodder shrubs moringa was found superior to sesbania and subabul under rainfed conditions.

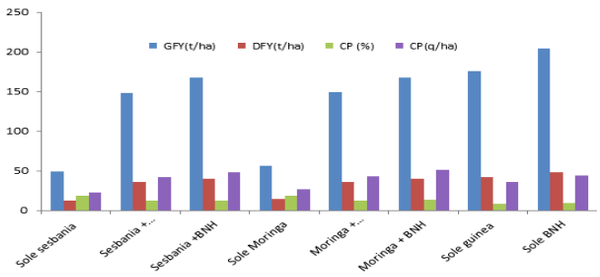

Fig. 3.3.9. Performance of forage shrub based inter cropping systems under irrigated conditions

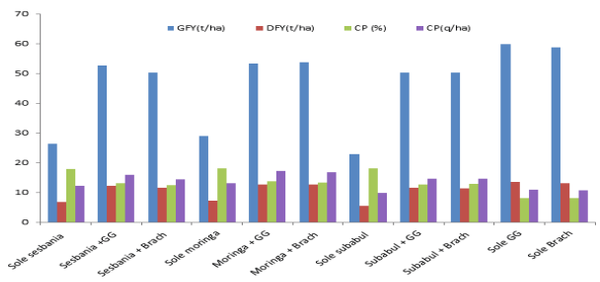

Fig. 3.3.10. Performance of forage shrub based inter cropping systems under rainfed conditions

3.3.13. 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 PGPMs. Two PGPMs (one bacterium and one fungus each) with 3 fertilizer doses combinations were used. In field evaluation, all PGPM treatments recorded GFY (236.0-310.0 q/ha) and seed yield (805.0-990.0 kg/ha) compared with 100% RDF (243 q/ha and 892.0 kg/ha, respectively) in the nutrient poor - light soil. All PGPM treatments recorded soil microbiological properties (TBC, TFC, PSB, PSF counts, acid and alkaline phosphatase enzyme activities) at par or higher than 100% RDF. Collected root exudates were analysed through HPLC and the HPLC chromatogram revealed enhancement of the peaks of root exudates in bacteria and fungi inoculated plants. Some extra peaks formed in root exudates influenced by bacteria. Experiment is being conducted this *rabi* for molecular data collection regarding plant-microbe interaction and analysis, since it could not be done in last *rabi* due to technical reasons.

Sr.No.	Sample code	Crop
1	Fim-22	Finger Millet/Kodo (*Eleusine coracana*)
2	Brr-22	*Brachiaria ruziziensis*
3	Zem-22	*Zea mays*
4	Set-22	Setaria
5	Brh-22	*Brachiaria humidicola*
6	Brd-22	*Brachiaria decumbens*
7	Brr-1-22	*Brachiaria ruziziensis*
8	Gun-22	Guinea grass (*Megathyrsus maximus*)
9	Tfe-22	Tall fescue (*Festuca arundinacea*)
10	Bot-22	Bothriochloa
11	Tim-22	Timothy (*Phleum pratense*)
12	Bro-22	Bromic grass (Bromus)
13	Rfe-22	Red feseue (*Festuca rubra*)
14	Tim-1-22	Timothy (*Phleum pratense*)
15	Orc-22	Orchard grass (*Dactylis glomerata*)
16	Baj-22	Bajra/Pearl millet (*Pennisetum glaucum*)
17	Cha-22	Chari (*Sorghum bicolor*)
18	CoP-22	Cowpea (*Vigna unguiculata*)
19	Ras-22	Rosnalum
20	Dia-22	Dinanath
21	Nap-22	Napier

3.3.14. Development of microbial inoculants for enhancing ensiling

(CRSCIGFRISIL20210702)

This experiment was aimed to isolate and characterize lactic acid bacteria to improve ensiling various types of grasses by increasing lactic acid production and rapid lowering the silage pH. About 100 lactic acid bacterial cultures (LAB) were isolated from phyllosphere region as well as endophytes of different grasses at available in IGFRI Jhansi such as Guinea grass, dinanath grass, dhawalu grass, anjan grass, dhaman grass, lampa grass, sen grass, and from silages of various grasses in different batches (including 22 LAB from temperate grasses silage and 48 LAB from apple silages) by using MRS agar media. Isolates were examined for colony morphology and catalase negative and gram positive bacterial isolates were screened for *in vitro* lactic acid production. About nine LAB isolates were chosen based on their lactic acid production and they were used as inoculants additives (@ ~1x10^8 CFU/ml) for ensiling Bajra Napier (BN) hybrid grass. Clean, surface sterilized plastic containers were utilized for making silage by maintaining airtight sealing to ensure anaerobic

conditions. Following incubation period of 45 days at room temperature, the containers were examined for fermentation and organoleptic properties. The average LAB count in the inoculated containers ranged from $42.5x10^3$ to $75x10^3$ CFU/g, compared to control ($40.8x10^3$ CFU/g). The boxes inoculated with the culture gave an average of 245.5 to 599.0 mg of lactic acid, while uninoculated control recorded 223.9 mg. The average pH drop in silage inoculated with LAB ranged from 4.82 to 4.21, compared to control (4.94 to 4.85). Percent DM reduction in silage ranged from 1.65-2.76%. Volatile fatty acid profile showed that acetic, propionic, isobutyric, butyric, isovaleric, valeric were found 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 from temperate grasses silage were also used to prepare BN hybrid (LA: 116.8-246.3 mg and pH: 4.87-4.58 *vs*. 69.5 and 5.07 in control) and *Cenchrus 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 which enhances the ensiling process and results in higher-quality silage.

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

3.4.1 Effect of storage container and storage time on germination of Anjan grass (*Cenchrus ciliaris*), Sewan grass (*Lasiurus scindicus*) and Dinanath grass (*Panicum pedicellatum*)

(CRSCIGFRISIL20190801)

Anjan grass (*Cenchrus ciliaris*) and Sewan grass (*Lasiurus scindicus*)

Three months old seed of Anjan and Sewan grass (fluffed and defluffed) was packed during mid March, 2020 in 5 storage containers: poly bag <300 gauge, poly bag >700 gauge, Al bag, polylined HDPE bag and cloth bag (control); and stored in ambient room condition of Avikanagar. Defluffing reduced the volume of seed about 5-6 times compared to fluffed seed. At the time of packing, germination of fluffed and defluffed seed was respectively 24 and 49.8% for Anjan grass, and 30 and 43% for Sewan grass, respectively.

Anjan grass (*Cenchrus ciliaris*)

In the fluffed seed, with the dissipation of dormancy naturally with storage time, germination increased upto 18 months of storage and onward it decreased. Decrease in germination was more pronounced in defluffed seed than fluffed seed. Among storage containers more decrease in germination was recorded in the cloth bag (control) than other storage containers for both types of seed. Among the storage containers, poly bag >700 gauge and Al bag were able to maintain 50% of peak germination up to 30 months of storage. The 50% decrease of peak germination was recorded for the cloth bag at 12 months storage. After 36 and 42 months storage no germination was recorded in the cloth bag due to insect damage.

Sewan grass (*Lasiurus scindicus*)

In the fluffed seed, with the dissipation of dormancy naturally with storage time, germination increased upto 12-18 months of storage and onward it decreased. Like fluffed seed, highest decrease in germination was recorded in the cloth bag. Among the storage containers, poly bag >700 gauge and Al bag were able to maintain 50% of peak germination up to 24 months of storage. Cloth bag was least effective in maintaining germination/ vigour of fluffed seed during storage. Significant decrease in the germination was recoded at 18 months of storage over the previous interval and onward storage. After 42 months storage no germination was recorded in the cloth bag due to insect damage. It is concluded that for both grasses defluffed seed is poor in storage than fluffed seed. Delfuffed seed should be used within 6 months of delfuffing. Defluffing is effective in reducing the volume by 5-6 times that minimizes the cost of transportation. Poly bag >700 gauge and Al bag were better storage container than other storage containers for maintaining germination and vigour of seed during storage.

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

(CRSCIGFRISIL20200104)

Berseem seed coat colour (yellow, red and dark red) is a key indicator of seed quality, with a shift to red and dark red being less preferred by farmers due to poor acceptance. Storing berseem seeds for 4 years in polythene bags (ambient and low temperatures) yielded higher germination percentages (95.09-96.73%) and lower electrical conductivity (0.25-0.30) compared to cloth bags (78.18-92.06% and 0.31-0.38). As storage duration increased, germination percentages for all colours decreased. The decline in germination is attributed to the loss of membrane integrity, leading to increased electrical conductivity in red and dark red seeds. Biochemical analysis showed higher total tannin, phenol and flavonoid content in dark-coloured seeds but lower free radical scavenging activity and total antioxidant enzyme compared to yellow seeds. *Fusarium* sp's potential role in seed deterioration, particularly in dark-coloured seeds was reported.

3.4.3. Role of smoke derived compounds in early establishment of forages

(CRSCIGFRISIL20190402)

The fabricated machine (Size: 1100×400×1000 mm; Capacity: Up to 150 l/h) is designed for efficiency, reducing time consumption in the study. The machine ensures uniform mixing of smoke water with minimal loss, enhancing the reliability and consistency of the study results. The prepared crude smoke water was diluted in different concentrations with distilled water and applied to seeds for its germination test in two grasses, *Pennisetum pedecellatum* and *Heteropogon* sp. It was found that when smoke water was applied at 100%

concentration it showed an inhibitory effect but out of all concentrations 1% smoke water increased germination percentage (54% in *Heteropogon* and 36% in *Pennisetum* grass) as compared to control (44% in *Heteropogon* sp. and 28% in *Pennisetum* grass).

3.4.4. Effect of elevated CO_2 and temperature on growth, forage yield, and seed quality of cowpea and oat

(CRSCIGFRISIL 20I90404)

Five oat varieties showed increased agromorphological traits under elevated CO_2 alone and with elevated temperature. Notably, spike length, seed production, and other traits exhibited improvement compared to the control. Elevated CO_2 marginally suppressed heat stress effects on oats. This suggests a complex interplay between CO_2 and temperature, emphasizing the need for further research on climate change impacts on crop yields.

3.4.5. Development of Near-infrared spectroscopy (NIRS) based prediction models for the assessment of seed viability and vigor in tropical grasses

(CRSCIGFRISIL20210401)

In the present study seed quality trait (germination %) was assessed for 206 diverse berseem lines. The NIR spectra of the seed samples were procured. The spectral data was then further subjected to Principal component analysis (PCA) to explore the direction of the highest variance of the spectral data in a multidimensional data space. Modified partial least squre builds its factors by catching the maximum possible variation in the spectroscopic data by actively utilizing the reference values (physical, chemical, etc.) during spectroscopic data decomposition. This method decreases the effect of irrelevant and large spectroscopic variations in the calibration modelling by counterbalancing the biochemical data and spectroscopic information.

3.4.6. Development of seed standards in temperate grasses and legumes

(CRSCIGFRISIL 20180402)

Five temperate forages included in the new project are timothy, red fescue, white clover, sainfoin and persian clover. Standardization of seed sample size (submitted and working samples) and identification of ideal germination conditions (temp, light, substrate, etc) are being studied. It has been noticed that there is a presence of different types of seed dormancy in studied crops ranging from physical, physicochemical and incomplete seed developmental emerging from asynchronous seed maturation.

3.4.7. Endophytes consortium as biocontrol for effective management of pest and diseases in fodder legumes

(CRSCIGFRISIL20I90401)

A total 40 endophytic microbes were isolated from the berseem plant including *Bacillus* spp. (18 no.), *Pseudomonas* sp. (12 no.), and Fungi (10 no.). Two endophytic bacteria showed inhibition of *Sclerotinia trifoliorum* under *in vitro* conditions. EPB-2 and EPB-18 recorded 54.81 and 47.77% radial mycelial growth inhibition of *Sclerotinia trifoliorum* (Fig. 3.4.1). Synthesized nanoparticles such as Magnesium sulphate, Zinc sulphate and Zinc oxides were evaluated against *Sclerotinia trifoliorum* under *in vitro* conditions. Synthesized nanoparticles failed to inhibit the radial mycelial growth of *Sclerotinia trifoliorum* even at 1000 ppm.

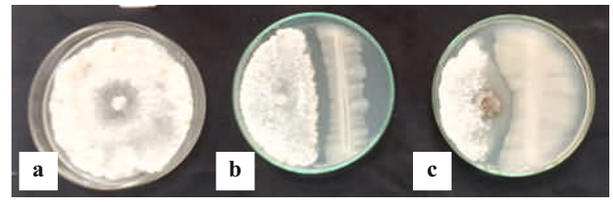

Fig. 3.4.1. Efficacy of bacterial endophytic EPB-18 (b) and EPB-2 (c) against *S. trifoliorum* (a)

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

3.5.1. Silage quality and *in vivo* evaluation of sugar rich *Sehima nervosum* genotypes in sheep

(CRSCIGFRICOL20130702)

Sehima nervosum genotypes IG-99-198, IG-02-716, BS-1 and IG-02-695-1 and bajra napier hybrid (BNH) were ensiled for to assess silage quality. BNH had higher crude protein (7.87%) than Sehima IG02-695-1 (6.34%) and BS1 (6.31%). Dry matter (DM), pH and lactic acid of ensiled grasses ranged 35.09-51.79%, 4.49-5.49 and 0.192-0.436%, respectively. For *in vivo* trial 15 sheep were divided into 3 groups and were offered silage from Sehima genotypes BS-1 and IG-02-695-1 to G1 and G2 while, in G3 sheep was offered BN hybrid silage. DM and organic matter (OM) digestibility tended to be similar for IG02-695-1 and BNH. Cellulose digestibility tended to be higher for BN hybrid. The N intake was similar in sheep on all grass silage diets (6.83-7.59 g/d). N retention was higher for BNH (49.44%) and lowest for BS1 (39.23%). Rumen liquor pH, total-N and NH_3-N ranged between 6.51-6.78, 78.4-104.5 mg/100 ml and 12.6-16.8 mg/100 ml, respectively.

3.5.2. Effect of grazing intensity on pasture quality, herbage intake, nutrients digestibility, and animal performance

(CRSCIGFRISIL20130701)

Natural pastures yielded 5.44- 9.013 t DM/ha herbage under treatment groups. Fresh herbage DM before grazing varied from 43.60-55.23% across pastures. After 5 month grazing pasture yield declined and ranged from 5.97-7.30 t/ha under different stocking rates and the DM of fresh herbage after grazing increased from 66.58-76.98%. CP contents before grazing of control pasture were higher (7.33) than experimental pastures (4.87-6.47%). An increase of 4-8% in NDF, 5-6% in ADF, 2-3% in cellulose and 3-8% in ADL were recorded in herbage samples collected after grazing. Nutrients digestibility was comparable except NDF was lower in higher stocking rate. Animals gained body weight in all stocking rates up to November; being highest in low stocking rate.

3.5.3. Ensiled TMR (Total Mix Ration) for livestock production

(CRSCIGFRISIL20220701)

TMR silage was prepared using BN hybrid fodder and concentrate mixture (mustard cake-35%, wheat bran-15%, maize-47%, mineral mixture-1% and salt-1%) in 70:30 ratio. TMR silage DM content was 32.95% whereas CP, NDF ADF contents were 11.60%, 60.77% and 44.19%, respectively. TMR silage pH and lactic acid content were 4.17 and 3.74%. TMR silage prepared using Hybrid fodder and concentrate mixture was used for feeding to Jalauni lambs weighing around 24 kg. Lambs in control TMR (G_1) fed chaffed BN hybrid green fodder and concentrate mixture (70:30) and TMR silage in G_2. Eating pattern studies indicated that at 2, 4 and 6 h post-offering period the intake of DM in G_2 was higher (38.40,49.32 and 60.78%) than G_1 (32.46, 41.84 and 50.79%). Dry matter intake was comparable in both groups (3.52 to 3.79%). DM, NDF and CP digestibility were higher for G_2 (64.67, 60.78 and 65.80%) than G_1 (62.02, 56.72 and 63.38%). Rumen liquor pH was comparable, while, NH_3.N (mg/dl) was higher (31.36) for G_2 than G_1 (22.59 and 66.33). Daily body weight gain (80.75 g) was improved in G_2than in G_1 (74.2 g).

3.5.4. Grazing behaviour of small ruminants on natural pasture during the rainy season

(CRSCIGFRISIL20220703)

A comparison was made between the grazing patterns of sheep and goats on natural pastures throughout the rainy season (1st to 31st August). Stocking was conducted at a rate of twenty animals per hectare. Ten goats (Bundelkhandi) and ten sheep (Jalauni) participated in the experiment. Goats exhibited a considerably longer average grazing time (34.16 min/hour) than sheep (23.33 min/hour) throughout the monsoon season. In contrast, sheep exhibited substantially longer walking time (5.34 min/h versus 3.64 min/h), standing time (12.09 min/h versus 9.76 min/h), and sitting time (19.24 min/h versus 12.44 min/h) than goats. Additionally, greater bite mass was observed in sheep. Furthermore, the morning hours exhibited the greatest average grazing time and walking time (Min/hour) for both sheep and goats. The morning hours exhibited the most substantial average bite rate (bite/min), bite mass (g DM/bite), and grazing consumption (g DM/day) for both species. Sheep favoured grasses throughout the majority of the day, including morning, afternoon, and evening.

Goats, on the other hand, exhibited a preference for a wider variety of plant species, including grasses during morning and afternoon, and thorny vegetation followed by shrubs in evening. Furthermore, goats' grazing and foraging habits demonstrated a discernible diurnal rhythm (Fig. 3.5.1).

Fig. 3.5.1. Study of grazing behavior in goat and sheep

3.5.5 Phytochemical control aflatoxins producing fungi in potato dextrose agar medium (CRSCIGFRI20220702)

Essential oil 7.913 g (0.79%) extracted from 1 kg *Curcuma longa* raw rhizome was tested for its bio efficacy against aflatoxin-producing fungi (*Aspergillus flavus* and *Aspergillus parasiticus*). All the tested concentrations 250, 500 and 1000 ppm inhibited the growth of both aflatoxin-producing fungi, however, inhibition activity was more against *A. flavus* than *A parasiticus* (Fig. 3.5.2 and 3.5.3).

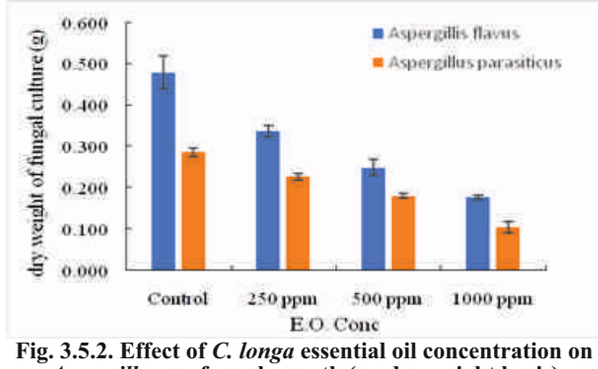

Fig. 3.5.2. Effect of *C. longa* essential oil concentration on *Aspergillus* sp. fungal growth (on dry weight basis)

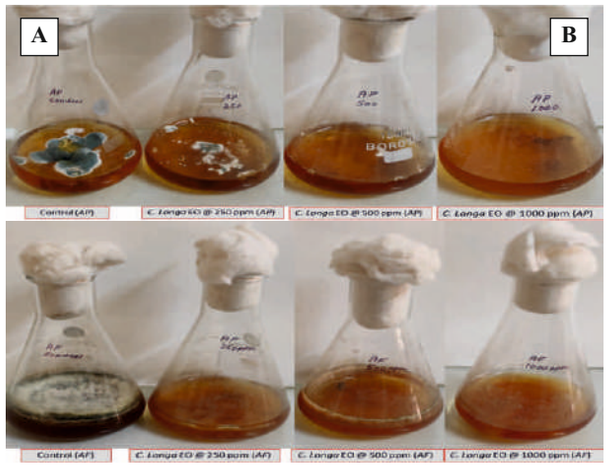

Fig. 3.5.3. Effect of C. longa essential oil against *A. parasiticus* (A) and *A. flavus* (B) fungi

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

Under Bundelkhandi goat conservation and improvement programme, during the year 2023, a total of 91 households and 1886 numbers of goats were registered. The flock size ranged from 3 to 86 with an average of 18.4 in adapted villages. The flock was predominated by adult/yearling females (62%), followed by growing kids (33%). Breeding bucks were available for 9.8% only. Average body weights at birth, 3, 6 and 12 months were 2.35±0.07, 9.41±0.27, 13.82±0.28, and 20.00±0.37 kg, respectively (Fig. 3.5.4). Average daily milk yield was 0.478 ± 0.03 kg, while average milk yield at 90 days was 41.99±3.07 litres with lactation length of 90.71±6.63 days. Selected bucks (2 no.) were distributed to goat rearing farmers as breeding bucks in adopted villages of Sera and Parasari. Vaccination (1632 no.) against FMD and PPR and periodic treatment (4150 cases) of diseased animals was carried out. The survey by NBAGR team has been completed to process breed registration applied by the unit (Fig. 3.5.5).

Fig. 3.5.4. Weighing of goat in the adapted villages

Fig. 3.5.5. Survey of Bundelkhand region for breed registration by NBAGR team

3.5.7. Performance evaluation and improvement of Bhadawari buffaloes

A herd of pure-breed Bhadawari buffaloes is being maintained under the project to produce superior breeding bulls. During the year 2023 average lactation milk yield, lactation length, standard lactation milk yield, and peak yield were 1657.40±65.6 kg, 352.8±14.4 days, 1496.98±549.9 kg, and 8.08±0.13 kg, respectively. Average milk fat, SNF, protein, and lactose were recorded as 8.23±0.17, 9.78±0.13, 3.54±0.04 and 5.32±0.07%, respectively. The average age at first calving was recorded as 49.17±4.5 months. The conception rate was 62.24% during the year. During the year there were 34 calvings. The average birth weight of the calves was 28.94±0.52 kg and the dam's weight at calving was 416.61±8.72 kg. A total of 12100 semen doses were frozen from the selected breeding bulls, and 1060 semen doses were sold.

3.5.8. Ensiling of temperate grasses/legumes for increase livestock productivity

(CRSCIGFRISIL20212001)

Among the grasses, legumes, and their mixtures, CP contents were highest in red clover (15.57) and lowest in *Dactylis* (10.50%). Grasses, legumes and their mixtures, NDF, ADF, cellulose and lignin contents varied between 51.54-68.48, 32.52-45.40, 27.26-35.34, and 3.41-10.16%, respectively. *In vitro* dry matter digestibility was higher for *Dactylis* and red clover (75.85 and 75.25%) and lowest for sainfoin (58.87%). Silage (Fig. 3.5.6) prepared from *Lolium* and tall fescue grass has lower pH (4.45 and 4.51) and higher lactic acid production (2.82 and 2.68% DM) than *Phalaris* (5.19 and 0.67) and *Dactylis* (5.24 and 0.98% DM). The DM contents of silages were lower and it ranged between 17.29 to 21.95%. Among the legumes silage from sainfoin was better in terms of pH (4.49) and lactic acid production (1.12) than red clover (5.17 and 0.80% DM). Study revealed that grasses, legumes, and their mixtures had more than 10% CP, higher digestibility and >50% TDN.

