ICAR-IGFRI

वार्षिक प्रतिवेदन
Annual Report
2022

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.....

ICAR-Indian Grassland and Fodder Research Institute, Jhansi (Uttar Pradesh), is a *sui generis* institute in Asia established with the mandate of conducting basic, strategic, applied and adaptive research on grasslands and fodder crops comprising both annuals and perennials. Institute has successfully served the nation for six decades and entered 7th decade of service, and has achieved several milestones in generation of need based and tailor-made grassland development and forage technologies with an ultimate aim to serve the farming community with green and sustainable fodder production technologies. The institute is continuously achieving successes of multi-disciplinary research composed of soil-plant-animal continuum by associating soil, plant and animal research. Shortage of green and dry fodder is the paramount challenge for the nation, since livestock population is on steady rise while area under fodder and grasslands on decline, for which institute is thriving on multi-directions with the focus to address the challenge through technological advancements and policy interventions.

The institute comprises seven target oriented divisions on technical aspects *viz*., crop improvement, crop production, grassland & silvipasture management, farm machinery and post harvest technology, seed technology, plant animal relationship and social science with multi-disciplinary scientists and three regional stations for different environmental conditions located at three agroclimatic zones. Institute is focussing on six specialised programmes of forage research, with multidisciplinary, inter-divisional and inter-institutional approaches along with national and international associations to address basic, strategic and applied research needs of the nation.

During the reporting year, two berseem varieties, Bundel Berseem 7 (JHB-18-1) and Bundel Berseem 8 (JHB-18-2) were notified and released by CVRC for hill, north-west and central zone of India and one dinanath variety, Bundel Dinanath-3 (JHD-19-4) was identified for release. Twelve entries *viz*., fodder pearl millet (3), berseem (3), *Dichanthium-Bothriochloa* complex (6) were submitted in AICRP trials. Institute maintains about ~ 10980 forage accessions of > 70 genera in midterm storage (MTS) module. Nucleus seed of IGFRI released varieties of berseem (78 kg) and cowpea (11 kg) were produced. About six novel tetraploid BN hybrids (TBN-22-21 to TBN-22-26) were developed with one fertile hybrid (TBN-22-23). Technologies for increased outputs from sole, mixed and inter-cropping patterns, integrated farming system as well as horti- and silvi-pasture models, round the year fodder production models suitable for arable and non-arable lands have been developed and upscaled. Institute has further extended technical guidance continuously in development of grasslands in Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Gujarat, Maharashtra, Karnataka and Jammu and Kashmir in association with state and union territory governments and NGOs. Institute has showcased forage and livestock technologies extensively in Meghalaya, Assam, West Bengal, Punjab, Himachal Pradesh, Jharkhand, Maharashtra, Karnataka, Rajasthan, Uttar Pradesh, Madhya Pradesh, Jammu and Kashmir and all over the country through various outreach programmes like Farmers first, TSP, SCSP, NEH, MGMG programmes.

To strengthen the fodder seed chain and availability of quality seeds to the end users, the institute has supplied 18.34 tonnes breeder seeds for further multiplication and 7.52 tonnes TFL seeds directly to the farming community, besides 10.0 lakhs rooted slips of perennial grasses. To make every Indian state as fodder surplus state, institute has arranged and organized workshops with animal husbandry departments of >25 states and successfully developed state specific 'Fodder Plan' for 25 states and remaining state plans are in progress.

During the year, institute organised about 7 sponsored training courses in various areas related to fodder production, conservation and utilization, grassland development, Agripreneurship development on value added fodder products, Sustainable Livestock Production. About 19 M.Sc. (Ag.) students from BU, Jhansi were trained for their dissertation**.** After the hindrance of COVID-19 pandemic period, institute organized a National Symposium on "Innovations in forage and livestock sector for improving entrepreneurship and farm

profitability" from 1-3 November, 2022 deliberated forage science updates of India *per se* had eight structured themes and concurrent sessions. We have also continued the key national programmes for the farmers' welfare such as Mera Gaon Mera Gaurav with complete zeal to develop fodder based dairying in 85 newly selected villages and Swachha Bharat Abhiyan in toto. Institute also organised "Technology and machinery demonstration meet cum farmers' fair" to educate Bundelkhand farmers about fodder technologies, machineries and various government schemes. In addition, institute also celebrated 61st Institute foundation day on 1st November, 2022, 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 (Republic and Independence day) with full fervour.

IGFRI is a Sardar Patel Outstanding ICAR Institution 2015 Awardee for its outstanding achievements and contributions to the farming community. We believe in strong collaboration is mantra of success and thus constantly continued to widen horizon for research and development by enhancing collaborations with many international (eg. Bioversity International-CIAT, ICRISAT and ICARDA) and national organizations as well as *Gaushalas*. During the reporting year institute has signed working MoUs with >10 organizations for widening the science and technology sharing.

While celebrating the pride moment of India's G20 Presidency with theme "Vasudhaiva Kutumbakam" or "One Earth-One Family-One Future" closely ties with LiFE (Lifestyle for Environment) and the beginning of "Amritkaal", institute is also emphasising on environmentally sustainable and greener technologies. Additionally, upon declaration of year 2023 as the 'International Year of the Millets', by the United Nations following a proposal by India, which would make our country as a global hub for millets, institute is also demonstrating the importance of millets. Rangelands cover over half (54%) of the worlds land surface and is thus our largest ecosystem, but is most endangered and least protected. Hence, United Nations General Assembly in New York unanimously declared '2026 the International Year of Rangelands & Pastoralists (IYRP)' to attract attention of all stakeholders. Towards its celebration and towards doubling farmers' income, the institute is also creating awareness on IYRP by organizing lectures on status of Indian grasslands/rangelands, forage production, natural and organic farming and addressing the needs of many *gaushalas* by providing both technical knowhow and improved seed and root slips of grasses. In addition, institute also committed to enhance Breeder seed production of different forage crops under NLM for the supply chain. In the reporting year, institute has filed for one patent, three oat varieties for PPVFRA registration and six technologies for commercialization through Agrinnovate India Ltd.

Our research and development endeavours were guided and supported by the Indian Council of Agricultural Research and Ministry of Agriculture and Farmers Welfare, GOI. I am deeply indebted to the advisory committees *viz*., Research Advisory Council, and Quinquennial Review Team for their proactive role in guiding the institute regularly. I also express my heartfelt gratitude to the Ministers of Agriculture and Farmers Welfare, DG-ICAR, DDG (CS), ADG (FFC) for their guidance, encouragement and positive attitude towards the development of institute in both scientific and administrative fronts. I take this opportunity to appreciate the IGFRI family including the Project Coordinator (FCU), Heads of Divisions, OICs-Regional stations, scientific, technical, administrative, supporting staff and contractual staff for their commitment towards the institute's growth and their sincerity in up keeping the reputation of this ISO 9001: 2015 certified institute. Their continuous hard work, trustworthiness and cooperation helped in achieving the set targets. I acknowledge the sincere efforts of the editorial committee in bringing out this Annual Report depicting the progress of the institute in last year and for documentation of institute activities and achievements well in time.

(Amaresh Chandra)

कार्यकारी सारांश

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

- वर्ष 2022 में बरसीम की 2 किस्में, बुन्देल बरसीम 7 (जे.एस. बी.–18–1) और बुन्देल बरसीम 8 (जे.एस.बी.–18–2) को राजपत्र अधिसूचना संख्या एस.ओ : 4065 (ई) के तहत भारत के पर्वतीय, उत्तर पश्चिम एवं मध्य क्षेत्र के लिये अधिसूचित किया गया।
- बाजरा की 3, बरसीम की 3 एवं डाइकैन्थियम की 6 प्रविष्टियों को एक्रिप में परीक्षण हेतु प्रस्तुत किया गया।
- 70 से अधिक वंशों की लगभग 10980 चारा प्रविष्टियों को मध्यावधि भंडारण माड्यूल में भंडारित किया गया।
- एक उपजाऊ जननयुक्त बी.एन. संकर (टी.वी. एन–22–23) से लगभग 6 नये टेट्राप्लोइड बी.एन.संकर (टी.वी.एन–22–21 से टी.वी.एन–22–26) विकसित किये गये।
- चारा उत्पादन के उद्देश्य से आईजीएफआरआई–एन–11 और आईजीएफआरआई– एन–30 लाइन्स तथा बायो एथेनाल उत्पादन हेतु आईजीएफआरआई– एन–15, आईजीएफआरआई– एन–32 एवं आईजीएफआरआई–एन–54 को विदेशों से लाये गये नेपियर जननद्रव्यों से मूल्यांकन द्वारा चयनित किया गया।
- ज्वार में बहुस्त्री जननांग अवस्था वाले एफ विशिष्ट जीनोटाइप (ईसी 484238) की पहचान की गई। ज्वार की 3 लाइन्स (आई.जी.एस.–1, आई.जी.एस.–141 और आई. जी.एस.–210) को ज्वार पर्णी रोग संवेदनशील क्षेत्रों (झाँसी, धारवाड़ और लुधियाना) में बहु पर्णीय रोग प्रतिक्रियाओं के लिये मूल्यांकन किया गया।
- मक्का की 5 लाइने (आईजी– 01–703, आईजी– 02–04–02, आईजी– 01–34, आईसी 396864 और आईसी 622330) को उच्च जैवभार उत्पादन और पीएचएम–91 को उच्च साइलेज गुणवत्ता के लिये पहचान की गयी।
- लोबिया के 159 जीनोटाइप में से 11 अधिक हरा चारा उत्पादन वाले जीनोटाइप का चयन किया गया। चयनित 11 जीनोटाइप में आईसी 20696 और आईसी 240885–2 में लिग्निन, एनडीएफ और एडीएफ सार्थक रूप से कम पायी गयी एवं ईसी 724773 में अधिक क्रूड प्रोटीन पायी गयी।
- बाजरा की दो अंतः प्रजातीय किस्मों को ब्लास्ट रोग के प्रति अत्यधिक प्रतिरोधी पाया गया।
- जई की 100 प्रविष्टियों में से 5 प्रविष्टियों (ईसी 209390, ईसी 096576, एनजीबी–6372–1, एनजीबी–6189 और ईसी–108656) को गर्मी के प्रति अत्यधिक सहनशील पायी गयी।
- बरसीम की जेएचबी–17 किस्म में ईएसएम का उपयोग कर उत्परिवर्तित पॉपुलेशन का विकास किया गया।
- स्वपरागण के माध्यम से मक्का में 40 एस$_1$, 43 एस$_5$, 20 एस$_4$ एवं चारा बाजरा में 50 एस$_1$, 133 एस$_2$, 93 एस$_3$ और 20 एस$_4$ इनब्रिड पीढ़ियॉ विकसित की गई।
- पेनिसेटम स्ककैमुलैटम के एपोमिक्टिक लोकाई को जननयुक्त बीएन संकर (टीबीएन–20–15) में स्थानान्तरित किया गया।
- मक्का में अफ्रीकन टॉल और जे–1006 का टीओसिन्ट (टीईओ–1) के संस्करण द्वारा विकसित एफ–1–एस को टिलरिंग के साथ टीबी' जीन आणविक माक्ररों का उपयोग यह सिद्ध किया गया कि एफ1 एस, टीबी1 फोकस विष्मयुग्मजी प्रकृति का है।
- चारा बाजरा में दो ए–2 मैचिंग पापुलेशन ब्लॉस्ट रोग के प्रति सहनशील एवं दो मैचिंग पापुलेशन की बीएमआर के प्रति सहनशील, विकसित की गई।
- गिनी घास प्लोइडी श्रृंखला में एसईआरके जीन की अभिव्यक्ति अध्ययन से पता चला कि प्लोइडीज में प्रीमियोटिक, मेयोटिक और पोस्ट मेयोटिक अवस्था में अभिव्यक्त का पैटर्न सेक्शुअल लाइन्स की तुलना में भिन्न है।
- बुन्देल दीनानाथ 2 की ट्रांस्क्रिप्टोम और मेटाबॉलिक प्रोफाइलिंग से पता चला कि फॉस्फोलिपेज, चाल्कोन सिंथेज, एबीए, कैल्शियम पर निर्भर प्रोटीन किनेज, सिंटैक्सिन, फेनिलएलनिन अमोनिया लाइसेज, कूमरेट और फ्लोवोनोइड सूखा सहनशीलता तंत्र में महत्वपूर्ण भूमिका निभाते हैं।
- आईजीएफआरआई की बरसीम (78 कि.ग्रा.), लोबिया (11 कि.ग्रा.) और जई (320 कि.ग्रा.) का न्यूक्लिस 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।

- अंजन वृक्ष आधारित त्रिस्तरीय वन चरागाह पद्धति में कैनोपी प्रबन्धन के अंतर्गत अंजन वृक्ष और झाड़ियों (देशी बबूल, बेर, घोट) की 70 प्रतिशत छटाई करने से सर्वाधिक टाप फीड (2.81 टन/हे.) और जलाऊ लकड़ी (3.80

टन/हे.) प्राप्त हुई। पचास प्रतिशत छटाई की तुलना में 6X6 मीटर की दूरी पर रोपित अंजन वृक्ष एवं झाड़ियों के अंतःस्थान में अधिक चारा उत्पादन (9.35 टन/हे. शुष्कभार) हुआ। अंजन वृक्ष आधारित द्विस्तरीय वन चरागाह पद्धति के अंतर्गत अंजन वृक्ष की 30 प्रतिशत एवं 45 प्रतिशत छटाई की तुलना में 60 प्रतिशत कैनोपी छटाई से सर्वाधिक टाप फीड (3.27 टन/हे.) चारा उपज (9.50 टन/हे. शुष्कभार) तथा जलाऊ लकड़ी (4.65 टन/हे.) प्राप्त हुयी, पुराने द्विस्तरीय वन चरागाह पद्धति में 15 वर्ष में कुल 23.04 टन/हे. कार्बन का भंडारण हुआ।

- अर्द्धशुष्क क्षेत्र में वन चरागाह पद्धति के पुर्नस्थापन पारिस्थितिकी अध्ययन में पाया गया कि विभिन्न वृक्षों एवं झाड़ियों के साथ गिनी घास से अधिकतम हरा चारा जैवभार उत्पादन (33.07 टन/हे.) प्राप्त हुआ, तत्पश्चात घबलू घास (22.54 टन/हे.) तथा *स्टाइलोसेंथिस सियाब्राना* (4. 62 टन/हे.) से प्राप्त हुआ। 30 प्रतिशत छटाई से सर्वाधिक हरा चारा पाकड़, सुबबूल, देशी बबूल एवं शहतूत से प्राप्त हुआ, जो क्रमशः 5.72, 5.01, 3.93 एवं 2.87 टन/हे. था। 12 वर्ष पुराने उपरोक्त वन चरागाह पद्धति में कार्बन का भंडारण (भूमि के उपर एवं भूमि के नीचे) 8.56 से 27.74 टन/हे. तथा मृदा कार्बनिक कार्बन का भंडारण (0 से 15 सेमी गहराई में) 5.74 से 10.09 ग्राम/कि.ग्रा. प्राप्त हुआ।
- अमरूद आधारित उद्यान चरागाह पद्धति में मध्यम स्तर के कृन्तन से अमरूद की दोनों किस्मों (ललित 17.5 और श्वेता 16.7 टन/हे.) में सर्वाधिक फलोत्पादन एवं उच्च भौतिक रासायनिक गुणवत्ता पायी गई। अंतःस्थान में लगी घासों से 2.9 से 3.9 टन/हे. शुष्कभार चारा प्राप्त हुआ तथा जैवभार से 19.18 से 25.15 टन/हे. कार्बन का भंडारण हुआ। आंवला आधारित उद्यान चरागाह पद्धति में बोरेक्स 0.5% + जिंक सल्फेट 0.25% के संयोजन का दो बार पर्णीय छिड़काव करने से सार्थक रूप से अधिक गुणवत्तायुक्त फलों का उत्पादन (12.8 टन/हे.) हुआ। अंतः स्थान की घास से 5.2 से 5.5 टन शुष्कभार/हे. चारा एवं उपरोक्त पद्धति से जैवभार द्वारा कुल 16.93 से 17.95 टन/हे. कार्बन का भंडारण हुआ।
- बेल के कैनोपी आक्रिटेक्चर प्रबन्धन का बेल वृक्ष की वृद्धि, फल उत्पादन, गुणवत्ता तथा अंतः स्थान से चारा उत्पादन में प्रभाव का अध्ययन किया गया। बेल की किस्म सीआईएसएचबी–2 में ओपन सेन्टर कैनोपी आक्रिटेक्चर प्रबन्धन के साथ गिनी घास की सर्वाधिक उपज (17.0 टन हरा चारा/हे.) प्राप्त हुई तथा बेल की किस्म एनबी–9 में सेन्ट्रल लीडर कैनोपी आक्रिटेक्चर प्रबन्धन के साथ सर्वाधिक (14.80 टन/हे.) हरा चारा प्राप्त हुआ। ओपन सेन्टर कैनोपी आक्रिटेक्चर प्रबन्धन द्वारा बेल का उच्च गुणवत्तायुक्त सर्वाधिक फलोत्पादन (45.54 कि.ग्रा./वृक्ष) प्राप्त हुआ।
- बादाम आधारित उद्यान चरागाह पद्धति में फलारिस + रेड क्लोवर घास के संयोजन में उच्चतम (79.85%) तत्पश्चात क्रमशः टाल फेस्क्यू + रेड क्लोवर घास (69.25%) और डैक्टाइलिस + रेड क्लोवर घास (68.64%) खरपतवार नियंत्रण दक्षता पायी गयी। बादाम के बागों के अंतर्गत उपलब्ध अंतः स्थान का उपयोग चारे की उपज बढ़ाने और खरपतवारों के प्रभावी नियंत्रण के लिए 50:50 के अनुपात में रेड क्लोवर घास तथा फलारिस, टाल फेस्क्यू और आरचर्ड घास उगाने की अनुशंसा की गयी।
- शहतूत आधारित वन चरागाह पद्धति में फलारिस + ऑचर्ड घास + सैनफॉइन + शहतूत 20.93 टन शुष्कभार/हे. एवं फलारिस + सैनफॉइन + शहतूत से 17.80 टन शुष्कभार/हे. चारा उपज प्राप्त हुयी। नियंत्रण उपचार (प्राकृतिक वनस्पति) के तहत न्यूनतम चारा उपज 6.42 टन शुष्कभार/हे. प्राप्त हुयी। इसी प्रकार फलारिस + आरचर्ड घास + सैनफॉइन + शहतूत से क्रूड प्रोटीन 32.06 क्विंटल/हे. एवं फलारिस + सैनफॉइन + शहतूत से 28. 22 क्विंटल/हे. क्रूड प्रोटीन प्राप्त की गई।
- विभिन्न घासों के संयोजन में टी2 (टालफेस्क्यू 25%, आरचर्ड घास 25%, सैनफाइन 50%) में (36.30 टन/हे.) हरा चारा प्राप्त हुआ जो टी3 (टालफेस्क्यू 25%, आरचर्ड घास 25%, रेडक्लोवर 50%) से प्राप्त चारे की तुलना में अधिक था। इसी प्रकार शुष्कभार भी टी2 (11.28 टन/हे.) में टी3 (10.6 टन/हे.) की तुलना में अधिक था। विभिन्न अंतराल के कटाई अध्ययन में पाया गया कि पहली कटाई के बाद प्रति 40 दिन के अंतराल पर कटाई करने से सर्वाधिक हरा चारा प्राप्त होता है। घास + दलहनी चारे की संयोजन में खेती करने से मृदा कार्बन में अच्छी बढ़त दर्ज की गई।
- बाकला के पितृद्रव्य में विभिन्न गुणों जैसे हरा चारा उत्पादन (15.5–23.6 टन/हे.), शुष्क भार (5.6–7.24 टन/हे.) और चारे की गुणवत्ता जैसे क्रूड प्रोटीन (16.6–22.3), एनडीएफ (33.1–45.5), एडीएफ (27.2–38.7), एडीएल (4.25–7.57) और खनिज तत्व (8.6–10.1) आदि में सार्थक रूप से विभिन्नता देखी गई।