Fig.3.5.6: Silage of Sainfoin and Dactylis+Red clover (50:50)

3.5.9 Development and evaluation of defluffing machine and pelleting machine for forage grass seeds

(CRSCIGFRISIL20180601)

Studies on seed pellet formation and its distribution on the basis of their size

Test trials for pelleting of the *Pennisetum pedicellatum* grass seeds were conducted. Separation of seed pellets in different sizes was made using different sieves. Samples of 5 kg soil + 100 g fluffy seeds were fed into the pelleting chamber which was converted into pellet form in 8-10 minutes (Fig. 3.5.7). The capacity of 60 kg/h pellets was achieved. The seed pellets size between 5 to 10 mm was ~90.24%.

Fig. 3.5.7. Cylindrical drum type seed pelleting machine and seed pellets

Studies on *Pennisetum* seed pellet germination

Seed pellets were made using 6 levels of true seeds (25, 30, 40, 50, 100 and 200 g with 5 kg soil) and also with 100 g fluffy seeds + 5 kg soil. The number of plants germinated had increasing trend with weight of true seeds and varied from 600 plants for 25 g true seeds to 6953 plants for 200 g true seeds. Similarly blank pellet was found with decreasing trend from 60 blank pellets for 25 g true seeds to nil for 100 g and 200 g true seeds indicating 15% blank pellets at 25 g true seeds and 10.25%, 5.75%, 2.75% for respective weight of true seeds *i.e.* 30g, 40 g and 50 g. The percent pellet germination and plants per pellet was also increasing with increasing weight of true seeds and has 100% germination for 100g and 200 g true seeds mixed with 5 kg soil in view to make the pellets. Plants grown per pellet were 10 plants for 100 g true seeds and 18 plants for 200 g true seeds. The result thus indicated that number of pellets required for optimum population per ha was 31,949 pellets for 100g true seeds and 17259 pellets for 200 g true seeds. Making seed pellets with 100 g fluffy seeds mixed with 5 kg soil resulted only 1.1 plants per pellet and only 56.5% seed pellets germination and needed 2,72,727 number of pellets for optimum population per ha. The results clearly indicated that making seed pellets with true seeds had more production and fewer requirements of pellets.

3.5.10 Development of automatic seed coating machine

(CRSCIGFRISIL20190605)

Machine Fabrication

A forage seed coating machine was fabricated for seed coating and treatment operation. Slider gate was used into hopper for controlling the seed rate. Chemical mixer (the part of the machine) was developed using 200W motor for 2 litre capacity for uniform mixing. A coating chamber was fabricated using stainless steel sheet of 2.5 mm thickness for 137 litre volume that can able to treat 15-20 kg of seeds in one batch depending upon the type/density of seeds. Overall dimension of machine was 1040×700×1350 mm (Fig. 3.5.8).

Fig. 3.5.8. Developed seed coating machine

Performance evaluation of developed machine

The speed of seed disc and angle of inclination of baffle wall in the coating chamber were optimum at 200 rpm and 30º, respectively. The coating capacity of machine was 6 q/h and 6.5 q/h for berseem and cowpea seeds, respectively. The coating efficiency was obtained about 97%. A skilled labor took one hour for coating of 51 kg berseem seeds. The developed coating machine could save 91% labor involved in coating process. The cost of seed coating was estimated at 10 Rs./kg. The developed machine can be used for seed treatment with powder or granular chemical material as well as for seed coating with liquid chemical agent/polymer. It applies liquid as well as powder uniformly over seed surface and also checks the exposure of operator/ stakeholders to the harmful chemicals. The machine is well suited for coating of different fodder seeds as well as grain/vegetable seeds.

3.5.11 Design and development of solar powered self-propelled multipurpose machine for agricultural operations

(CRSCIGFRISIL20190604)

Installation of solar charging station

The solar charging station (Fig. 3.5.9) for charging the solar powered multipurpose vehicle was installed at FMOU, CR Farm. It consisted of solar panel (SP), solar management unit (SMU), box, battery and different connecters. A solar panel (335W, 7×3 ft) was fitted over the iron pole (h= 10 ft) at the tilt angle of 40 degree from horizontal surface and facing towards south direction for maximum solar system efficiency. The connections were made between the SP, SMU and battery with the help of DC 4 mm^2 wire, DC connecters and battery lugs. The power output point was kept for directly charging the solar vehicle.

Fig. 3.5.9. Installed solar charging station

Fabrication of multipurpose vehicle's frame

It was fabricated using one inch MS angle for the dimension 300×700 mm (Fig. 3.5.10). Four traction wheels of diameter 300 mm were fitted over the corner of the frame for transportation as well as for providing traction force during weeding/tilling operation. Each wheel has been given support with the inverted sections for stability and load carrying. 250 W DC motor was used for providing the power to the rear wheel. Supporting shaft will be providing over the frame for placing other components of the vehicle *i.e.* battery, water tank, weeding tool and seeding mechanism *etc*.

Fig. 3.5.10: Fabricated frame of multipurpose vehicle

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

In Jhansi, the Institute is assessing promising Integrated Farming Systems (IFS) models with customized modifications at ten farmers' fields (Fig. 3.6.1). The results underscore the significant impact of forage technologies in addressing fodder deficits, leading to a remarkable reduction of 40-50%. Additionally, these technologies played a crucial role in enhancing animal productivity, with an impressive margin of 18-30%. Notably, marginal and small-scale farmers benefit from increased income through the adoption of forage technologies, demonstrating a promising return of 2-3 lakhs. Even medium to large-scale farmers experience substantial income growth, ranging from 1.6-2.0 times. Beyond economic gains, IFS-based farms serve as beacons of productivity, sustainability, and employment generation, highlighting the multifaceted benefits that forage technologies bring to agricultural practices.

Fig. 3.6.1. Monitoring at farmers field under livestock based integrated farming system for sustainable productivity

3.6.2 Impact of fodder and livestock technologies on livelihood of farmers of SCSP

An assessment of the welfare impact of agriculture-based technological interventions promoted under the 'Scheduled Caste Sub Plan (SCSP)' scheme was conducted using cross-sectional data collected from 398 Scheduled Caste (SC) farmers in Jhansi district, Uttar Pradesh. The primary technique for impact evaluation was the Inverse Propensity Weighting Regression Adjustment (IPWRA) method. Additionally, the robustness of the results was verified using inverse propensity weighting (IPW) and coarsened exact matching (CEM). The impact pathway was analyzed through simultaneous equation modeling.

The findings revealed that the technological interventions significantly enhanced farm income by 45-51% and increased farm and domestic asset possession among SC farmers by 23-27%. Several factors influenced technology adoption in the Jhansi district, including farming experience, livestock holdings, off-farm activities, and extension and training programs

3.6.3 RSD-15 (Phase-III) Participatory fodder production in fruits and plantation crops

An analysis of data collected from 33 mango and coconut farmers (Fig. 3.6.2) in Chikballapur and Kolar districts revealed valuable insights. The introduction of perennial fodder crops such as sorghum, Bajra Napier hybrid (DHN-6), and Guinea grass in the inter-spaces of mango and coconut orchards significantly addressed the shortage of green fodder. Specifically, the cultivation of fodder crops in interspaces reduced the shortage from 58.5% to 21.25%.

The decision-making patterns of these farmers regarding the adoption of new technologies, including horti-pasture, varied. Approximately 55% of the farmers decided to adopt technology after gathering the necessary resources. Meanwhile, 30% of them adopted technology as soon as they became aware of it, while only 15% waited to see its performance in other fields before adopting it.

Beyond addressing fodder shortages, the participating farmers observed several other benefits. These included reduced weed intensity (79%), soil erosion mitigation (55%), decreased insect and pest attacks (74%), and an increase in organic matter in the soil (55%). Moreover, a large majority (80%) reported increased milk yield (averaging 1 liter per day per household), leading to reduced livestock husbandry costs (as expressed by 85% of the farmers).

Interestingly, the adoption of horti-pasture technologies also led to a vertical spread, with neighboring farmers requesting seed material (53) and seed sources (71). The enormous benefits brought by horti-pasture technology in mango and coconut orchards suggest its potential for scaling up methodologies.

Fig. 3.6.2. Sri T.N. Ashok Babu, Ternahalli village with fodder sorghum in coconut plantation

3.7 All India Coordinated Research Project on Forage Crops and Utilization

Kharif 2022

3.7.1 Forage crop improvement

A total of 16 trials in 04 annual crops (maize, pearl millet, cowpea, and rice bean) and 3 perennial crops (BN hybrid, *Setaria anceps,* and *Dichanthium annulatum*) at 32 locations were conducted. 130 entries, including 87 annuals and 43 perennials, were tested. In IVT maize, twenty-nine entries were tested along with three national checks at 20 locations in five zones. Fourteen entries (ADFM-4; ADFM-5; AFM-23; AH4688; BMC-1853; DFH-2022-1; HPFM-12; IFH10-21 K2; KDFM-8; MAH 15-84; PMC-14; PMC-15; PMC-16; RCRMH2) performed better and promoted to AVT-1 in all five zones. In AVT-1M, six entries with three checks were tested at 20 locations in all zones and four entries (CMH-12-686; FSM2021-1; MFM-18-2; PJHM-1) performed better and promoted to AVT-2. In AVT-2M and seed, four entries with three checks were tested at 19 locations in HZ, NWZ, NEZ and CZ and all four (DFH-2; AFH-7; PFM-13 and HQPM-28) out performed and were recommended for VIC. In IVT pearl millet, seven entries with two NC and one ZC were tested at 19 centers in NE, NW, SZ and CZ. Four entries (ADV 2285; JHPM-22-2; JPM-18-74; SBH 002) performed well in NWZ and NEZ and promoted to AVT-1. In AVTPM- 1 PM, six entries with two NC and one ZC were evaluated at 19 locations in four zones (NW, NE, Central and SZ). Four entries (ADV175020; FBL-7; FSB2021-1; JPM-18-71) were promoted to AVTPM-2.In AVTPM-2 and (seed) PM, five entries with two NC and one ZC were tested across 19 locations in four zones and all five (JPM 18-37; 16ADV0111; TSFB-1610; PHBF-5 and FBL 4) outperformed and were recommended for VIC.In IVT cowpea, ten entries with three checks were tested at 28 locations in all five zones. Four entries (MFC-18-4; PFC-45; UPC-22-1; UPC-22-2) promoted to AVT-1 in all zones.In AVT-1C, four entries with three checks were tested at 13 locations in NE and CZ. None of the entries could perform significantly better than checks.In IVT-Rice bean, three entries were tested against 2 checks at 10 locations in NEZ and CZ and none were significantly better than the checks. In AVTRB-1 RB, four entries with two checks were tested at 10 locations in NE and CZ. The entry JOR-21-1 was promoted for AVT-2. In VTBN (perennial): BN hybrid perennial trial, fourteen entries were tested in 20 locations in all five zones and TSBN-15-15 was found superior to the checks in all five zones. The perennial trials on *Setaria*, Bajra Napier Hybrid and *Dichanthium annulatum*started in 2022 and are presently in the establishment year and will continue as such in coded form. In quality trials, selected genotypes were evaluated for quality traits (proximate and mineral contents) at different locations in maize, pearl millet, cowpea, and Napier.

3.7.2 Forage crop production

The programme on forage crop production was conducted at 63 locations. In total 12 experiments were conducted, out of which 6 in coordinated, 2 AVT trials and 4 in location specific mode with the aim to generate region as well as location specific forage production technologies for different growing conditions.

Research aspect consisted of bio-fortification of annual cereal fodder crops, response of fodder crops to micronutrient management, effect of PGRs and micronutrients on sorghum and maize, precision nitrogen management and cutting management on performance of forage pearl millet varieties. The trials on standardization of magnesium nutrition in bajra Napier Hybrid, precision nitrogen management for enhancing fodder yield and nitrogen use efficiency in forages, screening of high biomass maize lines for silage potential and enhancing the productivity and quality of fodder maize/pearl millet through Nano-Urea were also conducted at different locations in coordinated as well as location specific mode. Besides above, advanced varietal trials to evaluate the response of promising entries of pearl millet and maize to nutrient supplementation were also conducted and reported. From the trials, relevant database generated is presented hereunder;

K-20-AST-1a: Response of fodder crops to micronutrient management trial was conducted at Rahuri, Bikaner, Imphal, Ranchi and BUAT Banda. In BN hybrid and maize, on locational mean basis, GRDF + soil application of government notified multi-micronutrient grade I @ 25 kg ha^{-1} + two foliar sprays of grade II @ 1% at 30 and 45 DAS proved best. K-20-AST-1b: Yield enhancement and bio-fortification of *Kharif forages* with PGRs and micronutrients was conducted at Palampur, Srinagar, Mandya and Ayodhya. On the location mean basis the treatment 5 kg Zn + 2 kg B/ha soil application + triacontanol 10 ppm at 30 DAS foliar spray recorded significantly higher green forage, dry matter yield and crude protein yield. In K-20-AST-7: Effect of nitrogen and cutting

management on performance of forage pearl millet varieties conducted at Hyderabad, Raipur, Pusa, Ludhiana, and Jabalpur maximum GFY, DFY and CPY were recorded with variety TSFB 15-8 with 120 nitrogen kg/ha under three cutting management system. K-21-AST-5: Screening of high biomass maize lines for silage potential was conducted at six locations on mean basis, maximum green fodder yield was obtained at dough stage. Dry matter content was 20-21 percent at milk stage, 23-25 percent at dough stage and 27-28 percent at dent stage. Highest TSS was noted during dough stage. In K-22-AST-1: Yield maximization in fodder maize through micro-nutrients and bio-fertilizers experiment conducted at Ranchi, Ayodhya, Jabalpur, Mandya and Coimbatore. The application of recommended NPK + FYM (10 t/ha) + Micronutrients mixtures @ 1% (20 and 40 DAS) + BFC (5 kg/ha)) recorded higher GFY, DMY CP yield, net monetary returns and B:C ratio. K-22-AST-2: Enhancing the productivity and quality of fodder maize/ pearl millet through Nano-Urea was initiated at fourteen locations. In Hill and North West zone application of 75% recommended dose of N with spray of nano-urea at 4 ml/l of water gave higher green and dry fodder yield. In Central and North East Zone application of 75% recommended dose of N with spray of nano-urea at 6 ml/l of water gave higher green and dry fodder yield. In K-20-AST-5: Evaluation of promising fodder grass varieties under shade conditions was conducted at Vellayani, Sulabha under open condition recorded the highest GFY and DFY. Highest chlorophyll and crude protein content and lowest crude fiber content was recorded by the varieties under 50% shade. In K-20-AST-6: Precision nitrogen management for enhancing fodder yield and nitrogen use efficiency in forages experiment was conducted during *Kharif* 2022 at Srinagar, 150 kg N/ha (40% N basal) + remaining based on LCC 5 improved green fodder, dry matter yield, plant height; number of leaves per plant and quality. In R-19-AST-5: Standardization of magnesium nutrition in Bajra Napier hybrid conducted at Vellayani, significantly superior GFY and DFY were recorded with 100 kg$MgSO_4$/ha once in 6 months.

3.7.3 Forage crop protection

A total of 11 crop protection trials were conducted across 6 locations. During *kharif* 2022, the occurrence and abundance of major diseases and insect-pests in maize, sorghum and pearl millet was recorded at six locations and important diseases observed were leaf blast, downy mildew, grey leaf spot, and anthracnose of bajra, sorghum, and maize. Among disease management trials, two new technologies were recommended viz, management of leaf blast in forage pearl millet for Ludhiana, Palampur, and Bhubaneswar locations. Management of invasive insect-pest fall army worm, *Spodoptera frugiperda* L. on forage maize, for Rahuri. Yield losses due to aphids were estimated to be around 22.67% and due to shoot fly and fall armyworm were estimated to be around 10.79% and 62.60% respectively.

Germplasm evaluation programme against diseases and insect-pests in *kharif* forages: In maize, a total of 109 germplasm lines were tested at five locations for fall armyworm, maydis leaf blight, turcicum leaf blight, and sorghum downy mildew resistance. A total of 64 lines were evaluated for leaf blast of pearl millet. In cowpea, a total of 68 germplasm lines were tested against root rot, YMV, defoliators, and aphids at three locations. Among tested germplasm lines, 12 germplasm lines were found resistant to cowpea defoliators, root rot, and yellow mosaic virus.

3.7.4 Breeder seed production

The total indent for *kharif*-2022 was 7.20 t for 26 varieties in five forage crops (fodder maize, bajra, cowpea, rice bean, and rye grass). The BS production was 9.8 t and was surplus by 2.60 t. Production was surplus in fodder maize (2.1 t), fodder pearl millet (0.61 t), and rice bean (0.03 t), however it was deficit in cowpea (0.18 t).

Varieties Identified:

SN	Varieties	Breeding institute	Recommended for
Fodder maize			
1.	DHF-2	GBPUAT, Pantnagar	North-west and central zone
2.	AFH-7	IARI, New Delhi	North-west zone
3.	HQPM-28	CCS HAU, Hisar	Central zone
4.	PFM-13	PAU, Ludhiana	Central zone

Fodder Bajra			
5.	16ADV0111	UPL Limited, Hyderabad	All India except hill zone
6.	FBL-4	PAU, Ludhiana	North-west and south zone
7.	PHBF-5	PAU, Ludhiana	North-west zone
8.	TSFB-1610	PJTSAU, Hyderabad	North-west zone
9.	JPM-18-37	JNKVV, Jabalpur	North-west zone
BN Hybrid			
10.	TSBN-15-15	PJTSAU, Hyderabad	Central and south zone
11.	BNH-26	BAIF Urulikanchan	Central zone

Rabi 2022-23

3.7.5 Forage crop improvement

A total of 26 multi locational trials (22 annuals and 4 perennials) comprising of test entries (143 including 124 annuals and 19 perennials) along with their respective checks were conducted at 40 locations in the country.

In IVT Berseem, four entries along with one NC and one ZC in respective zones were evaluated at 20 and two entries (FB-22-1 and PC116) were promoted to AVT-1 in HZ and CZ. AVTB-1, five entries along with one NC and one ZC were evaluated at 6 centres in CZ and no one was better than check. In AVT-2B, four entries along with one NC and one ZC were evaluated at 17 locations in NW, CZ and NEZ and no one was better than check. In IVT Oat (Single cut), ten entries along with one NC and one ZC were evaluated at 28 locations in HZ, NWZ, NEZ, CZ and SZ and eight entries (OL-1964, OL-2000, OL-1976-1 JO-09-14, HFO-1211, HFO-1221, SKO-246, UPO-22-2) were promoted to AVT-1 in all zone. In AVTO (SC)-1, eleven entries were evaluated against two NC and one ZC at 7 locations in HZ and SZ and six entries (HFO-1113, SKO-245, JO-08-41, OL-1988, OL-1967, JHO-21-1) were promoted to AVT-2 in SZ. In AVTO (SC)-2 and seed, seven entries along with two NC and one ZC were evaluated at 28 locations in HZ, NWZ, NEZ, CZ and SZ and proposal was submitted to VIC. In IVTO-MC, nine entries were evaluated against two NC and ZC at 18 locations in HZ, NWZ, NEZ and CZ and three entries (OL-1942, OL 1964-1, NDO 222) were promoted to AVT-1. In AVTO (MC)-1, thirteen entries were evaluated against two NC at 7 locations in HZ and NWZ and nine entries (OL-1975, OL-1969, OL-1931-2, HFO-1123, HFO-1121, BAUO-104, JO-08-335, PLP-29, JHO-21-3) were promoted to AVT-2 for HZ and NWZ. In AVTO (MC)-2 and Seed, five entries were evaluated against two NC at 6 locations in HZ and NWZ and proposals were submitted to VIC. In IVTO (Dual), seven entries along with one NC and one ZC was conducted at 14 centers in NWZ, NEZ and CZ and five entries (OL-1861-2,OL 1896-2, JO-13-521, HFO-816-1, JHO-22-6) were promoted to AVT-1 in NWZ, NEZ, and CZ. In AVTO-1 (Dual), seven entries were evaluated against two NC at 9 locations in NWZ and NEZ and four entries (OL-1874-2, OL-1967-1, JO-13-518, HFO-1108) were promoted to AVT-2. In AVTO-2 (Dual) and seed, five entries were evaluated against two NC at 9 locations in NWZ and NEZ and varietal proposals were submitted to VIC.

In IVT Lucerne, four entries (AWL-6, LLC-9, AL-115, AL-104) with one NC and one respective ZC were evaluated at 10 locations in NW, CZ and SZ and all entries were promoted to AVT-1. In IVT Lathyrus, six entries were tested against the two NC at seven locations across the country and three entries (BAUL-106, BCK-19-21A, JCL-22-1) were promoted to AVT-1. In AVT-1 Lathyrus, seven entries evaluated against two NC at seven locations across the country and four (IPLa 2021-01, BL-3, BL-5, JCL-21-1, JCL-21-3) were promoted to AVT-2. In AVT-2 Lathyrus and seed, entry KL-5 along with checks in combination with AVT-1 were tested and proposal was submitted to the VIC. In IVT (MC, Summer Bajra), thirteen entries were evaluated against three NC at 7 locationsin CZ and SZ and only entry (TSMCBH-2301) was promoted to AVT-1. In AVT-1 (MC, Summer Bajra), seven entries were evaluated along with 3 NC at three locations in SZ and three entries (BAIF Bajra-10, SBH-104, ADV-2184) were promoted to AVT-2. In VT Lucerne Perennial (3rd year), trial was established in 2020-21 with 3 entries and two NC at seven locations in NWZ, CZ and SZ. The trial has been completed this year and entries proposals were submitted to VIC. In VT Tall Fescue Perennial (1st year), trial was

established in 2021-22 at 8 locations with 09 entries including 2 checks in Hill Zone. In VT Sainfoin Grass Perennial (1st year), trial was established in 2021-22 at 8 locations with 07 entries in HZ. The data were not reported by the respective centers. In VT Orchard Grass Perennial (1st year), trial was established at 8 locations with 07 entries in HZ during 2021-22. It is a perennial trial and will continue in coded form.