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

- कानपुर और भोपाल में दूशित चारा खाने वाले पशुओं के दूध और रक्त के नमूनों में क्रोमियम, कैडमियम और शीशा जैसे तत्वों का अवशेष अधिकतम स्वीकार्य सीमा से अधिक पाया गया।
- जई में एसपीडी मान 40 पर नत्रजन देने से नत्रजन की आवश्यकता 10 प्रतिशत कम हो जाती है और अनुशंसित उर्वरक के समान चारे की पैदावार होती है। इसके अलावा इसी मान पर सर्वाधिक सस्य दक्षता (43.9 कि.ग्रा. शुष्क भार वृद्धि/कि.ग्रा. नत्रजन लागू) भी दर्ज की गई।

- टीएसएच + सेसबानिया + (ज्वार + लोबिया–चना) फसल प्रणाली में टीएसएच की चार कटाई में उच्चतम हरे चारे और शुष्क पदार्थ की उपज क्रमशः 27.9 और 5.18 टन/हे. पायी गई।
- जई की पाँच किस्मों का गैर –तनावपूर्ण परिस्थितियों में किये गये प्रयोग के आधार पर विभिन्न परिदृश्यों में जलवायु परिवर्तन के प्रभाव का आकलन करने के लिए आनुवंशिक गुणांक विकसित किये गये।
- आरचर्ड घास में पुष्पन अवस्था और 60 दिनों में कटाई करने से सर्वाधिक हरा चारा (27.0 टन/हेक्टेयर) और शुष्कभार उत्पादन (7.97 टन/हेक्टेयर) प्राप्त किया गया। 60 दिन के अंतराल पर कटाई करने से सर्वाधिक हरा चारा (26.6 टन/हेक्टेयर) और सूखा चारा (8.31 टन/हेक्टेयर) प्राप्त हुआ।
- एचपीएलसी क्रोमैटोग्राम द्वार ज्ञात हुआ कि पीजीपीएम उपचारित जई के जड़ के स्राव में कई नये और अलग–अलग रासायनिक यौगिक थे।
- लैक्टिक एसिड जीवाणु को संकर बाजरा नेपियर एवं अंजन घास में डालने से अच्छी गुणवत्ता वाले साइलेज का उत्पादन किया जा सकता है।

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

- पुरानी बीज शैया का प्रयोग करके बरसीम बीज उत्पादन में, ग्लाइफोसेट @ 1.0 कि.ग्रा. सक्रिय तत्व/हे. एफबी इमाजेथापर + इमाजामॉक्स @ 0.07 कि.ग्रा. सक्रिय तत्व/हे. का प्रयोग करने से सार्थक रूप से अधिक हरा चारा (28.03 टन/हे.), भूसा (2.98 टन/हे.) तथा बीज उत्पादन (525 कि.ग्रा./हे.) प्राप्त किया गया।
- जई के सस्य दाहिकी लक्षणों के अध्ययन से यह ज्ञात हुआ कि उच्च कार्बनडाई ऑक्साइड (550 + 50 पीपीएम), समान्य से (>3^{0}C अधिक) गर्मी के प्रभाव से उत्पन्न लक्षणों को कुछ हद तक कम कर देती है।
- चारे की प्रारंभिक स्थापना पर धुएं के पानी के प्रभाव का अध्ययन करने के लिए न्यूनतम हानि के साथ समान रूप से मिश्रित धुआं पानी उत्पन्न करने में सक्षम एक कुशल, कम समय लेने वाली धुआं पानी मशीन का निर्माण किया गया।
- परिवेश सामान्य और उससे कम तापमान पर भंडारित बरसीम किस्म वरदान, बुंदेल बरसीम–3 और जेबीएससी–1 के बीजों को आरएचएस रंग चार्ट का उपयोग करके तीन समूहों (पीले, लाल और गहरे लाल बीज) में वर्गीकृत किया गया। पीले बीजों (161–ए, 162–ए) में लाल (164–ए, 164–बी) और गहरे लाल बीज (165–बी) की तुलना में अधिक जीवनबल और ओज पाया गया था, भंडारण समय में वृद्धि करने से सभी बीजों का अंकुरण कम हो गया।
- अंजन और धामन घास के बीजों को अफुज्जीकरण (डिफ्लफिंग) करने से फुज्जीकृत (फ्लफिंग) बीजों की तुलना में अफुज्जीकृत बीजों की शेल्फ लाइफ कम पायी गई। फुज्जीकृत (फ्लफिंग) बीजों को 6 माह में ही प्रयोग कर लेना चाहिए। अफुज्जीकृत (डिफ्लफिंग) बीज का आयतन 5–6 गुना कम हो जाता है जिससे यातायात में आसानी रहती है।

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

- सेब के पत्तियों के पोशक मूल्य से ज्ञात होता है कि इसमें क्रूड प्रोटीन 10.3–12.4% पायी जाती है, जोकि हरे चारे के बराबर होती है तथा इसमें रेशा भी कम पाया जाता है और खनिज तत्व (कैल्शियम, लोहा, मैगनीज, जिंक, तॉबा और कोबाल्ट), उच्च पाचन क्षमता, टीडीएन इत्यादि भी पर्याप्त मात्रा में पाये जाते हैं। सेब की पत्तियों को जुगाली करने वाले पशुओं को एक अच्छे से मध्यम गुणवत्ता वाली चारे के स्त्रोत के रूप में प्रयोग किया जा सकता है।
- चिन्हित सेहिमा जीनोटाइप आईजी–02–695–1 से बने साइलेज की गुणवत्ता नेपियर से बने साइलेज से मिलती जुलती पाई गई, जबकि बीएस–1 साइलेज, किण्वन में कम अम्ल और लैक्टिक अम्ल की मात्रा के कारण, पशु ग्राह्यता एवं पाचन की दृष्टि से ख़राब पाई गई।
- अलग–अलग स्टॉकिंग (पशुओं की संख्या) दरों के तहत प्राकृतिक चरागाह पर भेड़ों ने (2.02–2.51), बकरियों (2.76–3.14%) की तुलना में कम चारे का सेवन किया । भेड़ और बकरी के शरीर वजन में सभी स्टॉकिंग दरों में सितम्बर से नवम्बर तक वृद्धि एवं दिसंबर के बाद कमी दर्ज की गई। लेकिन एसआर 1 में एसआर 2 और एसआर 3 की तुलना में वजन गिरने की दर कम थी।
- बरसीम हे मील प्रोटीन से सरसोंकी खल (मस्टर्ड केक) प्रोटीन का प्रतिस्थापन और पशु आहार में एन. पी. एन. @ 0.75 प्रतिशत मिलाने से पोषक तत्वों के उपयोग, दुग्ध उत्पादन और दुग्ध उत्पादन की लागत पर पड़ने वाले प्रभावों का अध्ययन क्रॉसब्रेड दुधारू गायों में किया गया। प्रयोगात्मक परिणामों से ज्ञात हुआ है कि इससे पोषक तत्वों के उपयोग, दुग्ध उत्पादन (7.01 बनाम 7.21 किग्रा) और दुग्ध संरचना पर कोई प्रभाव नहीं पड़ा। लेकिन प्रति कि.ग्रा. दुग्ध उत्पादन (4% एफसीएम) के लिए लगने वाले पशु आहार की लागत जो 13.57 रुपये थी, उपचारित समूह में घटकर 11.19 रुपये हो गई, जो दर्शाता है कि दुग्ध उत्पादन की लागत को 17.53 प्रतिशत तक कम किया जा सकता है।