3.7.6 Forage Crop Production

The forage crop production programme was executed at 67 locations in five zones. In total 19 experiments were conducted, out of which 11 were in network (6 coordinated and 5 AVT based) and 8 were in location specific mode. The main emphasis was to increase the system productivity and resource use optimization in forages and forage-based cropping systems. In addition to above, the results of nutrient management for productivity enhancement in dual purpose oats, integrated nutrient management in fodder chicory, Nano-Urea supplementation in single and multi-cut Oat, organic nutrients for rice bean-oat under irrigated situation, foliar nutrition to grass pea, enrichment of BN hybrids and maize silage quality by amalgamation with legumes have also been presented. The trials were also conducted on organic nutrient management for round the year fodder production system, optimum seed rate and spacing for hedge lucerne seed production, and effect of Nano Zn on yield and its content in fodder sorghum –oat- fodder bajra cropping sequence. The summary of research achievements of the forage crop production trials during *Rabi* 2022-23 are as follows:

In R-22-AST -1: Response of dual-purpose oat to different sources of plant nutrition and bio fertilizers conducted at Jobner and Hisar, application of 3 t ha^{-1} biogas slurry + 50% RDF and inoculation of *Azotobacter* + PSB + KSB was significantly superior in increasing green forage yield, crude protein content and yield, grain and straw yields of dual-purpose oat. R-22-AST -2: Effect of integrated nutrient management on growth, yield and quality of fodder chicory conducted at Anand and Bikaner, At Anand, significantly higher green and dry fodder yield was reported with 25% RDN + 50% N through FYM + Biofertilizer + *Jeevamrut* but at Bikaner, 25% RDN + 75% N through FYM reported significantly higher biomass yields. In R-22-AST-3: Effect of Nano-Urea on productivity and quality on single cut fodder oat conducted at Anand, Mandya, Ayodhya, Kalyani, Pusa, Jorhat, Raipur, Bikaner, Palampur, Hisar, Imphal and Hyderabad, application of 100 per cent recommended nitrogen (100 kg/ha) through chemical fertilizers recorded higher green forage yield, dry matter yield, crude protein yield (374.4 q, 83.5 q and 7.7 q ha^{-1} respectively) on locational mean basis. In R-22-AST-4: Enhancing Productivity and quality of Multi cut Oat as influenced by Nano urea conducted at Jabalpur and Pantnagar, highest green and dry fodder yield as well as economics were obtained with application of 125% RDF (75 kg Nha^{-1} basal + top dressing of 37.5 kg N ha^{-1} each at 1st cut (40DAS) and 2nd cut (75DAS). K-20-AST-1c: Efficacy of plant growth regulators on forage yield and quality of maize-oat cropping system conducted at Urulikanchan, Srinagar, Pusa, Raipur, Hisar and Ranchi on maize and oat. In forage maize, application of mepiquat chloride at 300 ppm produced the highest mean green forage, dry matter and crude protein yield over locations, whereas, in oat, application of GA_3 at 400 ppm had the highest mean green forage yield. K-19-AST-2: Studies on organic source of nutrient on green forage yield and quality of Rice bean-oat under irrigated situation conducted at Kalyani, Imphal, Pusa and Ranchi. The highest GFY and DMY recorded in 50% RDN through FYM + 50% RDN through vermicompost at all locations except Ranchi. In R-21-AST -1: Effect of foliar nutrition on forage yield, quality and seed yield in grass pea (*Lathyrus sativus* L.) conducted at Kalyani, treatment Panchagavya @ 3% (30g per litre of water) recorded significantly superior green forage yield, dry matter yield and crude protein yield. In K-20-AST-4b: Organic nutrient management for soil health and sustainability of round the year fodder production system conducted at Palampur, application of FYM @ 10 t/ha resulted in significantly higher plant height, green and dry fodder yield of system. In K-20-AST-4c: Studies on the performance of organic nutrient management practices on soil health and sustainability of round the year fodder production of Sorghum-Oat cropping system conducted at Ayodhya, application of 5t/ha FYM basal + Natural Farming with mulch recorded significantly higher GFY, DFY, CPY, NMR, B: C ratio, Available N, P, K, OC, Microbial population and slight reduction in pH of sorghum-oat cropping system. In K-20-AST-4d: Optimizing production technology for sustainable organic fodder production and soil health conducted atPantnagar,

green fodder yield was significantly higher under organic farming. Among cropping systems, BN hybrid + (Cowpea-berseem-ricebean) gave the highest green fodder yield. In K-21-AST-1: Enrichment of BN hybrids and Maize silage quality by amalgamation with legume tree and fodder crops conducted at Hyderabad silage prepared from fodder maize reported the lower pH levels when compared to APBN 1 silage. Addition of tree fodders and fodder legumes darken the colour of silage. Dry matter was decreased with the addition of legume tree and fodder species. In K-21-AST-2: Evaluation of Hedge Lucerne for optimum seed rate and spacing for Seed Production conducted at Hyderabad, spacing of 120 cm with seed rate of 6 kg ha^{-1} realised higher seed yield, net returns of and B:C ratio. In K-21-AST-3: Intensive fodder-based cropping system for year-round supply conducted at Hyderabad sole Super Napier recorded higher green fodder yield but was on par with APBN-1. In K-21-AST-4: Effect of Nano Zn on crop growth, green fodder yield and its content in fodder sorghum –oat- fodder Bajra cropping sequence conducted at Anand, Nano Zn treatment significantly improved the green fodder yield, dry matter yield and crude protein yield of sequence.

3.7.7 Plant protection

In *rabi* 2022-23, total nine trials were conducted and the occurrence and abundance of major diseases and insect-pests in berseem, lucerne and oats was recorded at six locations. Maximum stem rot incidence in berseem was 61.7%, leaf blight severity in oats was 49.3% and incidence of lucerne downy mildew was 44.7%.

Germplasm evaluation programme against diseases and insect-pests in Rabi forages: In Oat, a total of 132 germplasm lines were tested against different diseases and insect-pest at various locations. Germplasm lines UPO-18-1-3, UPO-18-4-4, OGP-3, OGP-8, HFO-707, HFO-6, HFO-8, HFO-28, EC-605838, IG-03-254, and JHO-99-1were found moderately resistant against leaf blight, powdery mildew, and aphids at Ludhiana, Bhubaneswar, and Palampur locations. In Berseem, a total of 65 germplasm lines were tested against different diseases and insect-pest at Ludhiana and Bhubaneshwar. Germplasm lines viz, BM-3, HFB-1, HFB-7, HFB-8, HFB-15, HFB-16 and JHB-18-1 were found moderately resistant against stem rot, leaf blight as well as root rot. In lucerne, a total of 24 germplasm lines were tested against different diseases and insect-pest at Ludhiana. Against downy mildew, all the lines were moderately susceptible.

3.7.8 Breeder seed production

AICRP on FCU received breeder seed indent for 56 varieties in four forage crops *viz*., oat (31), berseem (19), lucerne (5) and hedge lucerne (1). The total quantity allocated was 71.47 t with production of 64.55 t which is 6.92 t deficits. For fodder oat, the production was 54.58 t against the allocation of 62.65 t making a deficit of 8.06 t. Out of 31 allocated varieties, there was a deficit in production in 14 varieties. For berseem, the total production was 9.41 t against the allocation of 8.06 t making a surplus of 1.35 q. There was indent of 19 varieties and production was in surplus or equal in 12 varieties. For lucerne, the total production was 0.45 t which was 0.20 t lower than the indent of 0.66 q. Out of 5 varieties, the target was achieved in Anand-2, GAUL-3, and Lucerne CO-3 and CO-2. For hedge lucerne, there was an indent of 0.10 t seed of one variety and production was equal to the allocation.

Varieties Identified:

SN	Varieties	Breeding institute	Recommended for
Berseem			
1.	PC-114	PAU, Ludhiana	North-west zone
2.	JHB 20-1	IGFRI, Jhansi	Central zone
3.	JB 08-17	JNKVV, Jabalpur	Central zone
Fodder Oats			
4.	JO 13-513 (dual)	JNKVV, Jabalpur	North-west and north east zone
5.	HFO-1014 (dual)	CCS HAU, Hisar	North-west and north east zone
6.	HFO-917 (dual)	CCS HAU, Hisar	North-west and north east zone
7.	OL-1931 (dual)	PAU, Ludhiana	North east zone

8.	SKO-224 (SC)	SKUAST, Srinagar	North-west and hill zone
9.	HFO-915 (MC)	CCS HAU, Hisar	Hill zone
10.	OL-1949 (MC)	PAU, Ludhiana	Hill zone
Perennial lucerne			
11.	LLC-7	PAU, Ludhiana	North-west zone
12.	BAIF Lucerne-5	BAIF Urulikanchan	North-west zone
13.	AWCL-2	SRRS-IGFRI, Dharwad	North-west zone
Lathyrus			
14.	KL-5	BCKV, Kalyani	Lathyrus growing areas of India

3.8 Externally Funded Projects

3.8.1 Developing cheaper Nutrigel for improving water and nutrient use efficiency in degraded lands of Bundelkhand (DST-SYST)

The nutrigels (Fig. 3.8.1a) are biodegradable and release nutrients based on the environmental scenario. Rate of degradation and nutrient release increases with ambient temperature. Application of 50% NPK through Nutrigel + 25% NPK through mineral fertilizer could improve biomass yield, nutrient uptake, nutrient use efficiency of fodder sorghum (Fig. 3.8.1b) and oat crops. Application of 50% NPK through Nutrigel + 25% NPK through mineral fertilizer could improve water use efficacy of crops also. Thus, application of 50% NPK through Nutrigel + 25% NPK through mineral fertilizer could save 25% of mineral fertilizer and 17-22% of water without reducing crop yield.

Fig. 3.8.1a. Developed nitrient, b. Its effect on nutrient and water use efficacy in sorghum

3.8.2 Grassland restoration and rejuvenation for enhancing grazing resources using remote sensing and drone technologies (NLM)

Double layer bio-fencing with bamboo + *Morus* and subabul has been installed around experimental field. Three grasses *C. ciliaris*, *M. maximus* and *P. pedicelletum* were selected based on climatic conditions, soil, and survivability. Seed pellets were prepared using suitable combination of farm yard manure, soil, and binding agent. Heaxacopter drone was used for broadcasting seed pellets in the field. *Pennisetum pedicelletum* had the best germination in the field condition (Fig. 3.8.2).

Fig. 3.8.2. Grassland rejuvenation using drone seeding

3.8.3 Development and evaluation of annual moringa for food, fodder, and nutritional content in Uttar Pradesh (UPCAR)

The PKM-1 has recorded higher plant height (295.33 cm), number of branches (9.24), green fodder yield (83.86 t ha^{-1}), dry matter yield (17.08 t ha^{-1}) and crude protein content (17.51%) as compared to local variety. Among the planting geometry, 23 × 15 cm has noticed significantly superior plant height (268.58 cm), number of branches (8.44), green fodder yield (76.56 t ha^{-1}), dry matter yield (15.58 t ha^{-1}), and crude protein content (16.89%) as compared to planting geometry of 30×30 cm. Feeding of moringa foliage as an alternate feed for Jalauni sheep was conducted and concluded that feeding of moringa fodder replaced the conventional concentrate mixture and reduced the concentrate requirement by 50% without affecting feed intake and the overall health of Jalauni sheep.

3.8.4 Agri drone project (SMAM)

More than twenty demonstrations on Nano urea application using Drone were organized in the institute research farm and farmers' field (Fig. 3.8.3) at Datia (MP).

Fig. 3.8.3. Demonstrations on nano area application using drone

3.8.5 Use of fly ash in agriculture for sustainable crop production and environmental protection (NTPC)

Impact of various fly ash treatments was observed on yield of oat and lathyrus crop as well as on soil (Fig. 3.8.4) properties under these crops. Oat (10.56 t ha^{-1}) and lathyrus (9.59 t ha^{-1}) produced maximum dry biomass yield under application of fly ash at 200 t ha^{-1}. Application of fly ash had no significant effect on soil physical properties under both crops, except soil moisture and infiltration rate which was found maximum under application of fly ash at 200 t ha^{-1} and 400 t ha^{-1}. Among soil chemical properties, soil organic carbon was influenced. Among available of soil nutrients under both crops N and S was

maximum under fly ash application at 80 t/ha (alternate year); P, K and Ca + Mg under application of fly ash at 200t/ha and Fe, Mn, Zn, Cu and B under application of fly ash at 400t/ha. As per the total soil nutrients status under oat crop, N, S and Ca + Mg was maximum under fly ash application at 80 t/ha (alternate year); P and K under application of fly ash at 200 t/ha; Fe, Mn, Zn, Cu and Mo under application

Fig. 3.8.4. Impact of fly ash in oat and *Lathyrus* production

3.8.6 Use and conservation of agro biodiversity for food and nutrition security, increased agricultural sustainability, and resilience to climate change in India (Alliance Bioversity-CIAT)

For the present study, remote sensing (LANDSAT-8) satellite data, soil parameters (pH, EC, organic carbon, available nitrogen, potassium and phosphorus) were estimated for the Tikamgargh district of Bundelkhand region. For quantitative evaluation of these parameters multi-criteria decision analysis method was used. Based on this data it revealed that Tilpura region had better grassland health while Chirpura, Neguwan Khas and Ramnagar places had poor grassland health in the Tikamgarh district.

3.8.7 Bioprospecting of abiotic stress tolerance genes in grasses

Chloris gayana plants were grown in pots and subjected to salinity stress by exposure to 300 and 400 mM NaCl. The control group received normal water (Fig. 3.8.6). Leaf samples were collected two days after the treatment and underwent transcriptome sequencing and metabolic profiling. *De novo* transcriptome analysis of *Chloris gayana* revealed a total of 13,495 genes that were differentially regulated in response to salt treatment. Under 300 mM NaCl treatment, 4955 genes were significantly up-regulated, and 1595 genes were down-regulated. Similarly, under 400 mM NaCl treatment, 5454 genes were up-regulated, and 1491 genes were down-regulated.

Genes expressed differentially in response to salinity stress were associated with various biological processes, including MAP kinases, fatty acid synthesis, response to oxidative stress, flavonoid synthesis, photosynthesis, osmotic stress, cellular response to oxidative stress, cellular response to stress, positive regulation of response to salt stress, and stress-activated protein kinase signaling cascade. Metabolic pathway analysis revealed that more flavanone and flavone pathway metabolites were produced in the presence of 300 mM NaCl compared to the control.

Fig. 3.8.5. *Chloris gayana* plants exposed to salinity stress

3.8.8 Mapping and validation of genomic regions associated with brown midrib mutant in pearl millet

The generation advancement of recombinant inbred line population (bmr line) ICBbmr07 × ICBP19 (non bmr line) has been done during *kharif* 2023 (Fig. 3.8.6). The lignin content of the parental lines was determined through proximate analysis, revealing 3.17% lignin content in ICBbmr07 and 6.18% in ICBP19. Subsequently, 15 non-bmr and 15 bmr families were identified from the RIL population. DNA was extracted from these families and bulked to create bmr and non-bmr bulks. These bulks, along with the parental lines, will be utilized to identify markers associated with the bmr trait. To broaden the genetic base, the bmr lines were crossed with TSFB 15-8, Giant bajra, Baif bajra 1, Moti bajra, and IP2269. The resulting F1 progeny were phenotyped for plant height, leaf area, and days to fifty percent flowering. The selected genotypes were then selfed, and the F2 generation is expected to exhibit segregation for the bmr trait.

Fig. 3.8.6 a. Germination advancement of bmr RIL mapping population, b. bmr in the RIL population

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

A field experiment was conducted to explore possibility of growing *rabi* crop using soil moisture conservation practices. In the *kharif* season, fodder sorghum produced 45.8 t/ha green fodder which was almost doubled than cowpea. In *rabi* season growing of taramira after cowpea yielded 29.5% higher seed yield than taramira grown after fodder sorghum led to higher net returns and BC ratio. Furthermore, highest system productivity (5.44 t ha^{-1}) in terms of taramira equivalent yield was found under mulching which was at par with plot bunding resulting higher economic returns.

Seven cropping systems were evaluated under rainfed condition. Sweet corn–chickpea cropping system (Fig. 3.8.7) had highest system productivity (4.97 t ha^{-1}) followed by baby corn–taramira (4.27 t ha^{-1}), and sorghum (F)–mustard (2.82 t ha^{-1}). Mungbean – linseed recorded the lowest system productivity (1.75 t ha^{-1}). The highest net returns (Rs. 188199/ha) and BCR (2.61) were also computed in sweet corn–chickpea system in spite of the highest cost of cultivation.

Fig. 3.8.7. Sweet corn - chickpea cropping system

3.8.10 Optimizing growth and yield of cactus pear as a 4f crop (food, fodder, fertilizer, and fuel): Exploring the effects of plant density and fertilizer application

The trial was started during July 2023 and aimed to investigate the effects of plant density (25000, 16000 and 10000 plants per hectare) and fertilizer application on the growth and yield of cactus pear plants (Fig. 3.8.8). The new cladodes were sprouted from planted cladodes. Total 61-67 new cladodes/plot were emerged up to end of August 2023 and it further increased to 457-482 up to end of December 2023.. In general, it was observed that the increment in emergence of new cladodes from August to October was 5-7 times while it was only about 1.5 times in October to December. Secondary cladodes were emerged from primary cladodes. There were no secondary cladodes observed up to end of August in any treatments. Thereafter, it started and lasted up to end of December.

Fig. 3.8.8. Overview of the experiment

3.8.11 AMAAS Project: Microbe based drought and nutrient management in forage crops

Oat seeds were inoculated with drought tolerant plant growth promoting bacterial (PGPB) consortia like *Actinobacter* sp., *Ensifer* sp., *Achromobacter insolitus, Pectobacterium caratovorum, Enterobacter cloacae* each along with *Burkholderia cepacia* and then were sown with 50% RDF fertilizer along with different control treatments (100 and 50% RDF and 100% irrigation and drought). After drought imposition, the relative leaf water content of PGPR-treated plants ranged from 80.20-85.3% at 20.60% soil moisture. One consortia treatment (T7) recorded significantly higher proline content (3.09 mg/g FW), while others ranged from (3.02-3.05 mg/g FW) over control (100% nutrient and irrigation; 3.01 mg/g FW). About two treatments recorded more green and dry fodder, with yields ranging from 255.3 to 261.0 q/ha and 48.9 to 51.1 q/ha, respectively, compared to control (drought induced and 50% fertilized; 202 q/ha GFY and 37.6 q/ha DFY, respectively), under drought stress. Average number of plants per meter row and number of panicles was also higher in the culture-treated plots (25.25 to 30.75 and 24.5 to 28.25, respectively) compared to control (25.25 plants per meter row and 19.25 panicles). Similarly T6 treatment recorded significantly higher seed yield (701.3 kg/ha) compared control (602.7 kg/ha) under drought stress. From this experiment, it is concluded that the use of drought tolerant microbial consortia enhances oat plant growth and production of fodder and seed yield under drought stress, which can be used at farmers' field to overcome terminal drought.

3.8.12 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

Under the NIAP-Network project, economic impact assessment of four key varieties: IGFRI-727 (*C. ciliaris* grass), Bundel Dinanath-2 (*P. pedicellatum* grass) and JHO-822 and UPO-212 (oat) was done using the economic surplus method. The estimation of area for *C. ciliaris* grass (IGFRI-727) and *P. pedicellatum* grass (BD-2) relied on TFL seed production, while the estimation for oat (JHO-822 and UPO-212) was based on breeder seed production. Given that the benefits of green fodder contribute to milk production, the surplus was quantified in terms of equivalent milk production resulting from the selected variety's green fodder production. Assuming that green fodder produced from the selected variety has been fed to lactating animals (cows and buffalo) in proportion to their population, the equivalent milk produced from cattle and buffalo was estimated. It is clear that *C. ciliaris* grass has generated more economic impact (Rs. 7.17 crore) than that of *P. pedicellatum* (Rs. 3.14 crore), while between the two selected oat varieties; the impact of UPO-212 was higher than that of JHO-822 (Table 3.8.1).

3.8.13 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

Vulnerable hotspots to climate change in the smallholder dairy production system of the Indo-Gangetic plains of India were identified and mapped in GIS environment. To identify the vulnerable hotspots, an index for district-level assessment of the climatic risk concerning future as well as historical hazards was developed to comprehend the dynamics of change in climatic risk of the smallholder dairy production system of IGP across the 174 districts of the five states namely Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. It was found that the majority of highly risk-prone districts were present in middle Gangetic and lower Gangetic plains while trans-Gangetic plains had relatively lower risk-prone districts. Further, the exploratory spatial data analysis revealed highly significant hotspots and cold spots. The area under hotspots with respect to historical risk was found to be present in the middle and lower Gangetic plains covering 13.96% of total Indo Gangetic plains which has been projected to rise to 21.75% by 2050s. The cold spots were found to be present in trans Gangetic plains covering 21.73% of the total Indo Gangetic plains and are further projected to rise to 28.01% by 2050s. Hence, a climate adaptation policy may be formulated for the middle and lower Gangetic plains to improve the climate resilience of the smallholder dairy production systems of these regions.

3.8.14 All India Coordinated Research Project on Farm Implements and Machinery on PFT & FLD

proto type feasibility testing was performed for tractor operated front mounted forage harvester during Jan-Sep, 2023January-March, 2023 to evaluate the machine and workability. It was observed that while harvesting in oats and BN hybrid crop, machine performed harvesting well but not able to bind and convey the crops properly. Then machine's binding mechanism was removed and used for harvesting purpose in different forage crop. Machine was found suitable for only harvesting of forage crops not binding. Harvested forage crops was used for preparation of silage in institute.

3.8.15 ICAR-National Agriculture Innovation Fund (NAIF) component-II establishment of Agri-Business Incubation Centre (ABIC)

- ABIC conducted three EDP "Entrepreneurship Prospects in Commercial Goat Farming",

Table 3.8.1. Estimated economic impact

Forage crop	Variety	Estimation period	Consumer surplus Rs. (crores)	Producer surplus Rs. (crores)	Total surplus Rs. (crores)
Anjan grass	IGFRI-727	2010-2022	4.30	2.86	7.17
Dinanath	BD-2	2012-2023	1.90	1.26	3.14
Oat	JHO-822	2002-2022	17.75	11.83	29.59
	UPO-212	2000-2023	22.98	15.32	38.31

"Entrepreneurship Prospects in Bajra x Napier Hybrid Production and Utilization" "Entrepreneurship Prospects in Converting Green Fodder to Silage" engaging 38 trainees.

- ABIC celebrated World Intellectual Property Day" on the theme "Women and IP: Accelerating Innovation and the Creativity" on 26 April 2023 in IGFRI Jhansi. Prof. Charu Virmani, Head of the Department, CSE, School of Engineering Technology, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana delivered an online lecture and interacted to IGFRI scientists, technical and administrative staff.
- ABIC incubated Exceed Digital, Jhansi UP for silage production, M/s. Chitransh Agrotech Ltd. For selling vermicompost enriched with bio fertilizer, Mr. Mahesh Gupta has entered for establishment of commercial goat farm.
- ABIC-IGFRI unit Participated in Bundelkhand Agri-Startup Summit held at Jhansi on 09/09/2023. A total of 36 visitors saw the activities of ABI and interacted with the ABI team (Farmer 15 nos.; Policy makers 3 Nos.; Scientists/Professors 4 Nos.; Entrepreneur 10 Nos.; Students 4 Nos). Mr. Mahesh Gupta has recently signed MOA with ABIC IGFRI for establishment of commercial goat farm.

Agricultural Technology Information Centre (ATIC):

Kisan Chaupal/ Telecast on DD Kisan Channel: Hello Kisan (by Dr. Purushottam Sharma, PS and HD SS): Topic "*Mote anaj khadya prasanskaran evam chara prabandhan*"- programme telecasted on DD Kisan on 31 January 2023.

Total visitors at ATIC unit was 3918 (Farmers/ Govt. Employees/Students/ Pvt. companies/ NGO/Dairy etc.).

ATIC attended 332 Phone calls.

ATIC was involved in sale of publications, (Rs. 1070.00), seed, (Rs. 1080.00) and other products, (Rs. 4780.00).

ATIC issued 34 agro-met advisories/ on crop/weather related to the farmers.

Krishi Mela/ exhibition organized/ Goshthis organized

- Technology and Machinery Demonstration Meet held at ICAR-IGFRI, Jhansi on 01 March, 2023 – 300 farmers participated.
- International Women's Day on 06 March, 2023: 62 Farm women/40 staff participated.
- Anusuchit Jati Labharthi Kisan Sammelan and Inauguration of Seed Processing Lab – By Hon'ble Union Agril. Minister Shri Narendra Singh Tomer ji, Dr. Panjab Singh, Dr. Himanshu Pathak, Dr. A.K. Singh VC RLBCAU *etc.*, on 11 March, 2023 at ICAR_IGFRI Jhansi – 60 farmers participated.
- Exhibition cum farmers fair on the occasion of International year of millets on 02 April, 2023- 300 farmers visited.
- National Seminar by Himachal Pastureland Palampur, "Krishi Vigyan mein Takniki Shabdawali ka Upyog evam Mahatv", 27-28 April, 2023, IGFRI Palampur – Participants 100.
- SC Farmers Beneficiary Meet under SCSP Programme at IGFRI Jhansi on 16 may, 2023 – physical mode – distribution of farm implements – Participants 50.
- World Environment Day, on 05 June, 2023, Physical mode – 70 participants.
- Institute foundation day cum farmers fair on 01 November, 2023 – 127 Farmers.
- Celebration of World Soil Day on 05 December, 2023 – 22 Participant farmers.

Krishi Mela/ exhibition organized/ Goshthis participated

- Participation in Kisan Mela at RPCAU, PUSA, Bihar during 23-25 February, 2023.
- Participation in Bundelkhand Kisan Mela at RLBCAU Jhansi during 26-27 February, 2023.
- Participated in Krishi Vigyan Mela at IARI New Delhi during 02-04 March, 2023.
- Participation in pandit Deen Dayal Upadhyaya Vrihad Pashu Arogya Shivir evam Mela, Caubepur, Kanpur, organised by UP Govt. On 27 March, 2023.
- Paticipation in Vrihad Kisan Goshthi evam pradarshani at ICAR-IGFRI, Jhansi – organised by UP Govt. On 02 April, 2023 – 1000 Farmers and 400 students participated.
- Mann ki Batt – 100th episode on 30 April. 2023 by Hon'ble PM Webcast viewed at IGFRI – Participants 54.
- Foundation Day and Exhibition at CAFRI, Jhansi on 08 May, 2023 – Physical mode – IGFRI Participation in exhibition.

Farmers interface meeting (Online through Zoom):

Over the course of 33 weekly Zoom meetings, the Farmers Advisory Meeting facilitated informative sessions led by experts from institutions like IGFRI and IIFSR, covering a diverse array of agricultural topics. These sessions saw active participation, with participant numbers ranging from 20 to 55 in each meeting. The total number of participants was 987. Topics discussed included crop management, livestock health, natural farming principles, soil and water conservation, fodder crop cultivation, and post-harvest management, among others. The meetings provided a platform for farmers to engage in discussions, ask questions, and gain valuable insights into modern agricultural practices and techniques aimed at improving crop yields, livestock health, and overall farm productivity.

Farmer's FIRST Project

Under Farmer First programme, technological interventions at farmer's field were done under 5 modules namely field crop-based interventions, livestock interventions, horticulture interventions, IFS interventions, and capacity building of farmers. Introduction of improved variety of crops like green gram (IPM 2-3), groundnut (TG 37A),

and wheat (Raj-4079) resulted in higher benefit –cost ratio of 2.12, 3.00, and 2.54 respectively. Gross returns per rupee of investment due to improved variety of vegetables were around 40% higher than that of local cultivar. The impact assessment of technological interventions on monthly consumption expenditure was assessed using Endogenous Switching Regression Model. The results indicated that adoption of technology resulted in higher monthly consumption expenditure of households to the tune of Rs. 38880 per month.

3.11 Consultancy Project

Grassland development consultancy project in Zarapara village Bhuj district

(Host organization: Adani ports & SEZ)

Institute scientific team visited Zarapara village, Bhuj to assess the physical status of site, palatable grass and legume diversity and develop location specific plan for development of grasslands. The developed plan was communicated to host organization.

Grassland development consultancy project in Manesar, Gurugram District (Host organization: Maruti Suzuki India Limited)

Institute scientific team visited the at Manesar, Haryana and after soil sample analysis suitable plan for implementation was submitted to the host organization.

Chapter 4

Forage Seed Production

4.1 Seed production 2022-23

4.1.1 Variety-wise seed production of fodder crops

***Rabi* 2022-23**

Crops	Variety	Breeder Seed-BS (kg)	Truthfully labeled seed-TFL (kg)	Total (kg)
Oat	KENT	1120	975	2095
	JHO-822	3465	1085	4550
	JHO-851	200	50	250
	JHO-2012-2	80	20	100
	JHO-99-2	360	20	380
	JHO-2015-1	50	15	65
	JHO-2009-1	350	245	595
	JHO-2000-4	490	140	630
	Total	6115	2550	8665
Berseem	Wardan	970	100	1070
	JBSC-1	800	120	920
	BB-2	458	40	498
	BB-3	694	50	744
	JHB-17-1	100	18	118
	JHB-17-2	144	26	170
	JHB-18-1	32	8	40
	JHB-18-2	25	7	32
	Total	3223	369	3592

***Kharif* 2023**

Crops	Variety	NBS (kg)	TFL(kg)	Total (kg)
Sorghum	MP Chari	2300	-	2300
	PC-6	430	-	430
	PC-615	160	-	160
	Total	2890		2890

4.1.2 Grasses and legumes seed production

Grasses name	Variety	Truthfully labeled seed-TFL (kg)
Megathyrsus maximus	Non-specific	142
Cenchrus setigerus	Non-specific	02
Heteropogon contortus	Non-specific	03
Chrysopogon fulvus	Non-specific	1.5
Bothriochloa intermedia	Non-specific	08
Desmanthus	Non-specific	05
Brachiaria spp.	Non-specific	63

4.2 Seed sale (2023)

4.2.1 Total seed sale (2023)

Class of fodder seed	Sale (kg)
Breeder seed	8463.0
Truthfully labelled seed	6025.0
Total	14488.0
Perennial grasses root slips (in lakhs)	2,54,300.0

4.2.2 Crop wise seed sale (kg) of cultivated fodder crops (2023)

Crop	Variety	Breeder seed-BS	Truthfully labeled seed-TFL	Total
Oat	JHO-822	2565	1537.5	4102.5
	KENT	1095	606	1701
	JHO-851	200	92	292
	JHO-99-2	200	8	208
	JHO-99-1	200	80	280
	JHO-2000-4	530	610	1140
	JHO-2009-1	350	-	350
	JHO-2010-1	100	200	300
	JHO-2012-2	70	100	170
	JHO-2015-1	50	80	130
Total		5360	3313.5	8673.5
Berseem	BB-2	400	108.5	508.5
	BB-3	615	85.48	700.48
	BB-5	130	0.5	130.5
	BB-6	109	0.5	109.5
	JBSC-1	680	240.5	920.5
	JHB-17-2	-	10	10
	JHB-18-1	25	-	25
	JHB-18-2	20	-	20
	Wardan	795	133.5	928.5
	Total	2774	578.98	3353.0
Sorghum	MP-Chari	50	1722	1772
	PC-6	-	180	180
	PC-615	-	70	70
	Total	50	1972	2022
Cowpea	BL-2	8	-	8
	BL-4	13	-	13
	EC-4216	70	10.5	80.5
	Kohinoor	30	3.5	33.5
	Total	121	14	135
Maize	African Tall	150	6	156
	Total	150	6	156
Bajra	AVKB-19	-	0.25	0.25
	TOTAL	0	0.25	0.25
Subabool	NON SPECIFIC	-	1.25	1.25
	Total	-	1.25	1.25
Moringa	SPECIFIED	-	3.25	3.25
	Total	-	3.25	3.25
Deenanath	BD-2	8	103.95	111.95
	Total	8	103.95	111.95

Tropical Grasses: *viz.* Hetropogon contortus, Panicum antidotale, Guinea grass, Anjan Ghas, Braccharia, Dhaman Ghas etc. = 32.15 (kg)

Chapter 5

Outreach Programmes

5.1 Scheduled Castes Sub-Plan (SCSP)

Under the SCSP program, ICAR-IGFRI collaborated with Krishi Vigyan Kendras (KVKs) from six states-Uttar Pradesh, West Bengal, Punjab, Himachal Pradesh, Jammu and Kashmir, and Karnataka-to implement its activities. These included organizing twenty-two (22) training sessions that benefited 952 farmers. Additionally, 2633 demonstrations related to fodder technologies were conducted across 35.5 hectares. Livestock technologies were showcased through demonstrations involving 523 animals, while over 475 demonstrations on other agricultural technologies reached more than 600 farmers.

In Jhansi, ICAR-IGFRI collaborated with KVKs to conduct demonstrations showcasing improved farming equipment in five villages: Khajraha Bujurg, Khajraha Khurd, Mathurapura, Rampura, and Chamraua. The demonstrations featured various agricultural tools, including 10 mini power tillers, 10 earth augers, 10 power-operated maize shellers, 20 crop harvester sidepacks, 2 multi-crop threshers, 2 zero-till fertilizer drills, 2 spring-loaded fertilizer drills, 10 spiral seed separators, 10 hand-operated chaff cutters, 20 groundnut decorticators and 100 battery-operated sprayers.

Additionally, a series of demonstrations showcased improved varieties of fodder and crops, including Sorghum (MP chari), banyard millet (DHBM-93-2), bajra (VPMH-7, VPMH-9), BN hybrid, oat (JHO-822), brinjal (Kashi Sandesh), tomato (Kashi Aman), and chilli (Kashi Anmol). The number of demonstrations for these crops were as follows: 180 for Sorghum, 130 for banyard millet, 115 for bajra, 123 for BN hybrid, 123 for oat, and 100 each for brinjal, tomato and chilli.

Furthermore, four training and extension programs engaged 140 farmers, while three awareness programs were organized at institute. These awareness programmes attracted 119 Scheduled Caste (SC) farmers, including women farmers. Livestock interventions were implemented among farmers whose livelihoods predominantly rely on the livestock sector. During the demonstrations, 180 units of mineral mixture, 3 Bhadawari bulls, and 10 Bundelkhandi male goats were showcased to the farmers. Additionally, 23 Hindi leaflets were published as part of the SCSP project.

Fig. 5.1. Distribution of agricultural implements and training on vermicomposting to SC farmers

In Cooch Behar district, West Bengal, a series of demonstrations and equipment distributions were conducted to benefit local farmers. The initiatives included the distribution of 1 Automatic Egg Hatching Incubator, benefiting 100 families; 1 Chaff Cutter machine, benefiting 45 families; and 50 Hydroponic fodder trays, each benefiting 10 families. Livestock interventions were specifically targeted at Scheduled Caste farmers, whose livelihoods depend largely on the livestock sector. During these demonstrations, 30 Black Bengal Goats and 30 Large White Yorkshire pigs were showcased to the farmers.

Additionally, demonstrations of improved fodder varieties such as oats (var. Kent-5), berseem (var. JB-1), fodder maize (var. J1006), BN hybrid (var. Super Napier), cenchrus and azolla were conducted, with demonstration numbers of 44, 251, 6, 80, 26, and 60, respectively.

To further support the farming community, ten training and extension programs were held across ten different blocks, engaging a total of 255 farmers. Moreover, three awareness programs were organized under the SCSP project, two of which were held at the ICAR-KVK campus in Cooch Behar and one at Jaldapara, Alipurduar, West Bengal, benefiting 285 SC farmers. As part of the SCSP project, five Bengali leaflets were published to disseminate information and best practices among the farmers.

At the ICAR-IGFRI, Dharwad center in Karnataka, demonstrations and dissemination of enhanced agricultural machinery were conducted to benefit local farmers. This initiative included the

Fig. 5.2. Farmers-scientist interface-cum-workshop at and distribution of goat at Cooch Behar under SCSP project

distribution of 30 Fodder Chaff Cutters, 9 Fodder Trolleys, 120 Silage Bags, and 30 Knapsack Sprayers. Additionally, two training and extension programs were organized, engaging a total of 60 farmers. These efforts aimed to improve agricultural productivity and efficiency through the adoption of advanced machinery and techniques.

Fig. 5.3. Distribution of agricultural machineries to SC farmers at KVK, Kalaburagi

In Palampur, Himachal Pradesh, activities were conducted to demonstrate and distribute improved agricultural machinery, which included battery-operated sprayers (benefiting 100 farmers), seed storage bins (benefiting 100 farmers), and small farm tool kits (consisting of *khurpi, kulta,* sickle, hand fork, hand hoe, garden rack, line maker) (benefiting 150 farmers). Additionally, a series of demonstrations and distributions were carried out for improved varieties of fodder and crops. This included 120 FLDs on oat seed (500 kg) and white clover seed (10 kg), 120 FLDs on perennial grasses (Fescue) seed (100 kg) and 204 FLDs on perennial grasses rooted slips (*Brachiaria, seteria*, paspalum, BN hybrid) (201,500 units) and finger millet seed (100 kg). Two training and extension programs were organized, involving 220 farmers, and one awareness program involved 204 farmers. Furthermore, Livestock interventions were conducted during these demonstrations, including the distribution of Special milk ration (4225 kg) among 320 farmers, Power bolus (400 kg) among 120 farmers, Area-specific mineral mixture (450 kg) among 300 farmers, and Power bolus (100 kg) among 204 farmers.

Fig. 5.4. FLD at Palampur, Himachal Pradesh

Demonstrations showcasing enhanced agricultural equipment were carried out across four locations in Jammu and Kashmir: Jindlehar, Bishna, Chack Qadra, and Samba. These demonstrations featured a range of tools, including 277 sickles, 150 spades, 100 shovels, 98 secateurs, and 100 pruning saws. Furthermore, 277 FLDs were conducted to introduce improved varieties of fodder crops, including 277 FLDs of berseem *var* mescavi and 197 FLDs of fodder sorghum, benefiting a total of 1100 farmers. Additionally, 277 FLDs of chelated mineral mixture were presented to enhance livestock interventions. Four training sessions and extension programs, as well as four awareness programs, were organized, engaging a total of 277 farmers in each event.

Fig. 5.5. Awareness cum training programme organized as Samba, Jammu

5.2 Tribal Sub Plan Program (TSP)

Tribal Sub Plan interventions had been implemented across several districts: Dausa in Rajasthan, Nandurbar and Dhule in Maharashtra, Kulgam, Waliwar, Lar Ganderbal, Shopian, Aru, Pahalgam, Anantnag, and Baramula in Jammu & Kashmir, Badwani in Madhya Pradesh, and Chamba, Kinnaur, and Lahaul and Spiti in Himachal Pradesh.

In Rajasthan, 105 tribal farmers from the *gram panchayat* Hapavas were provided with agricultural resources, including 750 kg of oat (JHO-822) seeds, 1200 kg of calcium supplement, and 185 kg of mustard seeds. Additionally, two training cum awareness programs were conducted under TSP to

educate farmers on "Establishment of horti-pasture for enhancing farmers' income" and "Fodder and livestock production technology." These initiatives also aimed to promote the inclusion of millets in the human diet and benefited a total of 210 tribal farmers from the gram panchayats/villages of Khanvas and Malvas.

Fig. 5.6. Distribution of Ca supplement and oat seeds& training organized by RRS, Avikanagar for tribal women at Gram Panchayat, Hapavas, district-Dausa, Rajasthan

In Maharashtra, 300 tribal farmers across six villages in Nandurbar and Dhule districts received agricultural support. This assistance included the distribution of 8.0 quintals of perennial fodder sorghum (CoFS-29) and mineral mixture. To further enhance the knowledge and skills of farmers, four one-day training programs were organized in Nandurbar and Dhule districts, attended by a total of 100 farmers.

Fig. 5.7. Inputs distribution at Nandurbar and Dhule districts of Maharashtra

In Himachal Pradesh, World Environment Day 2023 was celebrated on June 5th with a special focus on Mission LiFE, which stands for Lifestyle for Environment. The celebration included the planting of various tree species such as Devdar, Robinia, and Salix, as well as agricultural crops like Pomegranate, Elephant grass, and Napier. A total of 150 tribal farmers actively participated in this event, contributing to the preservation and enhancement of the environment. Additionally, as part of the occasion, 150 Kisan Diaries were distributed to the tribal farmers, providing them with valuable information and resources to support their agricultural endeavors.

In Madhya Pradesh, a total of 150 tribal farmers were provided with essential agricultural resources, including 25,000 seedlings of chilli crop (hybrid NS2460), 100 kg of hybrid maize (PMH-2255) for fodder, 400 kg of wheat (var. HI-1634 & HI1544), and 200 kg of berseem seed (var. Long Standing). Additionally, to diversify income sources, 300 poultry birds of the Narmada Nidhi breed were distributed among the farmers. To enhance their knowledge and skills, three training programs focussing on improved crop and fodder production technology were organized. These programs were attended by a total of 145 tribal farmers and farm women, providing them with valuable insights and practical techniques to optimize their agricultural practices and improve productivity.

On October 6th, 2023, an one-day training programme and input demonstration were organized at Khirkhiri Panchayat, Karahal Tehsil, Sheopur District, Madhya Pradesh. The programme benefited 102 tribal farmers by providing them with valuable insights into enhanced fodder production technologies. Additionally, to support their efforts, essential inputs were provided to the farmers, including 455 kg of berseem seeds, 830 kg of oat seeds, 50,000 root slips of the BN hybrid, and goats.

Fig. 5.8. Inputs distribution and training organized by KVK Badwani in M.P.

Fig. 5.9. Inputs distribution and training organized by IGFRI at Sheopur district

In Jammu and Kashmir, a total of 9 training cum awareness programmes were organized, benefitting a total of 500 tribal farmers. These programs included 143 FLDs each of fodder maize, perennial temperate forage crops, and mineral mixture; 106 FLDs each of maize seed, deworming medicines, and chelated mineral mixture; 82 FLDs each of maize (SMC-7) and chelated mineral mixture; 70 FLDs of perennial grasses; and 46 FLDs each of calcium supplement, deworming medicine, and perennial grasses. These initiatives were carried out across various districts including Srinagar, Baramulla, Pahalgam, Anantnag, Bandipora, Kulgam, and Ganderbal, aiming to equip tribal

farmers with valuable insights and practical demonstrations to enhance their agricultural practices and improve productivity.

5.3 NEH plan

The NEH (North Eastern Hill) plan of the institute, focusing on "Fodder and livestock based interventions for livelihood improvement of NEH farmers," was successfully implemented in collaboration with four institutes *viz.* Central Agricultural University, Imphal, Manipur; Assam Agricultural University, Jorhat, Assam; ICAR-National Research Centre on Mithun, Nagaland; and North Eastern Regional Institute of Science and Technology, Itanagar, Arunachal Pradesh.

The implementation of the plan involved a range of activities focused on training and capacity building of stakeholders, field demonstrations of technologies, and welfare activities across Assam, Manipur, and Arunachal Pradesh. These activities were conducted in collaboration with local communities and stakeholders to ensure effective dissemination and adoption of the interventions. A total of 386 farmers, state officials, and extension personnel from four districts of Manipur (Thoubal, Bishnupur, Churachandpur, and Kakching), four districts of Assam (Jorhat, Lakhimpur, Morigaon, and Udalguri), and one district of Arunachal Pradesh (Papum Pare) benefited from the training and capacity building programs. Additionally, 133 field demonstrations on fodder production technologies, including maize, sorghum, oat, BN hybrid, as well as fodder planting material generation units (setaria, congo signal, BN hybrid, and para grass), and horti-pastoral systems were conducted. Furthermore, beneficiaries of the project were provided with essential resources such as silo tanks and literature on fodder production in the Assamese language to facilitate their adoption of improved agricultural practices. Overall, the NEH plan played a significant role in enhancing the livelihoods of NEH farmers by promoting sustainable fodder and livestock-based interventions in the region.

Fig. 5.10. Inputs distribution and trainings organized at tribal districts of Jammu & Kashmir

5.4 Agricultural Technology Information Centre (ATIC)

Kisan Chaupal/Telecast on DD Kisan Channel: Hello Kisan (by Dr. Purushottam Sharma, PS and HD SS): Topic "*Mote anaj khadya prasanskaran evam chara prabandhan*"- programme telecasted on DD Kisan on January 31, 2023.

Total visitors at ATIC unit was 3918 (Farmers/ Govt. Employees/Students/Pvt. companies/ NGO/Dairy *etc.*). ATIC attended 332 Phone calls. ATIC was involved in sale of publications (Rs. 1070.00), seed (Rs. 1080.00) and other products (Rs. 4780.00). ATIC issued 34 crop/agro-met advisories to the farmers.

Krishi Mela/exhibition/*Goshthis* organized

- Technology and Machinery Demonstration Meet held at ICAR-IGFRI, Jhansi on March 01, 2023 – 300 farmers participated.
- International Women's Day on March 06, 2023: 62 Farm women/40 staff participated.
- *Anusuchit Jati Labharthi Kisan Sammelan* and Inauguration of Seed Processing Lab – By Hon'ble Union Agril. Minister Shri Narendra Singh Tomer ji, Dr. Panjab Singh, Dr. Himanshu Pathak, Dr. A.K. Singh VC RLBCAU *etc.*, on March 11, 2023 at ICAR_IGFRI Jhansi – 60 farmers participated.
- Exhibition cum farmers fair on the occasion of International year of millets on April 02, 2023-300 farmers visited.
- National Seminar by Himachal Pastureland Palampur, "*Krishi vigyan mein takniki shabdawali ka upyog evam mahatv*", April 27-28, 2023, IGFRI Palampur – Participants 100.
- SC Farmers Beneficiary Meet under SCSP Programme at IGFRI Jhansi on May 16, 2023 – physical mode – distribution of farm implements – Participants 50.
- World Environment Day, on June 05, 2023, Physical mode – 70 participants.
- Institute foundation day cum farmers fair on November 01, 2023 – 127 Farmers.
- Celebration of World Soil Day on December 05, 2023–22 Participant farmers.

Krishi mela/exhibition/*Goshthis* participated

- Participation in *Kisan Mela* at RPCAU, PUSA, Bihar during February 23-25, 2023.
- Participation in *Bundelkhand Kisan Mela* at RLBCAU Jhansi during February 26-27, 2023.

- Participated in *Krishi Vigyan Mela* at IARI New Delhi during March 02-04, 2023.
- Participation in *Pandit Deen Dayal Upadhyaya Vrihad Pashu Arogya Shivir Evam Mela,* Caubepur, Kanpur, organised by UP Govt. on March 27, 2023.
- Paticipation in Vrihad Kisan Goshthi evam pradarshani at ICAR-IGFRI, Jhansi – organised by UP Govt. On 02 April, 2023 – 1000 Farmers and 400 students participated.
- *Mann ki Baat* – 100th episode on April 30, 2023 by Hon'ble PM Webcast viewed at IGFRI – Participants 54.
- Foundation Day and Exhibition at CAFRI, Jhansi on May 08, 2023 – Physical mode – IGFRI Participation in exhibition.