- प्रजनन क्षेत्र में भदावरी भैंसों के सुधार और संरक्षण के लिए उत्तम सांडों के हिमीकृत वीर्य की आपूर्ति की गई। किसान गोष्ठियों का आयोजन किया गया और भदावरी भैंसों पर बनी लघु फिल्म को आईसीएआर– आईजीएफआरआई के यूट्यूब चैनल में, किसानों को भदावरी भैंस पालन के लिए प्रेरित करने हेतु, अपलोड किया गया ।
- जब एलिसा तकनीक के माध्यम से बिनौले की खल की जांच की गई, तो यह पाया गया कि लगभग 88 प्रतिशत बिनौले की खल बीटी कपास प्रकार की थी। जो यह दर्शाता है कि आजकल लगभग हर जगह बीटी कपास का उत्पादन बढ़ रहा है।
- दीनानाथ घास के बीजों के लिए अफुज्जीकरण (डिफ्लफिंग) मशीन विकसित की गई एवं उसका परीक्षण किया गया, जिसकी अफुज्जीकरण क्षमता 4–9 कि.ग्रा. / घंटा थी और मशीन से शुद्ध बीज की प्राप्ति 22-82% थी। अफुज्जीकरण मशीन से शुद्ध बीज प्राप्ति की लागत 10.75 रुपये प्रति कि.ग्रा. थी।
- गोलाकार ड्रम टाइप (सीड पेलेटिंग) बीज गोली बनाने की मशीन का एक प्रोटोटाइप विकसित कर परीक्षण किया गया। दीनानाथ घास के बीजों की गोली बनाने की मशीन की क्षमता 65–70 कि.ग्रा. / घंटा एवं मशीन की कीमत रु. 90,000 / – थी।
- वाश्पीकरण शीतलन आधारित हाइड्रोपोनिक के अंतर्गत जिबरेलिक एसिड उपचारित मक्का बीज से हरे चारे का उत्पादन किया गया। जिनके जैवभार उत्पादन में वृद्धि पायी गयी। मक्के का जैवभार 6.03 कि.ग्रा. / कि.ग्रा. बीज पाया गया जबकि अनुपचारित बीज से जैवभार 3.38 कि.ग्रा. / कि.ग्रा. बीज ही प्राप्त हुआ।
- सॉलिडवर्क्स 2013 साफ्टवेयर का उपयोग करके तरल कोटिंग की सही मात्रा प्रयोग करने के लिये सेंसर आधारित माइक्रो–कंट्रोलर प्रणाली के साथ स्वचलित बीज कोटिंग मशीन (1600x800x1590 मिमी) का कम्प्यूटर सहायता प्राप्त डिजाइन विकसित किया गया।
- प्रोटीन, सुपाच्य पोशक तत्वों और खनिजों की आवश्यकताओं को संतुलित करने के लिए मोटे अनाज में पूरक जोड़ने के बाद 280 कि.ग्रा. / एम^3 घनत्व के साथ 2–5 मिमी के मेस आकार वाले कुल मिश्रित राशन (टीएमआर) को व्यावसायिक बकरी उत्पादन के लिए डिजाइन किया गया।
- विकसित ट्रैक्टर संचालित घास बीज हार्वेस्टर का परीक्षण दीनानाथ, सेंक्रस और गिनी घास के बीजों की कटाई के लिए किया गया और इसकी क्षमता क्रमशः 86, 94 और 90% की दक्षता के साथ 2.5–7.5 किलोग्राम बीज / घंटा के बीच थी। मशीन को 0.9 से 1.5 मीटर की फसल की ऊंचाई के लिए संचालित किया जा सकता है।

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

- समन्वित कृषि प्रणाली के चार प्रारूप {प्रारूप–I अर्द्ध मध्यम (3 हेक्टेयर, पशुधन आधारित), प्रारूप–II अर्द्ध–मध्यम (3 हेक्टेयर, फसल आधारित), प्रारूप–III मध्यम (5 हेक्टेयर), प्रारूप–IV : गौशाला (5 हेक्टेयर)} का उत्पादकता और लाभप्रदता विश्लेषण किया गया। प्रारूप–I, II, III, IV का लाभः लागत अनुपात क्रमशः 1.95, 1.67, 1.61 और 1.38 पाया गया।
- किसान मित्र परियोजना के निष्कर्षों से ज्ञात होता है अपनाये गये गॉव में तकनीकियों को अमल करने का संबंध सकारात्मक रूप से घर के मुखिया की लंबी औपचारिक स्कूली शिक्षा, तकनीकी सलाह, प्रशिक्षण और कृषि प्रदर्शनों, बड़े जोत और अच्छे नस्ल के भैंस इत्यादि पशुधन इकाइयों के साथ सीधा जुड़ा हुआ है। उन्नत चारा उत्पादन तकनीकियों को अमल करने की संभावना 0.23 गुना प्रशिक्षण और प्रदर्शनों के संपक्र में बढ़ जाती है। वार्षिक दुग्ध उत्पादन के संबंध में, तकनीकी अमल करने वाले परिवारों में तकनीकी न अपनाने वाले परिवार की तुलना में अधिक वार्षिक दुग्ध उत्पादन पाया गया। तकनीकी अमल किये गये परिवारों में जायद मौसम के दौरान फीड सोर्सिंग में लगने वाला दैनिक समय लगभग 2 घंटे और खरीफ सीजन के दौरान लगभग एक घंटे तक की समय की बचत पायी गयी।
- बरसीम की वरदान किस्म का आर्थिक प्रभाव अनुमान लगभग रु. 2640.50 करोड़ आंका गया। विकसित चरागाह में मृदा कार्बनिक कार्बन (एसओसी) 0–15 सेमी मिट्टी की गहराई में 4.05 से 4.75 ग्राम / कि.ग्रा. की सीमा में पायी गयी, जबकि बंजर भूमि में लगभग 3.31 ग्राम / कि.ग्रा. थी।
- फार्मर फर्स्ट कार्यक्रम (एफएफपी) के अंतर्गत तकनीकी हस्तान्तरण के परिणामस्वरूप प्रमुख फसलों की उत्पादन लागत में कमी आई, जिससे खेती से लागत : अनुपात और शुद्ध लाभ में भी वृद्धि पायी गयी। किसान के खेत तक तकनीकी हस्तान्तरण के परिणामस्वरूप खेती की लागत में बीज, उर्वरक और पौध संरक्षण रसायनों की हिस्सेदारी में धीरे–धीरे गिरावट पायी गयी। तकनीकी हस्तान्तरण के कारण उत्पादकता में वृद्धि से किसानों की उत्पादन लागत में कमी पायी गयी। खेती की लागत को कम करने के लिए निवेश मूल्य मुद्रास्फीति, विशेष रूप से मजदूरी दर को नियंत्रित करने के लिए नीतियां अनिवार्य होंगी। (छोटे जोत के कृषक के लिए भी सस्ती) उपयुक्त कृषि मशीनीकरण रणनीतियों को भी तैयार करने की आवश्यकता है।

Executive Summary

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

- In 2022, two berseem varieties Bundel Berseem 7 (JHB-18-1) and Bundel Berseem 8 (JHB-18-2) were notified and released by CVRC for hill, north-west and central zone of India which include Punjab, Haryana, Rajasthan, UT of Jammu and Kashmir, HP, Uttarakhand, UP, MP, Chhattisgarh and Maharashtra and one dinanath variety, Budel Dinanath-3 (JHD-19-4) was identified for release.
- Twelve entries *viz*., fodder pearl millet (3), berseem (3), *Dichanthium-Bothriochloa* complex (6) were submitted in AICRP trials.
- About 10980 forage accessions of > 70 genera are maintained in midterm storage (MTS) module.
- About six novel tetraploid BN hybrids (TBN-22-21 to TBN-22-26) were developed with one fertile hybrid (TBN-22-23).
- Lines IGFRI-N11 and IGFRI-N30 for fodder purpose; and IGFRI-N15, IGFRI-N32 and IGFRI-N54 for bioethanol production were selected from 65 exotic Napier germplasm evaluation.
- A novel sorghum genotype (EC 484238) with multiple gynoecia was identified. Three sorghum lines (IGS-1, IGS-141 and IGS-210) were evaluated for multiple foliar disease reactions at disease specific hot-spot locations (Jhansi, Dharwad and Ludhiana).
- Five maize lines (IG-01-703, IG-02-04-02, IG-02-34, IC396864 and IC622330) were identified for high GFY biomass and PHM9I for high silage quality.
- Out of eleven cowpea high GFY genotypes selected from 159 genotypes, IC20696 and IC240885-2 recorded significantly lower lignin, NDF and ADF and EC724773 recorded high CP content.
- Two forage pearl millet inbreds derived from landrace were found highly resistant for blast.
- Five (EC209390, EC096576, NGB-6372-1, NGB-6189 and EC-108656) out of 100 oat accessions were found highly heat-tolerant.
- In berseem mutant population using EMS was developed in the background of JHB-17-1.
- In maize 40 S_1, 43 S_5, 20 S_4 inbreds, in forage pearl millet 50 S_1, 133 S_2, 93 S_3 and 20 S_4 generations were developed.
- Apomictic loci of *Pennisetum squamulatum* was transferred in fertile BN hybrid *(*TBN-20-15).
- In maize, resultant F_1s [African tall and J-1006 crossed with teosinte (Teo-1 accession)] with tillering habit were genotypes for *Tb1* gene, F_1s at Tb1 locus were of heterozygous nature.
- In forage pearl millet two F2 mapping population for blast tolerance and two mapping population for bmr were developed.
- Expression study of somatic embryogenesis receptor kinase (*SERK*) gene in *guinea grass* ploidy series showed that pattern of expression was differing in ploidies at premeiotic, meiotic and post meiotic stages as compared to sexual line.
- Transcriptome and metabolic profiling of Bundel Deenanath 2 revealed that phospholipase, chalcone synthase, ABA, calcium dependent protein kinase, syntaxin, phenylalanine ammonia lyase, coumarate and flavonoid play important role in drought tolerance mechanism.
- Nucleus seed of IGFRI released varieties of berseem (78 kg), cowpea (11 kg) and oat (320 kg) was produced.

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 operations

- Under canopy management in *Hardwickia binata* (tree) based silvipasture systems (SPS), 70% lopping intensity of shrubs (*Acacia catechu, Ziziphus xylopyrus, Z. mauritiana*) and trees resulted in higher top feed (2.81 t/ha) and fire wood (3.80 t/ha) as compared to 50% lopping. Under three tier system, trees and shrub species in alternate row at 6x6 m spacing recorded higher understorey pasture (9.35 t/ha). In two tier SPS, 60% tree canopy pruning recorded higher pasture (9.50 t/ha), top feed

(3.27 t/ha) and fire wood (4.65 t/ha) than 30 and 45% pruning. *H. binata* trees under two tier SPS stored 23.04 Mg C/ha at 15 years age.

- While studying restoration ecology in SPS for semiarid region, maximum GFY was in *Panicum maximum* (33.1) followed by *Chrysopogon fulvus* (22.5) and *Stylosanthes seabrana* (4.62 Mg/ha). Maximum edible green biomass was recorded in *Ficus infectoria* (5.72 on 30% crown lopping) followed by *L. leucocephala* (5.01 on pollarding), *Acacia nilotica* (3.93 on 30%) and *Morus alba* (2.87 Mg/ha on 30% crown lopping). At 12 years age, total biomass C stock in SPS ranged from 8.56 to 27.74 Mg C/ha and SOC from 5.74 to 10.09 g/kg in 0-15 cm depth.
- In guava based horti-pastoral system (HPS), medium pruned trees produced highest fruit (Lalit 17.5 t/ha & Shweta 16.7 t/ha) yield and quality. Understorey pasture produced 2.9-3.9 t DM/ha and system stored 19.2 to 25.2 Mg C ha^{-1} in biomass. In aonla based HPS, foliar application of borax @ 0.5% + $ZnSO_4$ @ 0.25% produced higher fruit yield (12.8 t/ha) and quality, understorey pasture produced 5.2-5.5 t DM/ha and HPS stored 16.9-17.9 Mg C ha^{-1}.
- Among canopy architectures of bael based HPS, *Megathyrsus maximus* under bael (*cv*. CISHB-2) with open centre system recorded higher yield (17.0 t/ha) while under *cv*. NB-9 with central leader system (14.8 t/ha GFY). Open centre architecture produced higher fruit yield (45.54 kg/tree) and canopy managed trees resulted in higher physico-chemical composition of fruits.
- In an almond based horti-pastoral system, a combination of *Phalaris* + red clover exhibited highest weed control efficiency (79.8%) with enhanced forage yield. *Phalaris*, tall fescue and orchard grass in combination with red clover in 50:50 proportion is recommended for enhanced forage yield and effective control of weeds.
- In mulberry based silvopastoral system, maximum forage and CP yield (20.9 t DM ha^{-1} and 3.21 t/ha) was observed under the tertiary mixture comprising *Phalaris* + orchard grass + sainfoin + mulberry followed by *Phalaris* + sainfoin + mulberry (17.8 t DM ha^{-1} and 2.82 t/ha), respectively.
- A combination of tall fescue, orchard grass and sainfoin sown in 25:25:50 proportion, respectively, and harvested at the boot stage of grasses and subsequent cuts taken at an interval of 40 days resulted in highest fodder yield and higher SOC.
- Significant variation in Faba bean germplasm was observed for GFY (15.5-23.6 t/ha), DFY (5.6-7.24 t/ha) and fodder quality traits *viz*., crude protein (16.8-22.3), NDF (33.1-45.5), ADF (27.2- 38.7), ADL (4.25-7.57) and ash content (8.6-10.1%).

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

- Cr, Cd and Pb residue levels in milk and blood samples of animals consumed contaminated forages were found to be higher than the maximum permissible limit in Kanpur and Bhopal.
- Nitrogen fertilization in oats at SPAD value 40 reduces N requirement by 10% and produced fodder yield similar to the recommended dose of N fertilizer. Furthermore, it also recorded high agronomic efficiency (43.9 kg DM increase/kg N applied).
- TSH + *Sesbania* + (sorghum+cowpea-chickpea) cropping system recorded highest green fodder and dry matter yield (27.9 & 5.18 t/ha) in four cuts of TSH
- Genetic coefficient of five oat varieties was developed to assess the impact of climate change under different scenarios based on experiment carried out under non-stress conditions.
- Orchard grass recorded highest green (27.0) and dry (7.97 t/ha) fodder yield when harvested at flowering stage and cutting at 60 days interval recorded highest green (26.6) and dry fodder (8.31 t/ha) yield.
- PGPM treated oat root exudates had many new and different compounds as shown by HPLC chromatogram over untreated control.
- Three lactic acid bacterial additives produced good quality BN hybrid and *Cenchrus ciliaris* silage.

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

- In berseem seed production using stale seedbed technique, glyphosate @ 1.0 kg *a.i.*/ha *fb* imazethapyr + imazamox @ 0.07 kg *a.i.*/ha applied treatment recorded significantly highest,

no. of heads (739.6/m^2), GFY (28.03 t/ha), straw (2.98 t/ha) and seed yield (525 kg/ha).

- Oat agro-morphological traits indicated that the symptoms of heat stress (3°C > ambient temperature) were marginally suppressed under elevated CO_2(550+50 ppm).
- An efficient, less time-consuming smoke water machine capable of generating uniformly mixed smoke water with minimum loss was fabricated to study the effect of smoke water on early establishment of forages.
- Berseem (*cv*. Wardan, BB-3 and JBSC-1) seed stored at ambient and low-temperature was categorized into three groups (yellow, red and dark red seed) using the RHS color chart. Yellow seed (161-A, 162-A) showed higher viability and vigour than red (164-A, 164-B) and dark red seed (165-B) and increase in storage time decreased germination of all seed.
- Defluffed seed of Anjan and Dhaman grass had poor shelf life than fluffy seed and should be used within 6 months of delfuffing. Defluffing is effective in reducing volume by 5-6 times that minimise storage and transportation cost. Polybag >700 gauge and Al bag were better storage container than others for maintaining germination up to 30 months in ambient room condition.

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

- Nutritive value of apple leaves revealed that CP (10.3-12.4%) contents are comparable to green cereal fodder crops, while fibre contents are low. Adequate minerals (Ca, Fe, Mn, Zn, Cu and Co), higher digestibility, TDN, energy and RFV substantiate apple leaves as a good to medium quality forage source for feeding ruminants.
- Quality of silage prepared from identified *Sehima* genotype IG-02-695-1 was comparable to Napier silage, while that of BS-1 was poor in terms of fermentation quality (high pH and low lactic acid content), animal intake and digestibility.
- On natural pasture under different stocking rates (SR) sheep had low herbage intake (2.02-2.51) than goats (2.76-3.14%). Sheep and goat body wt. gain increased in all SR during September to November and decreased from December onward but the rate of decrease was less in SR_1 than SR_2 and Sr_3.
- Replacement of mustard cake protein with berseem hay meal protein and addition of NPN @ 0.75% in concentrate mixture in crossbred milch cows resulted similar nutrient utilization, daily milk yield (7.01 *vs* 7.21 kg) and milk composition. Cost of feed/kg (4% FCM) milk production was Rs 13.57 and 11.19 in control and treatment, respectively, indicating that feed cost can be reduced by 17.53% using economic diet.
- For improvement and conservation of Bhadawari buffaloes in the field, frozen semen from superior bulls was supplied in the breeding tract. Organization of kisan gosthies and uploading a short film on Bhadawari buffaloes in ICAR-IGFRI YouTube channel was done to motivate farmers to rear Bhadawari buffaloes.
- About 88% cotton seed cakes (53 samples out of 60) were from Bt cotton origin, when cotton seed cake was screened for Bt cotton origin through ELISA technique.
- Based on the physical properties of dinanath grass seeds, a prototype of defluffing machine was designed and developed, which had highest defluffing capacity (4.9 kg/h), efficiency (92.1%) and nucleus seed recovery (22.82%) at 7.0% and lowest at 11.0% moisture content for defluffing dinanath grass seeds. Patent application of the machine has been filed.
- A semi-automatic pelleting machine with the provision of motor, belt and pulley arrangement, hydraulic and water application systems to make the pellets of small and lighter grass seeds was designed.
- Developed evaporative cooling based hydroponic chamber recorded cooling efficiency from 57.6-83.3% with an average value of 74.1%. Fresh biomass yield of seven days hydroponic fodder maize was 4.0 kg/kg seed, with 13.1% CP and 15.3% crude fiber on DM basis.
- A computer aided design of automatic seed coating machine (1600×800×1590 mm) with sensor based micro-controller system to apply correct amount of liquid coating was developed using SolidWorks 2013 software.
- A total mixed ration (TMR) having a mess size of 2-5 mm with 280 kg/m^3 density was designed for commercial goat production after adding supplements to roughage ration in view to balance the protein, digestible nutrients and minerals requirements.

- Developed tractor operated grass seed harvester was tested for harvesting Dinanath, *Cenchrus* and Guinea grass seeds and its capacity ranged between 2.5-7.5 kg/h with respective efficiency of 86, 94 and 90%. The machine can be operated for a crop height of 0.9 to 1.5 m. A patent application of the machine has been filed.

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

- Productivity and profitability analysis of four IFS models *viz*., model I: semi medium (3 ha, livestock specialized), II: semi-medium (3 ha, crop specialized), III: medium (5 ha), IV: *gaushala* (5 ha) indicated B:C ratio of 1.95, 1.67, 1.61 and 1.38, respectively.
- KISAN MITrA project findings indicated that adoption is positively associated with longer formal schooling of the household head, exposure to technical advice, training and farm demonstrations, large farm size and higher buffaloes livestock units. Demonstrations on improved forage practices increased the probability of adoption by 0.23. Adopter households had higher annual milk yield than non-adopters.
- Economic impact of Wardan variety of berseem was estimated to the tune of Rs. 2640.50 crores. Soil organic carbon of developed grasslands ranged from 4.05-4.75 g/kg in 0-15 cm soil layer, while 3.31 g/kg in barren land.
- Farmer FIRST programme interventions resulted in decline in production costs of major crops leading to increase in net return to cost ratio from farming. There is need for devising suitable farm mechanization strategies which may be affordable to small farmers.