Farmers interface meeting (Online)

Over the course of 33 weekly Zoom meetings, the Farmers Advisory Meeting facilitated informative sessions led by experts from institutions like IGFRI and IIFSR, covering a diverse array of agricultural topics. These sessions saw active participation, with participant numbers ranging from 20 to 55 in each meeting. The total number of participants was 987. Topics discussed included crop management, livestock health, natural farming principles, soil and water conservation, fodder crop cultivation, and post-harvest management, among others. The meetings provided a platform for farmers to engage in discussions, ask questions, and gain valuable insights into modern agricultural practices and techniques aimed at improving crop yields, livestock health, and overall farm productivity.

5.5 Farmer's FIRST Project

Under Farmer First programme, technological interventions at farmer's field were done under 5 modules namely field crop-based interventions, livestock interventions, horticulture interventions, IFS interventions, and capacity building of farmers. Introduction of improved variety of crops like green gram (IPM 2-3), groundnut (TG 37A), and wheat (Raj-4079) resulted in higher benefit –cost ratio of 2.12, 3.00, and 2.54 respectively. Gross returns per rupee of investment due to improved variety of vegetables were around 40% higher than that of local cultivar. The impact assessment of technological interventions on monthly consumption expenditure was assessed using Endogenous Switching Regression Model. The results indicated that adoption of technology resulted in higher monthly consumption expenditure of households to the tune of Rs. 38880 per month.

Fig. 5.11. On field Farmer's FIRST activity

5.6 Mera Gaon Mera Gaurav (MGMG) programme at RRS, ICAR-IGFRI Dharwad

In the adopted MGMG village "Madanbhavi", PRA tools were used to understand the resources available in the village and conducted group meeting to develop grassland located next to the Goshala by RRS, ICAR-IGFRI Dharwad.

Fig. 5.12. Agro-ecological map of Madanbhavi Village

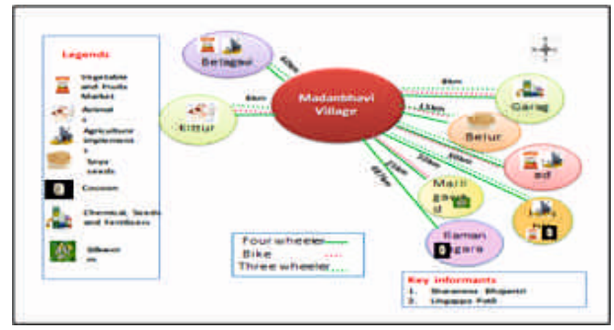

Fig. 5.13. Mobility map of Madanbhavi village

Fig. 5.14. Discussion with farmers in newly constructed *Gaushala* at Madanbhavi village

5.7 *In-situ* conservation of Bhadawari buffalo

For the improvement and conservation of Bhadawari buffaloes, various initiatives were undertaken in the field. Frozen semen from superior bulls was supplied in the breeding tract to facilitate breeding programs. AI (Artificial Insemination) services were provided to farmers involved in rearing Bhadawari buffaloes. During 2023, a total of 2571 Artificial inseminations were performed in Etawah, Bhind, and Morena districts, and 1060 semen doses were sold to the inseminators. Additionally, one breeding bull was sold to Banda University of Agriculture and Technology, Banda, UP, while two breeding bulls were sold to ICAR-IGFRI for distribution among farmers for breeding purposes under the SCSP (Scheduled Caste Sub Plan) program. Furthermore, 14 male calves were sold to farmers through auction.

As part of welfare activities, mineral mixture and veterinary medicines were distributed among 53 beneficiary farmers in villages selected under the SCSP program. To promote awareness and motivation among farmers, various events such as Kishan gosthy, exhibitions in Kishan mela, and meetings with farmers were organized in the breeding tract, encouraging farmers to engage in the rearing of Bhadawari buffaloes. These efforts aimed to contribute to the preservation and enhancement of Bhadawari buffalo breed, ensuring its sustainability and productivity in the region.

Fig. 5.13. Distribution of Mineral Mixture and veterinary medicines to the SC farmers

Chapter 6

Training and Capacity Building

This unit gives a great importance for training of different stakeholders including both government and non-government organizations and farmers group related to forage and livestock. It offers a niche of forage production knowledge hub for users of forage technologies and stakeholders of forage producers. Human resource development activities within the organization for the institute personnel was also given due importance. During the year, a number of personnel from scientific, technical and administrative category were deputed to different specialized short training courses in the emerging areas offered by various organizations across the country. Several sponsored programmes were designed and executed at this institute.

6.1 Capacity Building and Skill improvement thrust to IGFRI personnel

Under capacity building mode of activities, 13 scientists, 04 technical officers and 07 administrative, finance & account officer 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

S.No.	Name	Period	Institute	Title	Mode
Scientific category					
1.	Dr Gaurendra Gupta	05-25 Jan, 2023.	ICAR-IARI, New Delhi	"ICAR Sponsored 21 days' Winter School on Recent innovations in natural farming and organic production systems for sustainability"	Physical
2.	Dr. Ravi Prakash Saini	03-05th April 2023	NABI, Mohali	"Genome editing mediated by CRISPR/ Cas9: Tools, experimental design and its applications"	Physical
3.	Dr. K.K. Dwivedi	03-05th April 2023	NABI, Mohali	"Genome editing mediated by CRISPR/ Cas9: Tools, experimental design and its applications	Physical
4.	Dr. Amit Kr. Patil	22-26th May 2023	RLBCAU, Jhansi	"Emerging Technologies: Robotic process automation"	Physical
5.	Dr. Shashikumara P.	July 26-28, 2023	National association of Plant Breeders.	"Pearl-millet Breeding"	Online

6.	Dr. Mahendra Prasad	Jul. 31 to Aug. 21, 2023	ICRISAT HQ Campus, Hyderabad,	"Conservation Agriculture: Gateway for Productive and Resilient Cropping Systems in Asia"	Physical
7.	Dr. Pooja Tamboli	Sep. 8 to 23, 2023	ICAR-IASRI, New Delhi.	"Application of statistical softwares for analysis of agriculture and survey data"	Online
8.	Dr. Surinder Paul	Oct. 09 to 18, 2023	IASRI, New Delhi	"Omics Data Analysis: genome to Proteome"	Online
9.	Dr. Pooja Tamboli	Oct. 09 to 13, 2023	ICAR-NAARM, Hyderabad.	"Design thinking in agricultural education and research "	Online
10.	Dr. Tejveer Singh	Oct. 16 to 20, 2023	ICAR-NAARM, Hyderabad.	"Next generation sequencing and data analysis "	Online
11.	Dr Deepak Upadhyay	Nov. 02 to 22, 2023	NADCL Baramula.	"Recent advances in veterinary science and animal husbandry"	Online
12.	Dr. S.K. Meena	Nov. 07 to 09, 2023	CAFRI and MANAGE.	"Future prospects of crops bio-fortification In India"	Online
13.	Dr. Surinder Paul	Dec 11-13, 2023.	IASRI, New Delhi	"Metagenomics Data Analysis"	Online
Technical Category					
1.	Dr Harish Chandra Pandey	Jan. 20 to Feb. 03, 2023	ICAR-IARI, New Delhi	"Good Agricultural Practices (GAPs) for enhancing resource-use efficiency and farm productivity"	Physical
2.	Dr. Anjaly MV	Apr. 03 to 17, 2023	WVS, Ooty, Tamil Nadu	"Surgery and anesthesia"	Physical
3.	Sri Pradeep Kumar Tyagi	Oct. 04 to 06, 2023.	ISTM, New Delhi	Three days Offline Workshop on "MS-Word (MS-W-10)" for Officers & Staff working in Central Government, State Govemment, PSUs Constitutional Bodies and Autonomous Bodies.	Physical

Administrative Category					
1.	Ms Sanjana Yadav	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
2.	Mr Yash Kapoor	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
3.	Mr Jitendra Kushwaha	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
4.	Mr Renu Pundir	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
5.	Mr Brij Bihari	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
6.	Ms Priyanka Prajapati	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online
7.	Mr Bharat Singh	Jul. 20 to Oct. 06, 2023	ICAR-NIASM, Baramati, Pune	Pre-examination training for Limited Departmental Audit & Accounts Examination (LDA&A Exam.)	Online

6.2 Capacity building for forage resource development

Six sponsored trainings were organized in various areas related to engineering interventions, grazing and pasture management, climate resilient forage and livestock production which generated the revenue of Rs. 16 lakh and five institutional capacity building programmes were organized. The details are as in Table 6.2 & 6.3

Table 6.2 Sponsored capacity building programmes

S.No.	Training program	Sponsor	No. of participants	Duration
1	Training on improved fodder and livestock technologies for women farmers of Hamirpur district	BAIF-SLD-Banda	25	10-1-2023 to 12-01-2023
2	Training on improved fodder and livestock technologies for women farmers of Banda district	BAIF-SLD-Banda	25	18-1-2023 to 20-01-2023
3	Training on improved fodder and livestock technologies for women farmers of Bada district	BAIF-SLD-Banda	25	23-1-2023 to 25-01-2023
4	"Fodder production, conservation and utilization' for veterinarians and agricultural officers of Tamil Nadu (First batch)	DAHVS, Tamil Nadu	20	11-15 Sep, 2023
5	"Fodder production, conservation and utilization' for veterinarians and agricultural officers of Tamil Nadu (Second batch)	DAHVS, Tamil Nadu	19	18-22 Sep, 2023
6	"Fodder production, conservation and utilization' for veterinarians and agricultural officers of Tamil Nadu (Third batch)	DAHVS, Tamil Nadu	21	09-13 Oct, 2023
7	21 Days Faculty Development Programme On "Role of Science and Technology in Sustainable Agriculture, Horticulture, Animal Husbandry and Allied Sectors: Retrospective and Prospective"	NADCL Baramulla, J & K	144	03-23, Nov, 2022

Table 6.3 Institutional Capacity Building programmes

S.No.	Training program	No. of participants	Duration
1	'Farmers training on improved forage and livestock techniques' under SCSP, ICAR-IGFRI, Jhansi	10	10-1-2023 to 12-01-2023
2	'Farmers training on improved forage and livestock techniques' under Farmers First Project, ICAR-IGFRI, Jhansi	10	18-1-2023 to 20-01-2023
3	'Farmers training on improved forage and livestock techniques' under outreach IFS project of ICAR-IGFRI, Jhansi	10	23-1-2023 to 25-01-2023
4	Biosafety training for handling of hazardous chemicals and biological agents	50	06-02-203 to 09-02-2023
5	Intellectual property: farmers rights and protection	75	13-03-2023

6.3 Training cum exposure visits at IGFRI, Jhansi

Indian grassland and Fodder Research Institute, Jhansi has kept its door always open for all those who have been keen interest on fodder production and the related technologies. During the period, farmers, entrepreneurs, personnel from state and central governments and NGOs visited IGFRI and interacted with the experts in related subject through different sponsored visits. Visits by farmers, students and teachers to IGFRI and its research farm were always attended by our staff and experts. The details of the visitors are as in table 6.4.

Table 6.4 Training cum exposure visits

S.No.	Date	Department	No. of visitors	Category
1.	04.01.23	PD, ATMA, Panna (MP)	11	Farmers
2.	13.01.23	Staff from Military Hospital, Jhansi	5	Govt. Employees
3.	17.01.23	PD, ATMA, Panna (MP)	13	Farmers
4.	31.01.23	Govt. School, Badhpura, Jhansi	37	teachers+ students
5.	01.02.23	Govt. School, Badhpura, Jhansi	21	teachers+ students
6.	07.02.23	PD, ATMA, Shivpuri (MP)	29	Farmers
7.	07.02.23	Trainees from, CAFRI, Jhansi	30	Farmers
8.	08.02.23	Trainees from, CAFRI, Jhansi	30	Farmers
9.	09.02.23	Govt. School, Pura Birdha, Lalitpur	239	teachers+ students
10.	13.02.23	Govt. School, Pura Birdha, Lalitpur	91	teachers+ students
11.	13.02.23	PD, ATMA, Datia (MP)	13	Farmers
12.	27.02.23	Horti. Deptt., MP, Datia	38	Farmers
13.	01.03.23	Vikramaditya Univ., Sagar (MP)	38	teachers+ students
14.	03.03.23	RVC, Meerut (UP)	8	Govt. Employees
15.	15.03.23	Agri. Deptt., UP, Jalaun	26	Farmers
16.	22.03.23	Agri. Engg. Deptt., MP, Gwalior	20	Farmers
17.	2.03.23	Agri. Engg. Deptt., MP, Tikamgarh	7	Farmers
18.	23.03.23	Farmers under SC-SP, Sitapur	51	Farmers
19.	24.03.23	ITM Univ., Gwalior (MP)	26	students
20.	27.03.23	PD, ATMA, Niwari (MP)	8	Govt. Employees
21.	28.03.23	Govt. School, Mamhori, Mauranipur	59	teachers+ students
22.	29.03.23	GIC, Jhansi	56	teachers+ students
23.	30.03.23	Govt. Agri. College, Tikamgarh, MP	24	teachers+ students
24.	03.04.23	Suraj PrasadGirls Govt. Inter College, Jhansi	156	teachers+ students
25.	10.04.23	ICRISAT, Hyderabad	15	staff+Farmers
26.	17.04.23	Govt. High School, Dhamna Khurd, Jhansi	76	teachers+ students
27.	12.05.23	SRGI, Jhansi	32	teachers+ students
28.	15.05.23	SRGI, Jhansi	32	teachers+ students
29.	30.05.23	BU, Jhansi	5	students
30.	11.07.23	Agri. Deptt., UP, Balia	13	staff+Farmers
31.	17.07.23	DDM, NABARD, Jhansi	5	staff+Farmers
32.	11.08.23	UFTA, Haldwani, UK	37	Govt. Employees
33.	11.08.23	ICRISAT, Hyderabad	10	Farmers
34.	13.08.23	UFTA, Haldwani, UK	42	Govt. Employees

35.	15.08.23	UFTA, Haldwani, UK	27	Govt. Employees
36.	22.08.23	DD, ATMA, Nivari (MP)	30	Farmers
37.	23.08.23	DD, ATMA, Gwalior (MP)	32	Farmers
38.	27.08.23	Sh. Lallan Singh, Gaushala, Gorakhpur	4	Gaushala
39.	05.09.23	PD, ATMA, Morena, MP	9	Farmers
40.	12.09.23	PD, ATMA, Damoh, MP	27	Farmers
41.	19.09.23	Women Farmers from SC-SP villages, Jhansi	21	Farmers
42.	19.09.23	Farmers from FFP villages, Jhansi	4	Farmers
43.	22.09.23	Parmarth, NGO, Jalaun, UP	37	Farmers
44.	26.09.23	PD, ATMA, Vidisha, MP	40	Farmers
45.	26.09.23	Pragya Gramotthan Seva Samiti, Fatehpur	48	Farmers
46.	26.09.23	PD, ATMA, Raisen, MP	17	Farmers
47.	26.09.23	PD, ATMA, Morena, MP	9	Farmers
48.	03-10-2023	kVK Agra UP	02	Farmers
49.	04-10-2023	Army Public school Jhansi	156	Children and staff
50.	04-10-2023	FFP Farmers visit jhansi	05	Farmers
51.	05-10-2023	Army Public school Jhansi	169	Children and staff
52.	06-10-2023	Gaushala Chhatarpur	2	Farmers
53.	06-10-2023	Datia M.P.	2	Farmers
54.	09-10-2023	Hansari Jhansi	2	Farmers
55.	10-10-2023	Raksha Jhansi	2	Farmers
56.	11-10-2023	Khusinagar	2	Farmers
57.	12-10-2023	Lalitpur	2	Farmers
58.	13-10-2023	Bhojla , kanchanpur Jhansi	5	Farmers
59.	16-10-2023	Godham Gaushala Dabra M.P.	2	Farmers
60.	19-10-2023	BAUT Banda	7	Student
61.	19-10-2023	FFP Farmers visit jhansi	3	Farmers
62.	19-10-2023	Kotkhera , Jhansi	2	Farmers
63.	20-10-2023	FFP Farmers visit jhansi	7	Farmers
64.	25-10-2023	FFP Farmers visit jhansi	7	Farmers
65.	26-10-2023	FFP Farmers visit jhansi	12	Farmers
66.	30-10-2023	FFP Farmers visit jhansi	15	Farmers
67.	30-10-2023	DFO MP	2	Staff
68.	31-10-2023	Jhansi	2	Farmers
69.	02-11-2023	Khodan Jhansi	2	Farmers
70.	06-11-2023	FFP Farmers visit jhansi	15	Farmers
71.	07-11-2023	FFP Farmers visit jhansi	22	Farmers
72.	08-11-2023	FFP Farmers visit jhansi	31	Farmers
73.	09-11-2023	FFP Farmers visit jhansi	48	Farmers
74.	10-11-2023	Kochha bhabar	02	Farmers
75.	14-11-2023	FFP Farmers visit jhansi	05	Farmers
76.	15-11-2023	Hamirpur U.P.	2	Farmers

77.	21-11-2023	Kheri Datia	02	Farmers
78.	22-11-2023	Jabalpur M.P.	02	Farmers
79.	23-11-2023	FFP Farmers visit jhansi	02	Farmers
80.	24-11-2023	Gwalior M.P.	02	Farmers
81.	29-11-2023	SHG Mahoba U.P.	02	Staff
82.	29-11-2023	Kheridong Talbehat U.P.	02	Farmers
83.	04-12-2023	FFP Farmers visit jhansi	02	Farmers
84.	05-12-2023	NGO Parmarth Jhansi	03	Staff
85.	05-12-2023	IVDS Nepal	03	Student
86.	06-12-2023	Manjari Foundation	03	Staff
87.	07-12-2023	Lukhnow	02	Farmers
88.	11-12-2023	Sanora M.P.	02	Farmers
89.	12-12-2023	Sarmau U.P.	02	Farmers
90.	19-12-2023	Mahatma Gandhi Seva Sansthan Gwalior	02	Staff
91.	20-12-2023	Badagaon Jhansi	02	Farmers
92.	21-12-2023	Kendriya Vidyalaya Datia	82	Staff and students
93.	21-12-2023	Jhansi	140	Students
94.	27-12-2023	SCSP Farmers visit Jhansi	02	Farmers
95.	28-12-2023	RLPS School Jhansi	170	Staff and students
96.	05-01-2024	Farmers visit Jhansi	02	Farmers
97.	08-01-2024	Kargua ji Jhansi	02	Farmers
98.	15-01-2024	KVK Faridabad Haryana	30	Staff and Farmers
99.	25-01-2024	Agra U.P.	18	Forest officers
100.	31-01-2024	Swami Vivekanand University, Sagar	23	Staff and students
101.	05-02-2024	Guna & Shivpuri M.P.	20	Farmers
102.	07-02-2024	ATMA Damoh M.P.	20	Staff and Farmers
103.	07-02-2024	Morena M.P.	27	Farmers
104.	08-02-2024	KVK Bhind M.P.	18	Staff and Farmers
105.	08-02-2024	KVK Vidisha M.P.	12	Staff and Farmers
106.	08-02-2024	Shri Narmada Nandini Gaushala Seva Sansthan, Kareli Narsinghpur M.P.	02	Farmers
107.	13-02-2024	Kendriya Vidyalaya Babina	99	Staff and students
108.	13-02-2024	Chirgaon Jhansi	02	Farmers
109.	15-02-2024	ATMA Shivpuri M.P.	32	Staff and Farmers
110.	16-02-2024	Govt. Girls Inter college, Barua sagar Jhansi	15	Staff and students
111.	16-02-2024	Baba Haridas Gausala, Garautha Jhansi	02	Farmers
112.	17-02-2024	Deepak Memorial Inter College, Mauranipur, Jhansi	171	Staff and students
113.	19-02-2024	ATMA Rewa M.P.	60	Farmers
114.	20-02-2024	BU Jhansi	04	Students

6.4 Students dissertations/internship/RAWE

Human Resources Development team facilitated 14 MSc student for dissertation, 3 MSc (Biotech) students for one month training, one BSc student for RAWE. In addition team facilitated 8 MSc student, 3 Ph D students for one for dissertation.

6.5 Memorandum of Understanding (MoUs)

- MoU between ABI Unit ICAR-IGFRI, Jhansi & Mr. Mahesh Gupta of Beejor, Niwari, M.P. for entrepreneurship development
- MoU between ABI Unit ICAR-IGFRI, Jhansi & incubatee Mr. Deepak Purohit of M/s Talbehat Adrek evam Haldi Producer Company Limited for entrepreneurship development
- MoU between ICAR-IGFRI, Jhansi & ICARDA for conducting research activities in cactus
- MoU between ICAR-IGFRI, Jhansi & APAHD, Govt. of Andhra Pradesh for training/technology dissemination/research
- MoU between ICAR-IGFRI, Jhansi & Galgotias University, Greater Noida for Academic Collaboration
- MoU between ICAR-IGFRI, Jhansi & M/s Harda Narmadeshwar Bamboo Initiative, Bhopal for sustainability and better management of energy and resources.
- MoU between ICAR-IGFRI, Jhansi & CSIR-IHBT, Palampur (H.P.) for research/ training/ consultamcy services.

6.6 Academic collaboration

Team HRD is facilitating the academic collaboration with institutions like RLBCAU, BU Jhansi, SRGI etc. A total of 38 scientists of ICAR-IGFRI, Jhansi are engaged in teaching courses at RLBCAU, Jhansi.

Chapter 7

List of Publications

7.1 Research Papers

Ahmed, S., Patel, R., Rana, M., Kumar, N., Indu, I., Choudhary, M., Chand, S., Singh, A.K., Ghosh, A. and Singhal, R.K., 2023. Corrigendum to: Effect of salt, alkali and combined stresses on root system architecture and ion profiling in a diverse panel of oat (*Avena* spp.). *Functional Plant Biology*, pp. 51(3), FP 23031.

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7.6 Review Paper

Singhal, R.K., Fahad, S., Kumar, P., Choyal, P., Javed, T., Jinger, D., Singh, P., Saha, D., Md, P.,

Chapter 8

Approved Ongoing Projects

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

(CRSCIGFRISIL**2012**0101): Genetic improvement of barley for forage and grain yield.

(PI: A.K. Singh, Co-PI: H.S. Mahesha)

Duration: 2016-2023

(CRSCIGFRISIL**2016**0103): Genetic improvement of sorghum for high biomass, forage quality and resistance to foliar diseases.

(PI: Indu, Co-PIs: Shahid Ahmed, Sultan Singh, Maneet Rana, R.K. Singhal, H.S. Mahesha and N. Dikshit)

Duration: 2016-2023

(CRSCIGFRISIL**2018**0901): Combined stress tolerance of water logging and salinity in fodder grasses.

(PI: Edna Antony, Co-PIs: Vinod Kumar, Kuligod and Doddamani, UAS Dharwad and Md. Akbar, UAS Agricultural Research Station, Heballi, Dharwad).

Duration: 2018-2023

(CRSCIGFRISIL**2018**0101): Development of genetic and genomic resources for low moisture stress tolerance in berseem.

(PI: Tejveer Singh, Co-PIs: Reetu, S.R. Kantwa, H.S. Mahesha and R.P. Saini)

Duration: 2018-2024

(CRSCIGFRISIL**2019**0902): Studies on invasive pest *Spodoptera frugiperda* in fodder maize.