Chapter 1

ICAR-IGFRI : An Introduction

To serve the nation with the largest livestock population in the world, on forage needs and to conduct systematic scientific research exclusively on grasslands and fodder production and their utilization, Government of India established the prestigious 'Indian Grassland and Fodder Research Institute' (IGFRI), an institute of national importance on 1st November, 1962, at Jhansi, the biodiversity hotspot in India for grasses. The institute was later associated with the Indian Council of Agricultural Research (ICAR) on 1st April, 1966. Further, the All India Coordinated Research Project on Forage Crops and Utilization was created in 1972 with IGFRI as head quarter for multi-location testing of forage varieties and technologies in different agro-climatic zones of the country through 22 coordinating centres at various State Agricultural Universities under the National Agricultural Research System.

The institute consists of seven multi-disciplinary divisions *viz*., crop improvement, crop production, farm machinery and post-harvest technology, seed technology, social science, grassland and silvipasture management and plant animal relationship wherein, two divisions mentioned at last are unique. It also has PME, HRD, ATIC, ITMU, AKMU, ABIC units and facilities *viz*., Library, Central Research Farm, Dairy, Central Instrumentation Lab and MTS. As offshoot, institute has three regional stations located in Dharwad (Karnataka), Avikanagar (Rajasthan) and Srinagar (Jammu & Kashmir) to conduct focussed forage research on humid tropic, semiarid to arid and temperate climatic conditions, respectively and a grassland centre at Palampur (Himachal Pradesh).

ICAR-IGFRI has successfully served the nation for six decades and entered in seventh decade of service achieving several milestones in generation of various need based tailor-made technologies with an ultimate aim to serve the farming community with green and sustainable production processes. It has made remarkable progress and contributions in the field of forage research, grassland development, extension, capacity building and infrastructure development. IGFRI is an ISO 9001: 2015 certified sexagenarian institute, active and vibrant in conducting, collating and coordinating organized forage research, transfer of new technologies and also offers training to government and non-government organizations, trainers, farmers, forest officers and other stake holders. Institute is endeavouring in basic and applied research in both cultivated and range species in all aspects *viz*., 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, livestock nutrient management, *etc*. Institute is undertaking numerous research projects at many levels like institute, inter-institute, externally funded national and international collaborative projects to address the lasting problems of fodder shortage and lack of quality forages. Other important activities of the institute are multifaceted outreach programmes, *viz*., 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, NEH, *etc*. to demonstrate the developed technologies at the farmers' and other stakeholders' fields in addition to demonstrations in national events and platforms.

Being nodal centre for forage genetic resources, about 10980 forage accessions of > 70 genera are maintained in midterm storage (MTS) module. In the reporting year, two berseem varieties Bundel Berseem 7 (JHB-18-1) and Bundel Berseem 8 (JHB-18-2) were notified and released by CVRC for hill, north-west and central zone of India which include Punjab, Haryana, Rajasthan, UT of Jammu and Kashmir, HP, Uttarakhand, UP, MP, Chhattisgarh and Maharashtra and one dinanath variety, Budel Dinanath-3 (JHD-19-4) was identified for release. Twelve entries *viz*., fodder pearl millet (3), berseem (3), *Dichanthium-Bothriochloa* complex (6) were submitted in AICRP trials. About six novel tetraploid BN hybrids (TBN-22-21 to TBN-22-26) were developed with one fertile hybrid (TBN-22-23). A

novel sorghum genotype (EC 484238) with multiple gynoecia was identified. Five maize lines (IG-01-703, IG-02-04-02, IG-02-34, IC396864 and IC622330) were identified for high GFY biomass and PHM9I for high silage quality. Out of eleven cowpea high GFY genotypes, IC20696 and IC240885-2 recorded significantly lower lignin, NDF and ADF and EC724773 recorded high CP content. Two forage pearl millet inbreds derived from landrace were found highly resistant for blast. In berseem mutant population using EMS was developed in the background of JHB-17-1. In maize 40 S_1, 43 S_5, 20 S_4 inbreds, in forage pearl millet 50 S_1, 133 S_2, 93 S_3 and 20 S_4 generations were developed. Transcriptome and metabolic profiling of Bundel Deenanath 2 revealed that phospholipase, chalcone synthase, ABA, calcium dependent protein kinase, syntaxin, phenylalanine ammonia lyase, coumarate and flavonoid play important role in drought tolerance mechanism. Nucleus seed of IGFRI released varieties of berseem (78 kg) and cowpea (11 kg) oat (320 kg) were produced.

For improving productivity and livelihood option through diversification and sustainable intensification of forage production in different land use systems, such as in an almond based horti-pastoral system, a combination of *Phalaris* + red clover exhibited highest weed control efficiency (79.8%) with enhanced forage yield. In mulberry based silvopastoral system, maximum forage and CP yield (20.9 t DM ha^{-1} and 3.21 t/ha) was observed under the tertiary mixture comprising *Phalaris* + orchard grass + sainfoin + mulberry followed by *Phalaris* + sainfoin + mulberry (17.8 t DM ha^{-1} and 2.82 t/ha), respectively. A combination of tall fescue, orchard grass and sainfoin sown in the proportion of 25:25:50 per cent, respectively, harvested at the boot stage of grasses and subsequent cuts taken at an interval of 40 days resulted in highest fodder yield. Higher SOC was recorded in all the grass + legume combinations after harvesting.

Towards managing natural resources and soil health of arable and non-arable lands, it was found that nitrogen fertilization in oats at SPAD value 40 reduced N requirement by 10% and recorded high agronomic efficiency (43.9 kg DM increase/kg N applied). Heavy metals (Cr, Cd and Pb) residue levels in milk and blood samples of animals fed with contaminated forages were found to be higher than the maximum permissible limit in Kanpur and Bhopal. TSH + *Sesbania* + (sorghum+ cowpea - chickpea) cropping system recorded highest GFY and DFY (27.9 & 5.18 t/ha) in four cuts of TSH. Genetic coefficient of five oat varieties was developed to assess the impact of climate change under different scenarios. Orchard grass recorded highest green (27.0) and dry (7.97 t/ha) fodder yield when harvested at flowering stage and cutting at 60 days interval recorded highest green (26.6) and dry fodder (8.31 t/ha) yield. *Burkholderia cepacia* and *Chryseobacterium* dual culture treatment with 50% RDF recorded 29.6% and 6.7% higher GFY than 100% fertilized treatment in fodder sorghum (*cv*. MP chari) and bajra (*cv*. AVKB19), respectively.

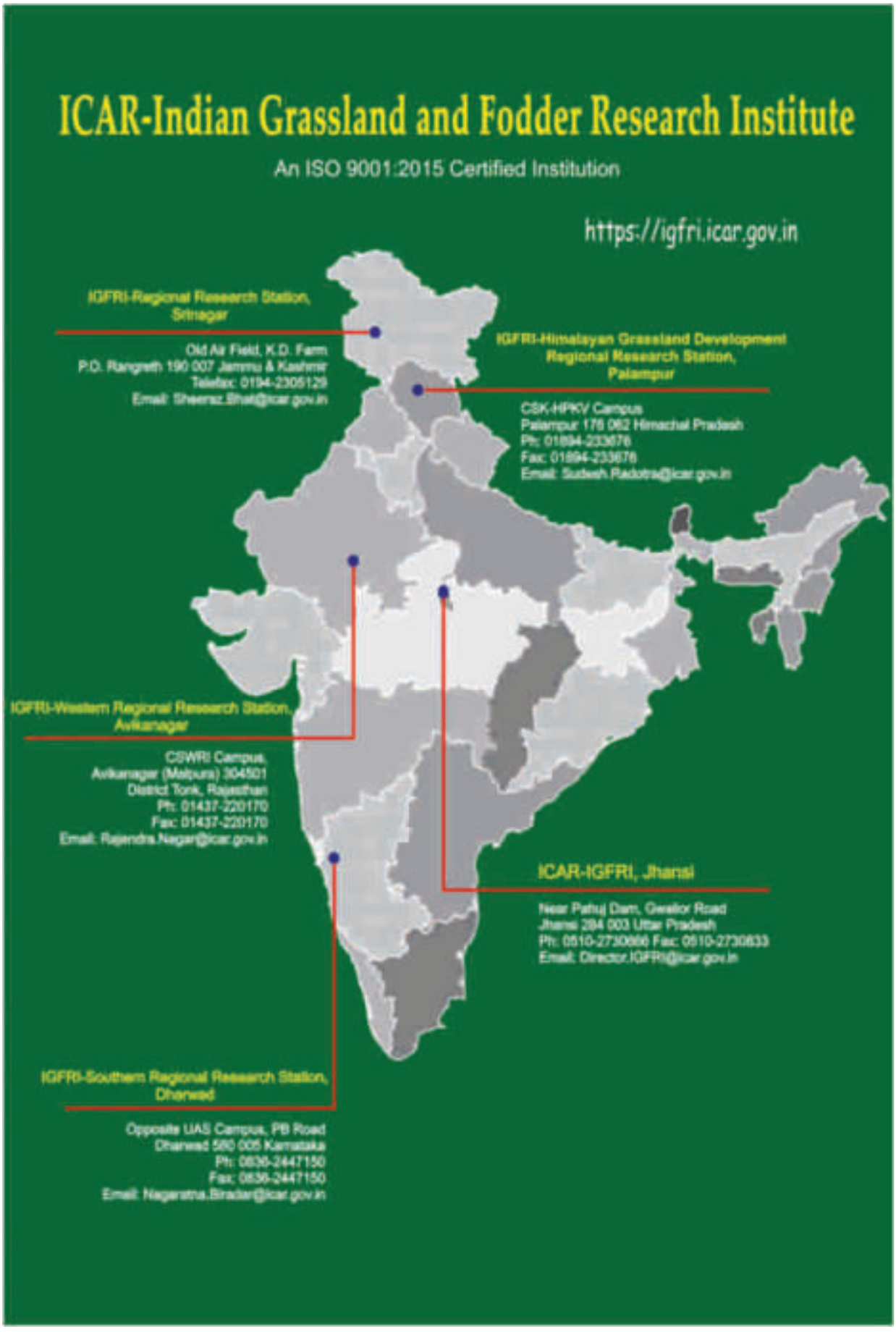
Towards enhancing quality forage seed production in berseem using stale seedbed technique, it was found that glyphosate @ 1.0 kg *a.i.*/ha *fb* imazethapyr + imazamox @ 0.07 kg *a.i.*/ha applied treatment recorded significantly highest plant height at harvest (60.7 cm), no. of effective tillers (305.1/m^2), no. of heads (739.6/m^2), GFY (28.03 t/ha), straw (2.98 t/ha) and seed yield (525 kg/ha) among all nine weed control treatments, except weed-free check. The observations in agro-morphological traits indicated that the symptoms of heat stress (3°C > ambient temperature) were marginally suppressed under elevated CO_2 (550+50 ppm) in oat. An efficient smoke water machine capable of generating uniformly mixed smoke water with minimum loss was fabricated. Berseem (Wardan, BB-3 and JBSC-1) seed stored at ambient and low-temperature was categorized into three groups based on color (yellow, red and dark red seed) using the RHS color chart. Yellow seed (161-A, 162-A) showed higher viability and vigour than red (164-A, 164-B) and dark red seed (165-B) and increase in storage period decreased germination percentage of all seed invariably.