(PI: N.S. Kulkarni, Co-PIs: B.G. Shivakumar)

Duration: 2019-2024

(CRSCIGFRISIL**2020**0102): Augmentation, characterisation, conservation and documentation of forage genetic resources.

(PI: N. Dikshit; Co-PIs: R.K. Singhal, H.S. Mahesha, E. Antony, S.S. Bhat, P. Shashikumara, B.K. Mehta)

Duration: 2020-2025

(CRSCIGFRISIL**2020**0105): Genetic improvement of maize for high biomass and fodder quality.

(PI: B.K. Mehta, Co-PIs: P. ShashiKumara, H.S. Mahesha, Anup Kumar, K.K. Dwivedi and Firoz Hossain, IARI, New Delhi)

Duration: 2020-2025

(CRSCIGFRISIL**2020**0101): 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, H.S. Mahesha and Anup Kumar)

Duration: 2020-2025

CRSCIGFRISIL**2020**0103): Identification of oat (*Avena sativa*) lines for heat stress tolerance.

(PI: Reetu; Co-PIs: Parichita Priyadarshini, P. Shashikumara and M. Tomar)

Duration: 2020-2025.

(CRSCIGFRISIL**2020**0101): 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, Tejveer Singh and Amaresh Chandra)

Duration: 2021-2025

(CRSCIGFRISIL**2020**0903): Breeding Lucerne (Medicago sativa L.) for high foarge yield and nutritional quality for different ecosystems (phase II).

(PI: K. Sridhar, Co-PIs: E. Antony, N.S .Kulkarni, R.P. Nagar, Sultan Singh, S.S. Meena, Suheel Ahmad, Shahid Ahmad, Reetu, H.S. Mahesha and Ramyashree)

Duration: 2020-2025

(CRSCIGFRISIL**2021**0102): Genomics assisted breeding for zinc and iron bio-fortification in oat.

(PI: Maneet Rana,Co-PIs: K.K. Dwivedi, Shahid Ahmed, R.K. Singhal, Surendra Paul and [Satpal, Agronomist and Vinod Kumar, Biochemist, HAU, Hisar])

Duration: 2021-2024

(CRSCIGFRISIL**2021**0103): Developing erect type and multicut fodder cowpea with enhanced nutritional quality.

(PI: B.K. Mehta; Co-PIs: N. Dikshit, Reetu and K. Sridhar)

Duration: 2021-2026

(CRSCIGFRISIL**2021**0104): Breeding oat for improved productivity and quality.

(*PI: Shahid Ahmad, Co-PIs: Maneet Rana, Indu, R.K. Singhal, Sultan Singh, N.R. Bhardwaj and Subhash Chand*)

Duration: 2021-2026

(CRSCIGFRISIL**2022**0101): Genetic improvement of novel fertile Bajra-Napier hybrid for enhanced productivity and quality traits.

(*PI: Maneet Rana, Co-PIs: Shashikumara P., Shahid Ahmad, Rajesh Kumar Singhal and Anup Kumar*)

Duration: 2022-2027

(CRSCIGFRISIL**2022**0101): Genetic improvement of novel fertile Bajra-Napier hybrid for enhanced productivity and quality traits.

(*PI: Maneet Rana, Co-PIs: Shashikumara P., Shahid Ahmad, Rajesh Kumar Singhal and Anup Kumar*)

Duration: 2022-2027

(CRSCIGFRISIL**2022**0102): Identification and characterization of cowpea genotypes for phosphorus use efficiency.

(*PI: S.K. Meena, Co-PIs: B.K. Mehta, Maneet Rana and Mahendra Prasad*)

Duration: 2022-2025

(CRSCIGFRISIL**2023**0101): Identification and characterization of multi-cut sorghum lines for low HCN and moisture stress tolerance.

(PI: Rajesh Kumar Singhal, Co-PIs: Indu, Shahid Ahmed and Maneet Rana)

Duration: 2023-2026

(CRSCIGFRISIL**2023**0102): Genome-wide identification, characterization and expression analysis of flowering locus T (*FT*) genes controlling floral induction in cowpea.

(PI: Parchita Priyadarshini, Co-PIs: K.K. Dwivedi, B.K. Mehta and S.K. Meena)

Duration: 2023-2026

Program 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**2018**0304): Evaluation of ecosystem productivity in grown up Hortipastoral System for fruit and forage security with management practices.

(PI: Sunil Kumar, Co-PIs: A. Ghosh, A. Kumar Singh, Kamini, S.S. Manjanagouda)

Duration: 2018-2023

(CRSCIGFRISIL**2018**0303): Canopy management in *Hardwickia binata* based silvipasture system for optimizing forage production.

(PI: S.N. Ram, Co-PIs: Kamini, Manjanagouda S.S.)

Duration: 2018-2023

(CRSCIGFRISIL**2019**0802): Canopy management for enhanced productivity and sustainability of neem based silvi-pastoral system in semi arid tropics.

(PI: H.S. Meena, Co-PIs: Kamini, A. Ghosh and R.P. Nagar)

Duration: 2019-2024

(CRSCIGFRISIL**2020**0302): Recuperated canopy architecture for higher bael (*Aegle marmelos; Rutaceae*) productivity and forage security in semi-arid region.

(PI: R.K. Patel, Co-PIs: Sunil Kumar, S.S. Manjanagouda, A. Ghosh, Amit Kumar Singh and Deepak Upadhyay)

Duration: 2020-2025

(CRSCIGFRISIL**2020**0303): 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: R.K. Patel, A.K. Handa (CAFRI), S.S. Bhat (Srinagar), Maneet Rana, Anup Kumar, R.P. Nagar (Avikanagar)

Duration: 2020-2025

(CRSCIGFRISIL**2020**1001) Studies on temperate pastureland for enhanced forage yield, quality and environmental sustainability.

(PI: Suheel Ahmad, Co-PIs: S.S. Bhatz, J.P. Singh, A. Ghosh and N. Biradar)

Duration: 2020-2025

(CRSCIGFRISIL**2020**0301): Study of restoration ecology in silvipasture system for semiarid region.

(PI: R.V. Kumar, Co-PIs: A.K. Roy, Sunil Kumar, Amit K. Singh, Kamini, and *A. Ghosh)*

Duration: 2020-2025

(CRSCIGFRISIL**2021**0301): Development of grassland assessment system using geospatial technology.

(PI: Amit Kumar Singh, Co-PIs: J.P. Singh, A. Ghosh).

Duration: 2021-2024

(CRSCIGFRISIL**2022**0201): Studies on natural farming practices in forage crops.

(PI: S.R. Kantwa, Co-PIs: D.R. Palsaniya, A.K. Dixit, Srinivasan R. and Mahendra Prasad)

Duration: 2022-2027

(CRSCIGFRISIL**2022**0202): Assessment of water requirement for fodder based cropping system in different parts of Uttar Pradesh.

(PI: J.B. Singh, Co-PIs: Amit Kumar Singh, S.R. Kantwa and Ramesh Singh)

Duration: 2022-2025

(CRSCIGFRISIL**2023**0301): Solubilization of native soil phosphorus using natural silicon sources and P solubilizing microbes

(PI: Avijit Ghosh; Co-PIs: Amit K. Singh, Srinivasan R. and Mukesh Chaudhary)

Duration: 2023-2026

(CRSCIGFRISIL**2023**0302): Improved pasture management for sustaining soil-pasture-animal productivity

(PI: Avijit Ghosh; Co-PIs: Amit K. Singh, R. Srinivasan, Sultan Singh, S.N. Ram, Sunil Kumar and R.V. Kumar)

Duration: 2023-2028

(CRSCIGFRISIL**2023**0303): Sustaining productivity in grown up hortipastoral system for fruit and forage security with soil & tree management practices.

(PI: Sunil Kumar; Co-PIs: Amit Kumar Singh, Avijit Ghosh, S.R. Kantwa, Srinivasan R. and R.K. Patel)

Duration: 2023-2027

(CRSCIGFRISIL**2023**0302): Improved pasture management for sustaining soil-pasture-animal productivity.

(PI: Avijit Ghosh, Co-PIs: Amit K. Singh, Srinivasan R., Sultan Singh, S.N. Ram and R.V. Kumar)

Duration: 2023-2026

(CRSCIGFRISIL**2023**0304): Pruning management for optimizing forage and wood productivity from *Hardwickia binata* based silvopasture systems.

(PI: S.N. Ram, Co-PIs: Kamini, Avijit Ghosh and A.K. Shukla)

Duration: 2023-2026

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

(CRSCIGFRISIL**2017**0201): Food fodder based crop intensification and diversification with efficient soil water conservation approaches under rainfed condition**.**

(PI: S.R. Kantwa, Co-PIs: Sunil Kumar, Mukesh Choudhary, Mahendra Prasad and S.K. Rai)

Duration: 2018-2023

(CRSCIGFRISIL**2018**0202): Long term nutrient management strategies for sustainable forage production in guinea grass + (cowpea–berseem) cropping system.

(PI: A.K. Dixit, Co-PIs: D.R. Palsaniya and Mahendra Prasad)

Duration: 2018-2023

(CRSCIGFRISIL**2018**0201**):** Effect of long term use of sewage water irrigation on heavy metal accumulation in soil-plant-animal continuum.

(PI: Mahendra Prasad, Co-PIs: M. Vassanda Coumar (IISS, Bhopal), M.M. Das and J.K. Saha (IISS Bhopal),

Duration: 2018-2023

CRSCIGFRISIL**2019**0202): Precision nitrogen management in forage crops.

(PI: Mukesh Choudhary, Co-PI: A.K. Dixit)

Duration: 2019-2024

(CRSCIGFRISIL**2019**0201): 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)

Duration: 2019-2024

(CRSCIGFRISIL**2020**0201): 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)

Duration: 2020-2025

(CRSCIGFRISIL**2020**0902): Studies on fodder production potential of fodder shrub based Alley cropping systems in Peninsular India.

(PI: B.G. Shivkumar, Co-PI: N.S. Kulkarni)

Duration: 2020-2023

(CRSCIGFRISIL**2021**0202): Development of microbial inoculants for enhancing ensiling.

(PI: Srinivasan R. Co-PIs: Sultan Singh, K.K. Singh and Anup Kumar)

Duration: 2021-2024

(CRSCIGFRISIL**2021**0201): 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, Anup Kumar and T.K. Sahu)

Duration: 2021-2026

(CRSCIGFRISIL**2021**0203): Nutrient and water management in BN hybrid through drip irrigation in semi arid region of India.

(PI: A.K. Dixit, Co-PIs: Mukesh Choudhary and C.S. Sahay,

Duration: 2021-2024

(CRSCIGFRISIL**2022**0301): 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)

Duration: 2022-2026

(CRSCIGFRISIL**2022**1001): Intensive fodder production through crop diversification and zinc fortification in Kashmir Himalaya.

(PI: N.H. Mir, Co-PIs: Suheel Ahmad and S.S. Bhat)

Duration: 2022-2025

(CRSCIGFRISIL**2022**1101): Agronomical trait(s) improvement in forages using plant associated microbes from the North-Western Himalaya.

(PI: Surinder Paul, Co-PIs: S. Radotra and One scientist from CSIR-IHBT, Palampur)

Duration: 2022-2025

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

(CRSCIGFRISIL**2018**0401**)**: Stale seedbed technique for weed control in berseem seed production.

(PI: Vinod Kumar Wasnik, Co-PIs: H.M. Halli, R. Srinivasan and Anup Kumar)

Duration: - 2018-2021.

(CRSCIGFRISIL**2018**0402**)**: Development of seed standards in temperate grasses and legumes.

(PI: V.K. Yadav Co-PIs: Sanjay Kumar, Suheel Ahmad, Sunil Swami and H.M. Halli)

Duration: 2018-2023

(CRSCIGFRISIL**2019**0402**)**: 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)

Duration: 2019-2023

(CRSCIGFRISIL**2019**0801): Effect of different packaging materials on storability of seed of range grasses.

(*PI*: *R.P. Nagar Co-PIs: Vinod Kumar and R.P. Saini*)

Duration: 2019-2022

(CRSCIGFRISIL**2019**0901): Investigations on seed yield and quality enhancement techniques in *Brachiaria ruziziensis.*

(PI: Vinod Kumar, Co-PI: Mahesha H.S.)

Duration: 2019-2022

(CRSCIGFRISIL**2020**0104): 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)

Duration: 2020-2024

(CRSCIGFRISIL**2021**0401): 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)

Duration: 2021-2026

(CRSCIGFRISIL**2021**0901): Development of seed standards in forage grasses and legumes.

(PI: Vinod Kumar, Co-PIs: V.K. Yadav and R.P. Nagar)

Duration: - 2021-2024

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

(CRSCIGFRISIL**2013**0701): Long term effect of different grazing intensities on soil health and pasture-animal productivity.

(PI: S.N. Ram, Co-PIs: Sultan Singh, Srinivasan R., J.B. Singh, A. Ghosh and S.K. Mahanta)

Duration: 2018-2023 (Second Phase).

(CRSCIGFRISIL**2018**0701): Nutritional evaluation, improvement and utilization of newer feed resources for livestock production.

(PI: K.K. Singh, Co-PIs: Sultan Singh, V.K. Yadav, P. Govind Raj, R. Karuppiyan from SBI Coimbatore)

Duration: 2018-2023

(CRSCIGFRICIL**2018**0601): Development and evaluation of defluffing machine and pelleting machine for forage grass seeds.

(PI: S.K. Singh, Co-PIs: P.K. Pathak, C.S. Sahay, Amit Kumar Patil and Sunil Swami)

Duration: 2018-2023

(CRSCIGFRISIL**2018**0704): Feeding and management strategies to improve goat productivity under semi arid conditions.

(PI: Deepak Upadhyay, Co-PIs: K.K. Singh, Anup Kumar and Pooja Tamboli)

Duration: 2018-2023

(CRSCIGFRISIL**2018**0705): Screening and evaluation of tropical grasses diversity for yield, nutritive value and ensiling potential.

(PI: Sultan Singh, Co-PIs: K.K. Singh, Tejveer Singh and R. Srinivasan)

Duration: 2018-2023

(CRSCIGFRISIL**2019**0605): Development of automatic seed coating machine.

(PI: Amit Kumar Patil, Co-PIs: C.S. Sahay and S.K. Singh, Sunil Swami)

Duration: 2019-23

(CRSCIGFRISIL**2019**0602): Development of forage based feed for commercial goat farming.

(PI: P.N. Dwivedi, Co-PIs; P.K. Pathak, Amit Patil, S.K. Singh)

Duration: 2019-2023

(CRSCIGFRISIL**2019**0604): Design and development of Solar powered self-propelled multipurpose machine for agricultural operations.

(Pl: Amit Kumar Patil and Co-PI: C.S. Sahay)

Duration - 2019-2024

(CRSCIGFRISIL**2021**1001): Ensiling of temperate grasses/legumes for increased livestock productivity.

(*PI: S. Ahmad Co-PIs: S.S. Bhat, Sultan Singh, K.K. Singh and R. Srinivasan*)

Duration: 2021-2024

(CRSCIGFRISIL**2022**0701): Ensiled TMR (Total Mix Ration) for livestock production.

(PI: M.M. Das, Co-PIs: Sultan Singh, Anup Kumar, K.K. Singh and Pooja Tamboli)

Duration: - 2022-2025

(CRSCIGFRISIL**2022**0702): Phytochemical nano-formulations to control aflatoxins in animal feeds.

(PI: Anup Kumar, Co-PIs: Deepak Upadhaya, Dr. N. Bhardwaj, Srinivasan R. and Shubham Yadav, Institute of pesticide formulation, Gurugram)

Duration: 2022-2027

(CRSCIGFRISIL**2022**0703): Foraging behavior 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)

Duration: 2022-2026

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

(CRSCIGFRISIL**2019**0501): 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, Deepak Upadhyay, R.K. Patel, B.B. Choudhary, Manju Suman and S.K. Singh)

Duration: 2019-2024

(CRSCIGFRISIL**2020**0901): Participatory fodder production in fruits and plantation crops.

(PI: N. Biradar, Co-PIs: B.B. Choudhary, S.K. Shukla, CISH, Lucknow)

Duration: 2020-2023

(CRSCIGFRISIL**2021**0503): 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, R.K. Sharma and Avinash Chandra*)

Duration: 2021-23

(CRSCIGFRISIL**2021**0501): Impact analysis of grassland and fodder technologies.

(PI: B.B. Choudhary Co-PIs: P. Sharma, Avijit Ghosh, Gaurendra Gupta, H. Halli, Priyanka Singh (ICAR-CAFRI, Jhansi)

Duration: 2021-2026

(CRSCIGFRISIL**2021**0502): Impact of fodder and livestock technologies on livelihood of farmers of SCA schemes of IGFRI.

(Coordinator: P. Sharma)

Duration: 2021-24

Sub project I: Impact of fodder and livestock technologies on livelihood of farmers of SCSP

(*PI*: *B.B. Choudhary*, *Co-PIs: Gaurendra Gupta, B.G. Shivkumar, Suheel Ahmad, S.S. Bhat, R.S. Radotra, R.K. Sharma, Avinash Chandra and Shailendra Sinha*)

Sub project II: Impact of fodder and livestock technologies on livelihood of farmers of NEH plan

(PI: R. K. Patel, Co-PI: Maneet Rana)

Sub project III: Impact of fodder and livestock technologies on livelihood of farmers of TSP

(PI: Manju Suman, Co-PIs: S.N. Ram, Kamini, Suheel Ahmad, S.S. Bhat, N. Biradar and H.S. Meena)

Externally Funded Projects

S.No.	Project Title	Period	Budget	Funding Agency	PI/Co-PIs
1.	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	2023-24 to 2025-26 (3 years)	Rs. 27192153 (only Field Assistant is being provided)	DST (NMSHE)	(NDRI Karnal lead centre), Shiraz Bhatt, Suheel Ahmad
2.	AMAAS project: Development of microbial consortia for enhancing drought tolerance and efficient nutrient management in forage crops	2017- 23	12.25 lacs (2023-24)	ICAR-NBAIM, Mau	R. Srinivasan
3.	Developing hybrid nanofertilizers by using zeolite and hydroxyapatite for sustainable fodder production	2023-26	51.51 lacs	SERB, DST	Mahendra Prasad
4.	Optimizing Growth and Yield of Cactus Pear as a 4F Crop (Food, Fodder, Fertilizer, and Fuel): Exploring the Effects of Plant Density and Fertilizer Application	2023-26	US$ 8500 (2023-24)	ICARDA	D.R. Palsaniya, Mukesh Choudhary and M.M. Das
5.	AICRP on Dryland Agriculture (Voluntary Centre)	2018 - continue nature	1.30 Lacs (2023-24)	ICAR-CRIDA, Hyderabad	S.R. Kantwa Mukesh Choudhary R.K. Agarwal

S.No.	Project Title	Period	Budget	Funding Agency	PI/Co-PIs
6.	Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity and livelihood security in Bundelkhand region	2016-cointinue nature		Farmer FIRST programme	Purushottam Sharma Sunil kumar S.K. Singh Mukesh Choudhry B.Bhaskar Choudhry
7.	Building resilience model for the vulnerable hotspots to climate change in smallholder dairy production system of lndo-Gangetic Plain Region of lndia Using GIS and Fuzzy cognitive mapping approach.	2024-2027 (Ongoing) (3 years)	134.79 Lakhs (24.67 lakh for IGFRI)	ICAR-NASF	B.B. Choudhary, P. Sharma, Samir Barman, Sadhna Pandey
8.	Network project on ecosystems, agribusiness and institutions Component 1: Impact of Agricultural Technology (Crop Science Technologies) Subtitle : "Impact analysis of grassland and fodder technologies “	2021-26 (Ongoing) (5 years)	3 Lakhs (2022-23) 6 Lakhs (2023-24)	ICAR-NIAP New Delhi	B.B. Choudhary, P. Sharma, Gaurendra Gupta, Avijit Ghosh, Sunil Swami.
9.	AICRP (FIM)	2023-24	9,25,000	AICRP (FIM), ICAR-CIAE, Bhopal	P.K. Pathak, Amith Kumar Patil, S.K. Singh
10.	Enhancing climate resilience and ensuring food security with genome editing tools	2023-26	144.0 Lakh	ICAR	Parichita Priyadarshini, K.K. Dwivedi, Maneet Rana Ravi Prakash Saini
11.	Identification and characterization of candidate genes related to polyploidy and /or apomixes in guinea grass	March-2024 to Feb.2027	35.00 lakh	DST-SERB	K.K. Dwivedi, Maneet Rana
12.	Mapping and validation of genomic regions associated with brown midrib mutant in pearl millet	27 June 2023 to 26 June 2026	36.83 Lakh	SERB	Shashikumara P, B.K. Mehta Anup Kumar
13.	Bioprospecting of abiotic stress tolerance genes in grasses	5th Dec 2020 to 4th April 2024	34.24 Lakh	DST-SERB	Shashikumara P.