During nutritional evaluation of forage resources fibre fractions *viz*. NDF, ADF, cellulose and lignin contents were found low in leaves of ten apple cultivars with 10.3-12.4% CP content and 64.0-77.5% *In vitro* dry matter digestibility. Leaves had adequate Ca (1.01-1.77%), Fe (382-1077 ppm), Mn (71.8-191 ppm), Zn (8.12-60.9 ppm), Cu (4.96-12.97 ppm) and Co (5.10-6.02 ppm), respectively. Palatability parameters in terms of dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were quite high and ranged from 3.21-3.85, 66.17-75.37 and 174-213%, respectively. Adequate mineral, higher digestibility, TDN, energy

and RFV substantiate apple leaves as a good to medium quality forage source for feeding ruminants.

Institute is currently focussing research on 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 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 29th May against normal date of 1st June and covered the entire country by 2nd July. The South west monsoon advanced in some parts of Kerala and south Tamil Nadu, some parts of south and east central Bay of Bengal and some parts of north east Bay of Bengal on 10th June. There were six monsoon depressions formed during the season; one system intensified into deep depression during 19-23 August. Out of six depressions, four systems in August, one in July and one in September. During August, the country received normal rainfall due to formation of deep depression over Bay of Bengal and over Arabian Sea during 12-13 August. In September, the country as whole received excess rainfall over north & central India due to favourable conditions (strength of La Nina conditions and frequent passage of western disturbances). Strength of Madden Julian oscillation (MJO) was weak on most of the days during the month. The southwest monsoon starts retreating from the northwestern parts of India on September 17, and withdraws completely from the entire country by October 15 and it has withdrawn completely on 23rd October from the remaining parts of the country.

2.1 Rainfall Pattern

In Jhansi, total rainfall of 826.8 mm was recorded during the year 2022 (January-December) in 34 rainy days. The rainfall deficiency was found to be 9% 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, 128.4 mm of rainfall occurred in 9 rainy days and it was higher by166.7% from its LPA. Rainfall during monsoon season or *kharif* season have received 697.8 mm rainfall, the deficiency was 19% from its LPA. The monsoon was active during the *kharif* season *i.e.* mid of June - September and the rainfall during 23- 39th SMW was 697.8 mm. In the month of July (27th-31st SMW), four weeks received rainfall in the range of 22.4 to 36.2 mm except in 29th SMW and rainfall deficiency was 36.2 to 100 percent. Further two weeks (32 and 33 SMW) of August received rainfall below it normal value. However, continuous rainfall occurred during the ensuing weeks in the month August to October. A heavy rainfall of 134.8 mm and 165.0 mm recorded in 34th and 37th SMW (Fig. 2.2), respectively resulted in water logging and it turn damage of legumes crops. Also, the monsoon was active up to mid of October (40th-42nd SMW), rainfall occurred during this period was 35.8 mm and it was more than 211% from their LPA.

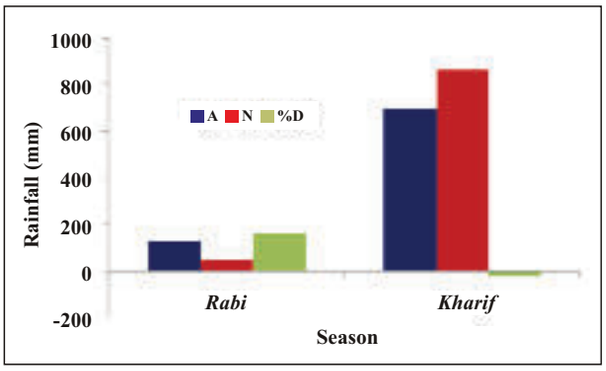


Fig. 2.1. Seasonal mean rainfall along with its departure from normal

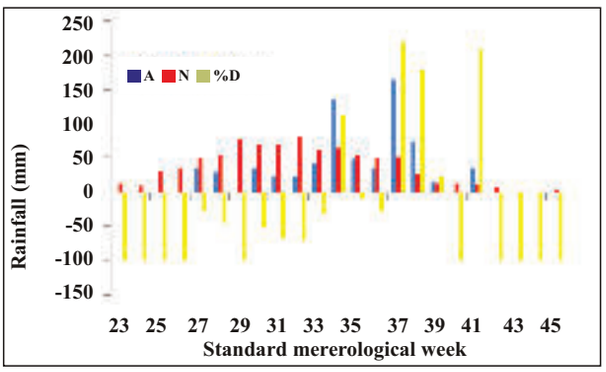


Fig. 2.2. Weekly rainfall distribution pattern and its departure (D) during *kharif* at Jhansi

2.2 Temperature

Mean annual maximum and minimum temperatures during 1-22 SMW were lower by 1.7 and 2.2°C than their respective corresponding normal value (MaxT=33.3°C and MinT=16.6°C). In *rabi* (1 to 10th SMW), maximum temperatures were lower from their corresponding normal temperature (Fig. 2.3) in the range of 0.24 (in 8th SMW) to 4.32°C (in 4th SMW). Further, in subsequent weeks (11-18 SMW) the maximum temperatures were higher than their corresponding normal in the range of 0.74 to 3.8°C, whereas, minimum temperatures were lower in the range of 0.7 (in 15th SMW) to 3.1°C (in 17th SMW) from their normal.

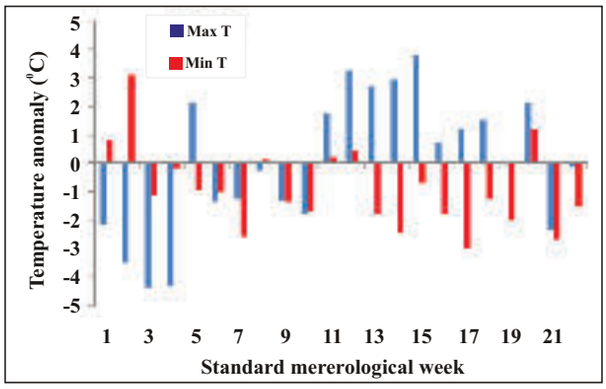


Fig. 2.3. Weekly anomaly pattern of maximum (MaxT) and minimum (MinT) temperature during *rabi*

Mean maximum and minimum temperatures for the period 23-52 SMW were slightly higher by 0.07 and 1.29 °C, respectively from their respective corresponding normal value (MaxT=30.5°C and MinT=17.1°C). In *kharif* season, maximum temperatures were in general higher in the range of 0.28 to 2.11°C from their normal values during 23-29th SMW. Further, 14 weeks (30-43 SMW) experienced lower maximum temperature from their normal in the range of 0.48 to 2.76°C. However, minimum temperature was higher in the range of 0.34-3.95°C during 25-50th SMW (Fig. 2.4).

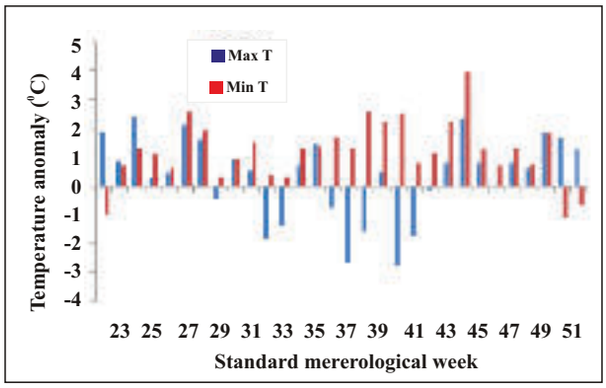


Fig. 2.4. Weekly anomaly pattern of maximum and minimum temperature during *kharif*

2.3 Evaporation

Mean *rabi* season evaporation rate (6.52 mm/day) was slightly higher by 2.9% than the normal (6.34 mm/day) evaporation rate (Fig. 2.5). Evaporation rate during 1-18 SMW period experienced high erevaporation rate in the range of 0.1 to 0.8mm/day against to its normal range (3.82 to 4.62 mm/day). Subsequent 4 weeks(19-22 SMW) recorded lower evaporation rate in the range 9.2 -10.0 mm/day from their corresponding normal (11.9-12.5 mm/day) value. Mean evaporation rate during *kharif* season was recorded to be 4.85 mm/day and it was slightly higher by 9.6% from its long period average (4.43 mm/day). Weekly evaporation rate/day during monsoon season (27-36 SMW) was higher in the range of 3.8 to 8.1 mm/day against their corresponding normal values (3.2 to 7.5 mm/day). In the post-monsoon (40-48 SMW) season, the evaporation rate oscillated in the range of 2.4 to 4.8 mm/day against its corresponding normal (2.6-4.1 mm/day).