S.No.	Project Title	Period	Budget	Funding Agency	PI/Co-PIs
14.	Characterization and multiplication of forage crops	2022-2026	4.0 Lakh	ICAR-NBPGR	Shahid Ahmed, Tejveer Singh, B.K. Mehta, Maneet Rana, Indu, Shashikumara P, Rajesh Kumar Singhal, Suheel Ahmed, S.S. Bhat,, Sudesh Radotra, H.S. Mahesha
15.	synthetic seed production in sterile Bajra-Napier hybrid via encapsulation of somatic embryos	2021-2024	29.65 Lakh	DST-SERB	Dr. Maneet Rana
16.	NTPC: Fly ash use in agriculture for Sustainable Crop Production and Environmental Protection	2021-2031	177 Lakh	NTPC	R.V. Kumar, Sunil Kumar, Amit K. Singh, Avijit Ghosh, Kamini
17.	RKVY-ICAR: Agri-Drone project	2022-Cont..	36 Lakh	RKVY	Amit Kumar Singh, Avijit Ghosh, Gaurendra Gupta
18.	NASF: Natural Grassland Ecosystem monitoring system for peninsular and trans Himalayan India to Sustain Pastoral communities. (CCRI Goa,IASRI New Delhi,, G B Pant institute, Leh are collaborative partners)	2024-2027	106 Lakh	NASF	Avijit Ghosh, Amit Kumar Singh, J.P. Singh, A.K. Shukla, Nagratna Biradar,
19.	1. Performance Recording and Improvement of Bhadawari Buffaloes.	2021-Cont.			B.P. Kushwaha
20.	2. AICRP on Goat Improvement Bundelkhandi Goat Unit.	2018-Cont.			Deepak Upadhyay, B.P. Kushwaha, Pooja Tamboli
21.	Development of effective mass propagation techniques for rapid multiplication and easy transportation of quality planting material in Bajra napier Hybrid.	2023-2026	Total: 179.39 lakhs Rs. 51.83 lakhs at Dharwad	NLM	V.K. Yadav, Vinod Kumar, Edna Antony H.M. Halli, NIASM, Baramati
22.	NLM: Grassland Restoration and rejuvenation for enhancing grazing resources using Remote sensing and Drone technologies.	2023-2026	117 Lakh	NLM	Amit Kumar Singh, Sunil Swami, Avijit Ghosh, Deepak Upadhyay, Amith Kumar Patil. R.V. Kumar

1. Development of climate resilient and sustainable (NMSHE) agri-based systems for better food, nutritional and livelihood security options to farming community of cold arid regions of Ladakh

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S.No.	Project Title	Period	Budget	Funding Agency	PI/Co-PIs
23.	Genetic improvement of forage crops for sustainable livestock production. Sub-projects	April 2023 to March 2026	376.84 Lakh	NLM	Sultan Singh, P. Shashikumara, Maneet Rana, B.K. Mehta, Shahid Ahmed, R K Singhal
	Genetic improvement of pearl millet for high biomass, multicut and forage nutritional quality				P. Shahsikumara, B.K. Mehta, Anup Kumar, Shahid Ahmed
	Utilizing genetic and genomic approaches for development of seed producing Bajra x Napier Hybrid for enhanced productivity and ensiling traits				Maneet rana, P. Shashikumar, R.K. Singhal, Deepak Upadhyay, Shahid Ahmed
	Development of dual-purpose maize hybrids with enhanced fodder yield and feed quality using marker-assisted selection				B.K. Mehta, P. shashikumara, Anup Kumar, Shahid Ahmed
	Genetic dissection of genomic regions associated with plant growth habit, multicut nature and forage nutritional quality in cowpea.				B.K. Mehta, P. Shashikumar, Anup Kumar
	Genetic enhancement of oat for multi-purpose potential under marginal and challenged environments.				Shahid Ahmed, Maneet Rana, R.K. Singhal, Anup Kumar
	Designing water use efficient stay green with multiple foliar disease resistance fodder sorghum ideo types for changing climates.	2023-24 to 2025-26 (only Field	Rs. 27192153 DST (NMSHE)	(NDRI Karnal centre), Shiraz	R.K. Singhal, Shahid Ahmed
	Deciphering nitrogen use efficiency in sorghum deploying molecular and physiological interventions	(3 years) Assistant is being provided)		Suheel Ahmad	Prabha Singh, R.P. Saini, V.K. Wasnik, V.K. Yadav
24.	Use and conservation of agrobiodiversity for food and nutrition security, increased agricultural sustainability, and resilience to climate change in India"	2021-2024	77.61 lakhs	ICAR-IGFRI-CIAT-Bioversity	V.K. Yadav, Sultan Singh, Amit Kumar Singh, Nagaratna Biradar, Tejveer Singh, P. Sharma (Division involved: CI Division, PAR Division, RRS Dharwad & SS Division)

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S.No.	Project Title	Period	Budget	Funding Agency	PI/Co-PIs
25.	Harnessing genetic diversity in pearl millet and sorghum for identification of trait specific gentoypes and trait mapping for fodder yield and quality component traits	2023-24 to 2025-26	50.00 lakhs	ICAR-IIMR Hyderabad	R.V. Kumar, P. Shashikumara, Subhash Chand, R.K. Singhal, Gaurendra Gupta, K.K. Singh
26.	Improving the adaptability and productivity of millets in Uttar Pradesh	2024-2028	70.00 Lakhs	ICAR-IIMR Hyderabad	Shahid Ahmed, Shashikumara P. Rajesh Kumar Singhal

Chapter 9

Events and Meetings

National Group Meet Kharif of Forage Crops and Utilization

National Group Meet Kharif 2023 of AICRP on Forage Crops and Utilization was organized during 15 -16th June,2023 at CSKHPKV, Palampur (HP).The event was chaired by Dr. H.K. Chaudhary,Hon'ble Vice Chancellor, CSKHPKV–Palampur (H.P.). Dr. T.R. Sharma, DDG (CS), ICAR was the Chief Guest and Dr. S.K. Pradhan, ADG (FFC), Dr. D.K. Yadava, ADG (Seeds), ICAR New Delhi and Dr. Amaresh Chandra, Director, ICAR-IGFRI were Guest of Honour. Dr. V.K. Yadav, Project Coordinator-Forage Crops presented the highlights of research activities carried out in previous year. Detailed discussion and center wise activities were reviewed, FTD and TSP achievements were also discussed. Pre-breeding and bio-fortification aspects in future guidelines and directions were suggested. During the meeting 11 varieties in 3 fodder crops (maize: AFH-7, DFH-2, PFM-13 and HQPM-28; Pearl millet: 16ADV0111 , FBL-4, PHBF-5, TSFB-1610 and JPM-18-37 and BN Hybrid: TSBN-15-15 and BNH-2.) were identified for cultivation in different zones of the country. In crop production, seven technologies *viz.,*nutrient management for forage sorghum hybrid for Himachal Pradesh, fodder maize in Karnataka, forage sorghum hybrid in Jammu & Kashmir and Uttar Pradesh were identified. Similarly, suitable varieties for multicut bajra for Chhattisgarh, Bihar, Punjab with three cutting management schedule coupled with defined nitrogen management were recommended. Management practices for the leaf blast in fodder pearl millet in North-West zone, in North-East and Hill zone were recommended. For the controlling of fall armyworm (*Spodoptera frugiperda* L.), foliar application of Emamectin benzoate 5 WG @ 0.5g/L was recommended to minimize yield loss in North-West, North-East and South zones.

Fig. National Group Meet *Kharif* 2023 of AICRP on Forage Crops and Utilization at Palampur (H.P.)

Celebration/participation

- Institute celebrated the 74th Republic Day (26th January, 2023) by hoisting the National Flag and addressing the staff by the Director Dr Amaresh Chandra .

Fig– National Flag hoisting on 26th January, 2023

- On March 18th 2023 Institute celebrate International Millet Year 2023, institute demonstrated various millet crops in TD block and organized "Millet Food Festival" in campus and its regional stations. Staff of the institute also virtually participated in "Global Millet Conference" which was inaugurated by Hon'ble PM Shri Narendra Modi Ji,. Institute also organized guest lectures on importance of millets, also distributed millets based snacks and provided logistic support to the millet promotion programes of the state and central government.

Fig.---- Celebration of International Millet Year 2023 by Institute

Fig. Celebration of International Millet Year 2023 by RRS Avikanagar

Celebration of International year of millets-2023 with school children at Malpura and tribal farmers at Dausa (Rajasthan)

- Institute celebrated International Women's Day in the gracious presence of Smt. Kalpana Mohapatra W/O Dr. T. Mohapatra, Ex-Secretary DARE and DG, ICAR, New Delhi.

Fig. International Women's Day

- On 26th April,2023 institute celebrated World Intellectual Property Right day and an online lecture was delivered by Dr.....

Fig.--- World Intellectual Property Right day

- Organized World Environment Day 5th June,2023 and made plantation in the institute and its regional stations

Fig.--- World Environment Day 2023

- On 2tst June,2023 Institute celebrate "International Yoga Day-2023" (June 21, 2023)

Fig .----- International Yoga Day 2023

Meetings

- Institute QRT meeting was held on 3rd -4th January 2024 under the Chairmanship of Prof. Panjab Singh, Former Secretary, DARE, GOI and DG, ICAR, New Delhi, in the institute.

- Institute Research Advisory Committee (RAC) meeting and Launching Ceremony of National Livestock Mission were held on 17th March, 2023 under the Chairmanship of Dr. S.L. Gaur, Former Chairperson, PVFRA, New Delhi

Fig.--- Research Advisory Committee meeting and Launching of National Livestock Mission,

- 48th Institute Management Committee (IMC) meeting was held under the Chairmanship of Director Dr Amaresh Chandra on 28 February, 2023.

Fig.--- Visit of Dr.T. Mohapatra, Ex. Secretary, DARE and DG, ICAR

- Institute PMC Visit was conducted under the Chairmanship of Director Dr Amaresh Chandra, and experts Dr S.K. Chaturvedi, Dean, College of Agriculture, RLBCAU Jhansi and Dr. A.K. Roy, Principal Scientist, (PC-FC unit), on 4th April, 2023.

Fig.---- Institute PMC Visit

- Under the Chairmanship of Dr. Amaresh Chandra, Director, ICAR-IGFRI meetings of Institute's Rajbhasha Implementation Committee was conducted on. 13th February and 12th May, 2023.

Fig.-- Rajbhasha Committee meeting

Mela/Conference/Workshop/Webinar

- Institute Regional research Station, Srinagar organized one day (January 18, 2023) Workshop on "Development of Fodder Resources for Jammu & Kashmir" at District Sheep Husbandry Office, Bandipore and it was attended by 25 officials & innovative farmers.

➢ Institute organised 2 Hindi Karyshala on March 15, 2023 and June 13, 2023.

Fig. Hindi Karyshala

➢ Institute Regional Research Station, Srinagar in collaboration with Satya zero grazing organized 4 webinars in June 2023 on Good feed and fodder management practices for goat and sheep farming (Dr. Manpreet Kour, SKUAST-J, 4th June), Feed Management of Sheep and Goats (Dr Nazam Khan, SKUAST-J, 11th June), Modern Goat Farming (Dr. Vandhana Bhagat, FVSc Durg, Chattisgarh, 18th June) and Process of making cheese and Chenna from Goat milk (Dr. Heena Sharma, NDRI Karnal, 24th June, 2023).

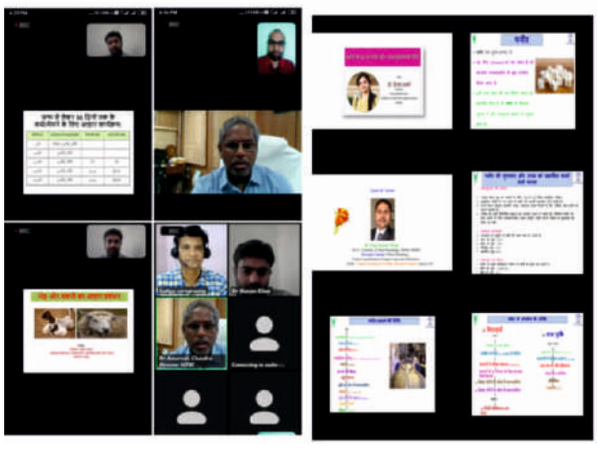

Fig. Online webinars

MoUs signed

1. MoU between ABI Unit of institute & Mr. Mahesh Gupta of Beejor, Niwari (M.P.) for entrepreneurship development.
2. MoU between ABI Unit & incubate Mr. Deepak Purohit of M/S Talbehat Ginger and Turmeric Producer Company Limited for entrepreneurship development
3. MoU between Institute & ICARDA for conducting research activities in cactus as alternate source of fodder.
4. MoU between Institute & APAHD, Govt. of Andhra Pradesh for training/technology dissemination/research.

Fig—Signature on MoU

Distiguished visitors:

➢ On March 06, 2023, Dr.Trilochan Mohapatra, Ex Secretary, DARE and DG, ICAR visited institute and interacted with staff.

➢ MOA&FW, GOI Hon'ble Shri Narendra Singh Tomer along with Secretary DARE & DG, ICAR, Dr. Himanshu Pathak, Chancellor RLBCAU, Prof. Panjab Singh and Vice-Chancellor Dr. A.K. Singh visited our Institute and inaugurated newly constructed Seed Processing & Storage Unit and distributed

agriculture inputs to beneficiaries in Labharthi Kisan Sammelan under SCSP at Central Research Farm on 11th March 2023.

Fig. Inauguration of Seed Processing & Storage Unit and distribution of agriculture inputs

- Minister of Agriculture, UP Govt., Hon'ble Shri Surya Pratap Shahi with Chief Secretary, UP Govt. Sh. Durga Shankar Mishra visited the institute on 2nd April, 2023.

Fig.---- Visit of Minister of Agriculture, UP Govt.

- Dr.T.R. Sharma, DDG (CS), ICAR New Delhi visited, Southern Regional Research Station Dharwad
- Prof. PV Vara Prasad, Director, Center for Sorghum Improvement, Department of Agronomy at Kansas State University visited ICAR-IGFRI Jhansi on June 20, 2023 and delivered his talk.

Fig.Interaction with Director, Center for Sorghum Improvement Kansas State University,

- Shri Nitin Kumar S. Khade (IAS), Joint Secreatary, Deptt. of Land Resources, Govt of India visited Central Research Farm and interacted with staff of the institute on 18th May, 2023.

Fig.----Visit & interaction of Shri Nitin Kumar S. Khade (IAS), Joint Secreatary,

संस्थान में हिन्दी पखवाड़ा का आयोजन

संस्थान में हिन्दी पखवाड़ा (14–29 सितम्बर, 2023) का आयोजन किया गया। संस्थान में दिनांक 18.09.2023 को प्रारूप एवं टिप्पणी लेखन, 19.09.2023 को निबन्ध, 20.09.2023 राष्ट्र के विकास में नागरिकों का योगदान पर डा. उमाशंकर पचौरी, सदस्य उच्च शिक्षा क्रियान्वयन समिति, मध्य प्रदेश का व्याख्यान एवं 27.09.2023 को भाषण प्रतियोगिता आयोजित की गई। दिनांक 21–26 सितम्बर 2023 को विभागों, अनुभागों, इकाईयों का हिन्दी कार्यों का मूल्यांकन किया गया। हिन्दी पखवाड़े का समापन माननीय शिक्षक विधायक, प्रयागराज–झाँसी खण्ड डॉ. बाबूलाल तिवारी के मुख्य आतिथ्य एवं कार्यवाहक निदेशक डॉ. विजय कुमार यादव की अध्यक्षता में किया गया। मुख्य अतिथि ने विजयी प्रतिभागियों को एवं वर्ष पर्यन्त हिन्दी में उत्कृष्ट कार्य

करने वाले कार्मिकों को भी पुरस्कृत किया गया। प्रक्षेत्र अनुभाग को वर्ष पर्यन्त हिन्दी में अधिक कार्य करने के लिये चल बैजयन्ती से पुरस्कृत किया गया।

मुख्य अतिथि का स्वागत करते हुए संस्थान निदेषक

चल बैजन्ती पुरस्कार प्रदान करते हुए मुख्य अतिथि

Institute Foundation Day

Insights into an International Conference on Feeding the Future through Sustainable Eco-Friendly Innovations in Rangelands, Forages and Animal Sciences

An International Conference was organized jointly by Range Management Society of India, ICAR-Indian Grassland and Fodder Research Institute, Jhansi and University of Agricultural Sciences, Bangalore (UASB) in association with national and international organizations from 2-4 December 2023 at UASB. About 300 participants representing 45 organizations from India and abroad attended the conference. It was inaugurated by Prof. C. Kole, Former VC, BCKV, Kolkatta, in the presence of Guests of honour Dr. S.K. Pradhan ADG (FFC), ICAR, New Delhi and Shri P. Dinesh, CGM NABARD Mumbai, Dr. M.B. Chetti, VC Sanskriti University Mathura, Conference Chairman Dr. Amaresh Chandra, Director, ICAR-IGFRI and President RMSI, Jhansi, Dr. S.V. Suresha, VC UAS, Bangalore and Dr. K.C. Veeranna, VC, KVAFSU, Bidar. Renowned scientist from various reputed organizations like ICRAF, ATREE, ICRISAT, ICARDA, Saskatoon Research and Development Center, Canada shared their work with the participants as lead lectures in different technical sessions.

10 industries from different types participated in scientist-industry session wherein industry representatives shared their company profile as well as their expectations from the scientific community. In Young Innovator session selected young scholars presented their work before the high level committee. Special session on harnessing the untapped potential of millets for food security, nutrition and sustainable agriculture was hosted by Genome India International.

Dr Dheer Singh, Director, ICAR-NDRI Karnal was the chief guest of the valedictory program of the International Conference.

Fig.-- International Conference on Feeding at University of Agricultural Sciences, Bangalore

ICAR Zonal Sports Meet (Western Zone) 16-19 December, 2023

ICAR Sports Meet (West Zone) 2023 was organized by the institute, during 15 – 18 December , 2023. In this sports more than 650 sports persons and officials from 20 ICAR institutes of West Zone were participated in the tournament. Shri Ravi Sharma, Member of Uttar Pradesh Legislative Assembly was the Chief Guest in inaugural function. Dr. Amaresh Chandra, Director, IGFRI, while welcoming the players highlighted the importance of the event towards fraternity development.

The Four-day event witnessed various athletics events, team events viz. volley ball (shooting and smashing), Kabaddi, Basketball, Football, Table

Tennis, Badminton, Carom, Chess and T-10 Cricket. Dr. Indu Scietist of IGFRI, Jhansi was adjudged as Best Woman and Mr. Bhuvnesh Verma of CAZRI, Jodhpur was declared Best Men Athlete. On the basis of the overall best performance in different events were as the overall Championship was awarded to NDRI, Karnal. Dr A K Singh, hon'ble Vice-Chancellor Rani Lakshmi Bai Central Agricultural University, Jhansi was the Chief Guest of the Closing Ceremony. Dr. Shahid Ahmed was Organizing Secretary of the Zonal Sports Meet

Regional Research Station Dharwad (Karnataka) activities

Participation in *Krishi Mela* at UAS, Dharwad from 9-12 September, 2023 and exhibited the technologies.

Swachatha Saptah was conducted during first week of October, 2023 and various cleaning activities were organized during the period.

क्षेत्रीय अनुसंधान केन्द्र धारवाड़ में हिन्दी पखवाड़ा का आयोजन

Vigilance Day was celebrated on 7th November, 2023 and during the program Dr.Narendra Kulkarni, Principal Scientist delivered a talk on "Say No to Corruption and Commit to the Nation"

Workshops on Pastoralism in Jammu and Kashmir

A two-days workshop on 'Pastoralism in Jammu and Kashmir: Issues, Challenges, and the Way Forward' was organized jointly by the Ministry of Tribal Affairs and the Tribal Research Institute, Jammu and Kashmir, ICAR-Indian Grassland and Fodder Research Institute, Regional Research Station, Srinagar, and Regional IYRP Support Group of South Asia (RISG-SA) during 31st July-1st August 2023 at Sher-e-Kashmir International Convention Centre, Srinagar. The workshop was attended by more than 200 participants, including officials from different line departments of Jammu and Kashmir viz,. forest department, animal husbandry department, sheep husbandry department, and agriculture department and others participants like

Fig. Workshop on 'Pastoralism in J&K: Issues, Challenges, and the Way Forward'

faculty members and students of different research institutions especially SKUAST-Kashmir, University of Kashmir, ICAR-Central Institute of Temperate Horticulture, Srinagar, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi, pastoralists across the Union Territory of Jammu and Kashmir, different NGOs and volunteers, besides participants from organizer institutions.

World Intellectual Property Day" celebrated

World Intellectual Property Day was organized on the theme "Women and IP: Accelerating Innovation and the Creativity" on 26th April 2023 in the Institute. On this occasion Prof. Charu Virmani, Head of the Department, CSE, School of Engineering Technology, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana delivered an online lecture on "Women and IP: Accelerating Innovation and Creativity" and interacted with scientists, technical and administrative staff of the institute.

Technology and Machinery Demonstration Meet cum Farmers' Fair Organized at IGFRI Jhansi on 1st March, 2023

ICAR-Indian Grassland and Fodder Research Institute, Jhansi, (Uttar Pradesh) organized a one-day Technology and Machinery Demonstration Meet cum Farmer's fair on 1st March, 2023. This fair was inaugurated by the Chairman Dr. A. Chandra, Director, with Chief Guest Dr. Pulak Mohan Pandey (Director, BIET, Jhansi), Special Guest Dr. A. Arunachalam (Director, ICAR-CAFRI, Jhansi). In this event, more than 20 Institutions, agri-startups, private companies, FPO's and line departments erected their stalls and displayed their technologies, services and products. This meet was attended by the more than 300 farmers, students and entrepreneurs. During the inaugural and interaction session, Dr. Pulak Mohan Pandey interacted the farmers and highlighted the importance of scientific technologies and machinery for energy and cost saving in agricultural operations. Dr. A. Arunachalam advocated the promotion and adoption of improved practices including natural agriculture for sustainable growth of agriculture and livestock. Dr. A. Chandra discussed about improved forage technologies and machineries developed by the institute and suggested to adopt for income enhancement. Dr. Rajiv Kumar Agrawal (PCFC), briefed about the activities and varieties developed by the All India Coordinated Research Project on Forage Crops and Utilization (AICRP FCU). Dr P.K. Pathak (PI, FIM Project), explained regarding farm machinery and post harvest technologies of the Institute. Dr P.N. Dwivedi (Head, FMPHT Division) interacted with the farmers and discussed about the issues of farm mechanization and animal nutrition. Followed by Inaugural session, the farmers-scientist-entrepreneur interaction cum discussion session was organized where different issues and queries of the stakeholders was dealt by the experts. The program was anchored and managed by Er. Amit Kumar Patil.

Fig ---- Technology and Machinery Demonstraition Mela

Activities of Rigional Research Station, Avikanagar (Rajashthan)

Exhibition of IGFRI fodder production technologies at RRS Avikanagar

On the occasion of Foundation day of CSWRI, Avikanagar on 4th January, 2023 an exhibition of technologies were arranged , our RRS Avikanagar also participated and exhibited stall visited by Dr. Balraj Singh, VC, Sri Karan Narendra Agriculture University, Jobner Rajasthan.

Fig. visit of RRS Avikanagat stall of fodder technologies.

Fig.----Visit of Hon'ble Vice- President of India at CSWRI, Avikanagar on 14-09-2023.

Fig. ----- Visit of exhibition stall of RRS Avikanagar by Dr. Himanshu Pathak, Secretary DARE and DG, ICAR on the occasion of 27th ICAR Regional Committee Meeting- VI on 03.11.2023 at CSWRI, Avikanagar

Chapter 10

Awards and Recognitions

1. Dr. Avijit Ghosh received Japan International Award-2023 for Young Agricultural Researchers, Japan International Research Center for Agricultural Sciences (JIRCAS).
2. Dr. Avijit Ghosh received "Young Scientist Award-2023" by the Indian Science Congress Association, (Agriculture and Forestry Section).
3. Dr. Bishwa Bhaskar Choudhary conferred with "Young Agricultural Economist Award" by Agricultural Economics Research Association, New Delhi.
4. Dr. Bishwa Bhaskar Choudhary received Director's Nominee Award for Best Worker (Scientific Category) on 62nd foundation Day of ICAR-IGFRI, Jhansi
5. Dr. Nagaratna Biradar received "Indian Society of Extension Education Fellow Award" during ISEE National Seminar 2023, UAS, Bangalore.

International Conferences Award

1. Dr. Avijit Ghosh & Dr. Amit K. Singh received Young Innovator Award at International Conference on "Feeding the Future through Sustainable Eco-friendly Innovations in Rangeland, Forages and Animal Sciences" from December 2-4, 2023 at University of Agricultural Sciences, GKVK, Bangalore, India.
2. Dr. Amit K. Singh received RMSI Young Scientist Award 2022 at International Conference on "Feeding the Future through Sustainable Eco-friendly Innovations in Rangeland, Forages and Animal Sciences" from December 2-4, 2023 at University of Agricultural Sciences, GKVK, Bangalore, India.
3. Dr. S.S. Bhat was conferred with Excellence in Extension Award during an International Conference on Current Advances in Agriculture, Animal Husbandry and Allied Sciences, July 10-11, 2023 at Shri Mata Vaishno Devi University, Katra, Jammu.
4. Dr. Suheel Ahmad was conferred with Distinguished Scientist Award and Best oral Presentation Award during the International Conference on Current Advances in Agriculture, Animal Husbandry and Allied Sciences, July 10-11, 2023 at Shri Mata Vaishno Devi University, Katra, Jammu
5. Dr. Suheel Ahmad was conferred with Eminent Scientist Award during the 3 days International Conference on Impact of Climate Changes on Global Food, Livestock, Livelihood and Environmental Security: Advanced Approaches and Mitigation Strategies (December 28-30, 2023) at Navsari Agricultural University, Gujarat

Scholarship and Grants

1. Dr. Avijit Ghosh received Elsevier scholarship-2024 from the International Soil and Tillage Research Organization.
2. Dr. Kamini received Full Sponsorship (Travel, Registration & Stay) Awarded from IUFRO to attend XXVI IUFRO World Congress, to be held in Stockholm, Sweden from June 23-29, 2024.

Ph.D. Work Award

1. Dr. Avijit Ghosh received Indian Society of Soil Science Best Doctoral Research Presentation Award 2023.
2. Dr Avijit Ghosh received KN Syngal Memorial Award 2024 from ICAR-IARI, New Delhi for outstanding performance in Ph.D. research.

International conference on "Feeding the Future through Sustainable Eco-friendly Innovations in Rangeland, Forages and Animal Sciences" held for the duration of December 2-4, 2023, at University of Agricultural Sciences, Bangalore, organized by RMSI and ICAR-IGFRI, Jhansi 284003 (Uttar Pradesh), India.

1. Dr. Suheel Ahmed received Best oral presentation award
2. Dr. R.V. Kumar, Dr. Kamini, Dr. Sunil Kumar, Dr. Amit Kumar Singh, Dr. Avijit Ghosh and

Dr. A.K. Roy received Best Oral Presentation Award

3. Dr. R.P. Nagar, Dr. Vinod Kumar and Dr. R.P. Saini received Best Oral Presentation Award
4. Dr. Pooja Tamboli received Best Poster Presentation Award
5. K. Anusree, M. Amulya, B. Aravind, Dr. Edna Antony, Dr. K. Sridhar, P.V. Rakshata, M.B. Doddamani and V.B. Kuligod received Best Poster Presentation Award
6. Dr. H.S. Meena, Dr. R.P. Nagar, Dr. S.S. Meena, Dr. Avijit Ghosh and Dr. Kamini received Best Poster Presentation Award
7. Dr. S.S. Bhat received Best Oral Presentation Award during the International Conference on Current Advances in Agriculture, Animal Husbandry and Allied Sciences" CAAAAS-2023" during July 10-11, 2023 at Shri Mata Vaishno Devi University, Katra (India).

Science Academy, New Delhi

2. **Rana, M. 2023.** Molecular mapping of QTLs for agro-morphological and biomass related traits in immortalised F_2 population of Bajra Napier Hybrid using SSR markers - **Best Oral Presentation Award** by Range Management Society of India, International Conference, December 2-4, 2023, UAS, Bangalore.

National conference of Indian Society for Buffalo Development (ISBD) and Symposium on Modern approaches for sustainable buffalo production in the scenario of climate change, DUVASU, Mathura, October 27-28 2023

1. Dr. B.P. Kushwaha received Best oral Presentation Award
2. Dr. Pooja Tamboli received Best Oral Presentation Award

National Conference of Plant Physiology during December 9-11, 2023 at IARI, New Delhi.

1. S.H. Pooja, M.B. Doddamani, Dr. K. Sridhar and Dr. Edna Antony received Best Poster Presentation Award.

Certificate of Appreciation

1. Dr. B.B. Choudhary received Award of Appreciation from Department of Agri. Economics, GBPUAT, Pantnagar for contribution in the field of agro economics.

Chapter 11

Administration and Accounts

Financial Statement (2021-2022)

12.1 Expenditure of ICAR-IGFRI, Jhansi

(Rupees in lakhs)

S.No.	Head	RE / Released 2021-22	Other than TSP, NEH, SCSP	Progressive expenditure			Total
				NEH	TSP	SCSP	(4+5+6+7)
1	2	3	4	5	6	7	8
1	G-I-A Capital	105.90	88.68	12.20	-	4.63	105.51
2	G-I-A Salary	3217.09	3209.61	-	-	-	3209.61
3	G-I-A General	-	-	-	-	-	-
	i) Pension	676.64	676.64	-	-	-	676.64
	ii) Other	923.00	823.05	7.99	39.76	48.56	919.36
4	Total	4922.63	4797.98	20.19	39.76	53.19	4911.12
5	Loan & Advances	0.00	0.00	0.00	0.00	0.00	99.77%

12.2 Expenditure of AICRP (FCU) IGFRI, Jhansi

(Rupees in lakhs)

S.No.	Head	RE / Released 2021-22	Other than TSP, NEH, SCSP	Progressive expenditure			Total
				NEH	TSP	SCSP	(4+5+6+7)
1	2	3	4	5	6	7	8
1	G-I-A Capital	12.20	6.10	6.10	-	-	12.20
2	G-I-A Salary	938.70	836.70	102.00	-	-	938.70
3	G-I-A General	-	-	-	-	-	-
	i) Pension	-	-	-	-	-	-
	ii) Other	260.00	189.98	17.00	40.00	13.00	259.98
4	Total	1210.90	1032.78	125.10	40.00	13.00	1210.88
5	Loan & Advances	0.00	0.00	0.00	0.00	0.00	100%

12.3 Staff Strength as on 31.12.2021

Cadre	Sanctioned	In position	Vacant
Research Management	01	01	-
Scientist	121	81	41
Technical	110	53	57
Administrative	77	40	37
Skilled Supporting Staff	55	51	04
Total	**364**	**225**	**139**

Departmental Promotion in respect of Scientific, Technical, Administrative and Skilled Supporting Staff during 01.01.2021 to 31.12.2021

12.4 Probation period confirmation

Sl.	Name of officer	Probation period confirmation date	Date of office order
	Scientist		
1	Sh. Sonu Kumar Mahawar (Agricultural Chemicals)	05.07.2019	31.03.2021
2.	Sh. Bholuram Gurjar (Farm Machinery & Power)	04.01.2020	09.07.2021
3.	Ms. Bhargavi H.A. (Genetics & Plant Breeding)	02.07.2020	09.07.2021
4.	Sh. Keerthi M.C. (Agricultural Entomology)	02.07.2020	09.07.2021
5.	Dr. Ravi Prakash Saini (Agricultural Biotechnology)	02.07.2020	09.07.2021
6.	Dr. Subhash Chand (Genetics & Plant Breeding)	02.07.2020	09.07.2021
7.	Sh. Avijit Ghosh (Soil Science)	02.07.2020	09.07.2021
	Administrative staff		
1.	Sh. Monu Ahirwar, LDC	01.06.2021	23.11.2021
2.	Ms. Renu Shah, LDC	16.05.2021	23.11.2021
3.	Sh. Prashant Saxena, LDC	15.07.2021	23.11.2021
4.	Sh. Bharat Singh, LDC	09.07.2021	23.11.2021
5.	Ms. Priyanka Prajapati, LDC	10.07.2021	23.11.2021
6.	Sh. Jitendra Kushwaha, LDC	09.07.2021	23.11.2021
7.	Sh. Yash Kapoor, LDC	17.07.2021	23.11.2021
8.	Sh. Vijay Kumar, LDC	15.07.2021	23.11.2021
9.	Ms. Sanjana Yadav, LDC	09.08.2021	23.11.2021
10.	Sh. Brij Bihari, LDC	20.08.2021	23.11.2021

12.5 Promotion to next level

Sl.No.	Name of officer	Nature of promotion and date w.e.f.	Date of office order
	Scientist		
1.	Dr. Mahendra Prasad, Scientist (Soil Science)	Research Level-11 (7th CPC) in pay matrix (PB-15600-39100 + RGP 7000/- pre revised) w.e.f. 01.01.2019	01.01.2021
2.	Dr. Vikas Kumar, Scientist (Agricultural Economics)	Research Level-12 (7th CPC) in pay matrix (PB-15600-39100 + RGP 8000/- pre revised) w.e.f. 23.06.2018	01.01.2021
3.	Dr. Kumar Durgesh, Scientist (Genetics & Plant Breeding)	Research Level-11(7th CPC) in pay matrix (PB-15600-39100 + RGP 7000/- pre revised) w.e.f. 01.09.2014	29.01.2021
	Technical		
1.	Dr. Ratnkar Singh Patel	T-4 to T-5 w.e.f. 28.01.2020	16.07.2021
2.	Dr. V.K. Gupta	T-4 to T-5 w.e.f. 31.07.2020	09.08.2021

3.	Sh. S.V. Shinde	T-4 to T-5 w.e.f. 29.06.2020	31.08.2021
4.	Sh. Pawan Kumar	T-4 to T-5 w.e.f. 11.05.2021	27.10.2021
5.	Sh. Virendra Pal Singh	SSS to T-1 w.e.f. 28.07.2021	28.07.2021
	Administrative		
1.	Shri. Kripa Ram	PA to PS w.e.f. 22.09.2021	22.09.2021
2.	Sh. Jagdish Prasad	PA to PS w.e.f. 22.09.2021	22.09.2021
3.	Smt. Kumud Khera	PA to PS w.e.f. 22.09.2021	22.09.2021
	Grant for MACP		
1.	Sh. Pavan Kumar Pandey, AF&AO	III MACP w.e.f. 16.10.2020	31.07.2021
2.	Sh. Faiyaz Ahmed Khan, Assistant	III MACP w.e.f. 22.10.2020	31.07.2021
3.	Smt. Shobhita Nair, Assistant	III MACP w.e.f. 18.03.2021	31.07.2021
4.	Sh. Amit Kumar Singh, Assistant	III MACP w.e.f. 18.03.2021	31.07.2021
5.	Sh. Vijya Kumar Tiwari, AAO	III MACP w.e.f. 04.02.2021	31.07.2021
6.	Sh. Kripa Ram, PA	III MACP w.e.f. 11.02.2021	31.07.2021
7.	Sh. Jagdish Prasad, PA	III MACP w.e.f. 15.02.2021	31.07.2021
8.	Sh. Badri Lal Jat, SSS	III MACP w.e.f. 03.04.2021	31.08.2021
9.	Sh. Sriprakash, SSS	III MACP w.e.f. 20.03.2021	31.08.2021
	As per DOPT Scheme of regularization of Casual Labour against the vacant post of Skilled Supporting Staff regularized		**27**

Chapter 12

Distinguished Visitors

Dr. Himanshu Pathak
Secretary DARE & Director General
ICAR, New Delhi

Dr. P.K. Chakraborty
Former Member
ASRB, New Delhi

Prof. Panjab Singh
Chancellor (RLBCAU), Former Secretary DARE & Director General, ICAR, New Delhi

Dr. P.L. Gautam
Former DDG & Chairman, RAC
ICAR, New Delgi

Mr. Nitin Khade, IAS
Joint Secretary
Min. of Rural Development, New Delhi

Dr. S.K. Pradhan
ADG (FFC)
ICAR, New Delhi

Prof. N. Sangwan
Professor
Central University of Haryana

Dr. Padamnabha Reddy
Vice Chancellor
SV Vety University, Trupati

Dr. B. Hemla Naik
Director
KSNVAH, Shivamogga

Dr. B. Mann
ADG
ICAR, New Delhi

Dr. U.S. Singh
Advisor, Asia & Africa Research & Development
New Delhi

Dr. R. Vishwanathan
Director
ICAR-IISR, Lucknow

Dr. Satbir Singh
Director (Administration), NRAA
Min. of Agril. & Farmers' Welfare, New Delhi

Dr. Sushil Solomon
Former Vice Chancellor
CSAUAT, Kanpur

Dr. T. Mohapatra
Former Secretary DARE & Director General
ICAR, New Delhi

Dr. Vijendra Singh
Vice Chancellor
CSAU, Kanpur

Dr. M.B. Chetti
Vice Chancellor
Sanskriti University, Mathura

Mr. Aruna
OSD, Min. of Agriculture & Farmers' Welfare
New Delhi

Dr. Major Singh
Member, ASRB
New Delhi

Dr. P.R. Jha
Project Manager
NABARD, Lucknow

Dr. Praveen Malik
CEO
Agrinnovate India Limited, New Delhi

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

Dr. J.S. Sandhu
Former VC, SKMAV & Former DDG (CS)
New Delhi

Mr. Surender Singh
Director
UP Seed Certification Institute, Lucknow

Dr. Shantanu Kumar Dubey
Director
ICAR-ATARI, Kanpur

Dr. Masood Ali
Former Director
ICAR-IIPR, Kanpur

Prof. A.C. Varshney
Former Vice Chancellor, DUVASU
Chandigarh

Chapter 13

List of Personnel

DIRECTOR

Dr. Amaresh Chandra	Director	w.e.f. 28.04.2021

SCIENTIFIC

Division of Crop Improvement

Dr. Shahid Ahmad	Principal Scientist (Plant Breeding) & Head	
Dr. Nilamani Dixit	Principal Scientist (Economic Botany and PGR)	
Dr. K.K. Dwivedi	Principal Scientist (Biotechnology)	
Dr. Tejveer Singh	Senior Scientist (Genetics)	
Dr. Maneet Rana	Scientist (Agricultural Biotechnology	
Dr. Reetu	Scientist (Plant Biochemistry)	Upto 22.03.2023
Ms. Bhargavi, H.A.	Scientist (Genetics & Plant Breeding)	Upto 15.12.2023
Ms. Indu	Scientist (Genetics & Plant Breeding)	Upto 28.12.2023
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 (Ag. Biotechnology)	On study leave
Sh. Tanmaya Kumar Sahu,	Scientist (Bioinformatics)	w.e.f.11.04.2023

Division of Crop Production

Dr. Sunil Kumar	Principal Scientist (Agronomy) & I/c Head	Upto 31.01.2023
Dr. D.R. Palsaniya	Principal Scientist (Agronomy) & Head	w.e.f.21.06.2023
Dr. J.B. Singh	Principal Scientist (Ag. Meteorology)	
Dr. S.K. Rai	Principal Scientist (Ag. Meteorology)	
Dr. A.K. Dixit	Principal Scientist (Agronomy)	Upto 13.12.2023
Dr. Sita Ram Kantwa	Principal Scientist (Agronomy)	
Dr. Srinivasan R.	Principal Scientist (Microbiology)	
Dr. Mukesh Choudhary	Senior Scientist (Agronomy)	
Dr. Mahendra Prasad	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	Head of Division GSM	w.e.f. 19.7.23
Dr. J.P. Singh	Principal Scientist (Geography)	
Dr. Shiv Nath Ram	Principal Scientist (Agronomy)	
Dr. Sunil Kumar	Principal Scientist (Horticulture)	
Dr. R.K. Patel	Principal Scientist (Horticulture)	Upto 05.12.2023
Dr. Amit Kumar Singh	Scientist (Ag. Meteorology)	
Sh. Vikas Chandra Tyagi	Scientist (Economic Botany & PGR)	on Study leave.
Dr. Kamini	Scientist (Agroforestry)	
Dr. Avijit Ghosh	Scientist (Soil Science)	
Dr. Manjanagouda S. Sannagoudar	Scientist (Agronomy)	Upto 31.03.2023

Division of Plant Animal Relationship

Dr. P. Sharma	Head, P.A.R. Division	w.e.f. 10.07.2023
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. Deepak Upadhyay	Scientist (LPM)	
Sh. Pushpendra Koli	Scientist (Agricultural Chemicals)	on study leave
Dr. Anup Kumar	Scientist (Agricultural Chemicals)	
Dr. Pooja Tamboli	Scientist (LPM)	

Division of Seed Technology

Dr. Awrindra Kumar Singh	Head, S.T. Division	w.e.f 23.11.2023
Dr. A.K. Singh	Sr. Scientist (Plant Breeding)	
Sh. Anirudhha Maity	Scientist (Seed Technology)	on study leave
Sh. V.K. Wasnik	Senior Scientist (Agronomy)	Upto 22.03.23
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. H.S. Mahesha	Scientist (Genetics & Plant Breeding)	Upto 22.12.2023
Dr. Surendra Kumar Meena	Scientist (Plant Physiology)	
Dr. Jitendra Kumar Soni	Scientist (Agronomy)	Upto 15.12.2023

Division of Farm Machinery and Post Harvest Technology

Dr. Sanjay Kumar Singh	Head, FM&PHT Division	w.e.f. 10.07.2023
Dr. P.K. Pathak	Principal Scientist (ASPE) & & I/c Head	
Er. Bholuram Gurjar	Scientist (Farm Machinery & Power)	on study leave
Sh. Amit Kumar Patil	Scientist (Farm Machinery & Power)	
Dr. Satpute Ajay Narayanrao	Scientist (L&WME)	w.e.f. 21.07.2023

Division of Social Science

Dr. Sadhana Pandey	Head, S.S. Division	w.e.f. 19.06.2023
Dr. (Mrs) M. Suman	Principal Scientist (Ag. Extension)	
Dr. Bishwa Bhaskar Choudhary	Scientist (Ag. Economics)	
Sh. Samir Barman,	Scientist (Agricultural Statistics)	w.e.f. 11.04.2023

AICRP (Forage Crops & Utilization)

Dr. V.K. Yadav	Project Coordinator	w.e.f. 26.04.23
Dr. R.V. Kumar	Principal Scientist (Plant Breeding)	
Dr. R.K. Agrawal	Principal Scientist (Agronomy)	
Dr. Subhash Chand	Scientist (Genetics & Plant Breeding)	

Regional Research Station, Avikanagar (Rajasthan)

Dr. R.P. Nagar	Principal Scientist (Plant Breeding) & Officer-in-Charge	
Dr. Hari Singh Meena	Scientist (Agronomy)	On study leave

Regional Research Station, Dharwad (Karnataka)

Dr. (Mrs) N. Biradar	Principal Scientist (Agricultural Extension) & Officer-in-Charge	

Dr. B.G. Shivakumar	Principal Scientist (Agronomy)	
Dr. K. Sridhar	Principal Scientist (Plant Breeding)	
Dr. Vinod Kumar	Principal Scientist (Seed Technology)	
Dr. N.S. Kulkarni	Principal Scientist (Ag. Entomology)	
Dr. (Mrs) Edna Antony	Principal Scientist (Plant Physiology)	
Mrs. Ramyashree Devi G.S.	Scientist (Plant Pathology)	

Regional Research Station, Srinagar (J & K)

Dr. Sheeraj Saleem Bhat	Senior Scientist (Forestry) & Officer-in-Charge	
Dr. Suheel Ahmad	Senior Scientist (Forestry)	
Dr. S. Radotra	Principal Scientist (LPM)	
Dr. Surinder Paul	Scientist (Plant Biotechnology)	
Sh. Nazim Hamid Mir	Scientist (Agronomy)	
Dr. Atufa Regu,	Scientist(Agril. Extension)	w.e.f. 22.01.2024

TECHNICAL

Dr. R.K. Sharma	Chief Technical Officer	Retired 31.08.23
Sh. P.K. Karpe	Chief Technical Officer	
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. K.P. Rao	Chief Technical Officer	
Sh. R.B. Bhondele	Assistant Chief Technical Officer	
Sh. Ram Asrey	Assistant 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	Asstt. Chief Technical Officer	
Sh. K.L. Meena	Senior Technical Officer	
Sh. U.P. Singh	Asstt. Chief Technical Officer	Retired 31.01.2023
Sh. Ami Chand	Asstt. Chief Technical Officer	
Sh. N.K. Tripathi	Asstt. Chief Technical Officer	
Dr. H.C. Pandey	Asstt. Chief Technical Officer	
Sh. Neeraj K. Dubey	Asstt. Chief Technical Officer	
Sh. Kapil Kumar	Asstt. Senior Technical Officer	
Sh. Raj Kapoor Singh	Asstt. Senior Technical Officer	
Sh. Shailendra Sinha	Senior Technical Officer	
Sh. Ashok K. Singh	Senior Technical Officer	
Sh. Limbalkar Omkar Maharudra	Senior Technical Officer	Upto 06.04.2023
Dr. Anjaly M.V.	Senior Technical Officer	
Sh. Dheeraj K. Dhingra	Sr. 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	
Sh. Devendra Pratap	Technical Officer	
Sh. Gopal Lal Meena	Technical Officer	
Sh. V.K. Gupta	Technical Officer	
Sh. Veeranna Rudrappa Kadakol	Technical Officer	
Sh. Syed Zulfikar Ali	Senior Technical Assistant (Driver)	
Sh. M.K. Tripathi	Senior Technical Assistant (Driver)	
Sh. Sudhir Ramteke	Technical Assistant	
Sh. Deepak Choudhary	Technical Assistant	
Sh. Arun Prajapati	Technical Assistant	
Sh. Uttam Singh Verma	Technical Assistant	
Sh. Mathura Prasad	Senior Technician	

ADMINISTRATIVE

Sh. Firoz Khan	Chief Adm. Officer (SG)	w.e.f. 01.01.2023
Sh. Kumar Vivek	Sr. Administrative Officer	Upto 27.01.2023
Sh. Ravi Badra	Sr. Finance & Accounts Officer	w.e.f. 01.05.2023
Sh. K.K. Sharma	Asstt. Administrative Officer	Retired 28.02.23
Sh. Gautam Saxena	Asstt. Administrative Officer	Upto 27.04.2023
Sh. H.S. Yadav	Asstt. Administrative Officer	
Sh. Vijay K. Tiwari	Asstt. Administrative Officer	
Sh. Raj Kumar Nayak	Asstt. Administrative Officer	Retired on 31.07.23
Sh. V.K. Paliwal	Asstt. Administrative Officer	
Sh. Yashpal	Asstt. Administrative Officer	
Sh. Sanjay Rajak	Asstt. Administrative Officer	
Sh. D.K. Namdev	Asstt. Administrative Officer	
Sh. R.S. Negi	Asstt. Administrative Officer	
Sh. Prem Chand	Principal Private Secretary	
Smt. Kumud Bhatia	Personal Secretary	
Sh. Jagdish Prasad	Personal Secretary	
Sh. Kriparam	Personal Secretary	
Sh. Ajay K. Gaur	Personal Assistant	Upto 10.11.2023
Smt. Neelam Swarnkar	Assistant	Retired on 30.06.23
Sh. Arvind Yadav	Assistant	Retired on 30.09.23
Sh. Faiyaz Khan	Assistant	
Smt. Shobita Nair	Assistant	

Sh. Amit Kumar Singh	Assistant	
Sh. R.K. Chhipa	Assistant	
Sh. Sanjay Kumar	Assistant	
Ms. Neha	Senior Clerk	
Sh. Rajkumar	Senior Clerk	
Sh. Uma Shankar	Senior Clerk	
Sh. H.P. Khaddar	Gestetner Operator	Retired 31.07.2023
Ms. Renu Shah	LDC	Upto 29.09.2023
Ms. Monu Ahirwar	LDC	Upto 23.11.2023
Sh. Jitendra Kushwaha	LDC	
Sh. Bharat Singh	LDC	
Ms. Priyanka Prajapati	LDC	
Sh. Prashant Saxena	LDC	
Sh. Yash Kapoor	LDC	
Ms. Sanjana Yadav	LDC	
Sh. Brij Bihari	LDC	
Smt. Girja	LDC	

Swachh Bharat Abhiyan

स्वच्छ भारत

एक कदम स्वच्छता की ओर

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

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