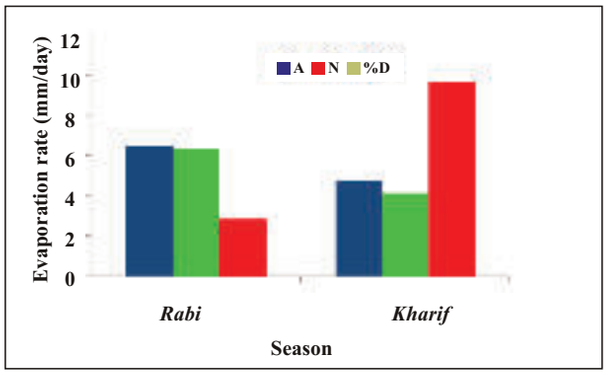


Fig. 2.5. Seasonal evaporation along with percentage departure (%D)

2.4 Relative humidity pattern

Mean morning relative humidity for both *rabi* (RH1) and *kharif* (RH1) season was found to be 72 and 82.1%, respectively and both were deficient by 5.6 and 10.7% from their normal. Morning relative humidity during the period (1-12 SMW) and (13-22 SMW) fluctuated between 81-95% and 53-77%, respectively. Similarly, morning relative humidity during the period 26-39 SMW and 40-52 SMW were fluctuated between 74-93 and 82-89%. Mean afternoon relative humidity during *rabi* (RH2) and *kharif* (RH2) was found to be 42.5 and 53.3%, respectively and these were significantly higher by 31.9and 6.5%, from their corresponding normal. After noon relative humidity was oscillated between 24-71% during 1-22 SMW. The afternoon relative humidity fluctuated between 60-72% and 32-73% for the period 26-39 and 40-52 SMW, respectively.

Chapter 3

Research Achievements

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

3.1.1 Augmentation, characterization, conservation and documentation of forage genetic resources

(CRSCIGFRISIL20100101)

Forage germplasm evaluation

Forty eight accessions of forage crops belong to 15 genera and 18 species from Chhattisgarh, Uttar Pradesh, Gujarat, West Bengal and Jharkhand were characterized during *kharif* 2022. They comprised *Apluda mutica* (11), *Cenchrus pedicellatus* (9), *Cenchrus ciliaris* (1), *Cenchrus setigerus* (2), *Sorghum bicolor* (5), *Dichanthium annulatum* (4), *Chloris guayana* (3), *Cymbopogon citratus* (1), *Dichanthium aristatum* (1), *Digitaria longifolia* (1), *Echinocloa crusgalli* (2), Kodo millet (1), *Paspalum dilatum* (1), *Setaria pumila* (1), *Sporobolus marginatus* (1), *Themeda triandra* (2), *Iselilema laxum* (1), and *Panicum* sp. (1). Agro-morphological traits were recorded and significant variability was observed in *Apluda mutica*, *Cenchrus pedicellatus*, *Sorghum bicolor* and *Dichanthium annulatum*. In *Apluda mutica* plant height varied from 83.7-147.2 cm, no. of leaves from 6.0-33.7, leaf length from 8.1-20.86 cm, inflorescence length from 7.2-20.0 cm and dry matter yield (DMY) from 7.83-63.0 g. *Cenchrus pedicellatus* recorded 74.0-132.2 cm plant height, 9.0-36.0 leaves, 14.6-25.3 cm leaf length, 8.3-12.3 cm inflorescence length and 28.0-160.8 g DMY. Lablab beans (137 accessions) were grown in a 3 m × 0.5 m plot and GFY ranged from 1.25-7.26 kg/plot.

Conservation of germplasm in NGB

A total of 87 accessions comprising *Cenchrus pedicellatus* (70) and cowpea (17) germplasm were sent for conservation at the National Gene Bank (NGB), New Delhi.

Rejuvenation of germplasm

Dinanath (116) and forage crops (48 accessions) collected from Indian states were rejuvenated during the reporting period.

AICRP trials in grasses

Six accessions of *Dichanthium-Bothriochloa* complex were submitted for AICRP trial.

Maintenance of germplasm in the Field Gene Bank

Three BN hybrid new varieties and one guinea grass were added to the 16 varieties of marvel grass, guinea grass, and BN hybrid maintained in the FGB.

3.1.2 Development of genetic and genomic resources for low moisture stress tolerance in berseem

(CRSCIGFRISIL20180101)

Introduction and multiplication of berseem germplasm

A total of 267 berseem germplasm introduced from NBPGR were multiplied for evaluation and conservation in NGB.

Induction and evaluation of mutant population

Mutant population using EMS (0.2%) in the background of JHB-17-1 was developed. Developed M2 mutants were screened and genotypes for delayed flowering with high biomass against check varieties were selected.

Notification of berseem varieties

Two berseem varieties Bundel Berseem 7 (JHB-18-1) and Bundel Berseem 8 (JHB-18-2) were released and notified vide gazette notification number S.O. 4065(E) dated 31st August 2022 for Punjab, Haryana, Rajasthan, Union territory of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra.

Nucleus seed production

Nucleus seed of institute berseem varieties *viz*., Wardan (5), Bundel Berseem-2 (4), Bundel Berseem-3 (2), JBSC-1 (10), JHB 17-1 (10) and JHB-17-2 (12), JHB-18-1 (15) and JHB-18-2 (20 kg) were produced.

Station trial

A station trial comprising 18 entries with two checks *viz*., Wardan, BB-2 was conducted. Entries STB-21-3, STB-21-5 STB-21-6 showed >10% superiority in GFY and DMY over check varieties were selected for multilocation testing.

Contribution of berseem entries to AICRP trials and Coordinated trial

Two berseem entries (JHB-20-1, JHB-20-2) in AVT-1 and one entry (JHB-22-1) in IVT were contributed in AICRP (FC&U) *rabi* 2022-23. In berseem coordinated trials *viz*., IVT, AVT-1, AVT-2 and AVT-2 (seed) were conducted.

Evaluation of berseem RILs under low moisture stress

Berseem recombinant inbred lines (RILs; 200 lines) developed from a cross between IL-16-8 6 (inbred line of Fahli ecotype) and IL-13-106 (line derived from *T. alexandrinum* × *T. apertum*) were evaluated for agro-morphological traits and physio-biochemical traits at 2.7, 13.1 and 26.3% available soil moisture in 0-15 (39.2°C), 15-30 and 30-45 cm (38.6°C) soil depths, respectively. The RILs showed variability for plant height (46-105 cm), basal branching plant^{-1} (1.0-11.0), days to 50% flowering (95-121 days), dry biomass plant^{-1} (1.5-13.8 g), SPAD (21.5-65.1) and canopy temperature depression (2.50-11.25°C). Based on these traits best performing lines were identified for further evaluation and utilization in breeding programme.

Evaluation of wide cross lines

A total of 126 lines derived from wide cross of berseem with *T. apertum* were evaluated for various agro-morphological, physiological and forage quality traits. Berseem lines *viz*., BTA-17-1-54, BTA-17-1-97, BTA-17-1-53, BTA-17-1-95, BTA-17-1-98 were found superior in green forage productivity, BTA-17-1-52 exhibited highest chlorophyll a, chlorophyll b and total carotenoids contents and two lines (BTA-17-1-95 and BTA-17-1-101) were found superior in forage quality traits.

Characterization and multiplication of unique berseem germplasm

The developed stable unique berseem lines *viz*., high and low chlorophyll contents line, deformed leaf line and dwarf line were characterized and multiplied.

3.1.3 Development of fertile variants of BN hybrids through *in vitro* plant regeneration

(CRSCIGFRISIL20160102)

Development and characterization of novel tetraploid BN hybrids

Using an embryo rescue technique, six novel tetraploid BN hybrids (TBN-22-21 to TBN-22-26) were developed by crossing tetraploid maintainer pearl millet with different Napier lines. Out of these, only one was fertile (TBN-22-23). Overall, 3 fertile tetraploid BN hybrids (TBN-20-15, TBN-21-19 and TBN-22-23) were generated and will be helpful in easy dissemination to the farmers' field and also for studying the pairing behaviour of pearl millet and Napier chromosomes.

Characterization of novel tetraploid seed producing BN hybrid (TBN-21-19)

The fertility of novel tetraploid seed producing BN hybrid (TBN-21-19) was confirmed by stigma receptivity and pollen viability studies. This hybrid has 80-90% seed germination ability with more vigour and biomass than TBN-20-15. The hybridity was confirmed by morphology, molecular and cytogenetic studies. The seed size is more than TBN-20-15. Interestingly, few seeds of TBN-21-19 were of bajra type.

Stabilization and Fixation of novel tetraploid seed producing BN hybrid

About 1100 F_3 plants and 750 F_4 plants of TBN-20-15 were advanced to the next generation using a rapid generation advancement technique. During last year, apomictic loci of *Pennisetum squamulatum* was transferred to TBN-20-15, and a total of 27 hybrid plants were recovered with completely different morphology. The transfer of the apomictic loci to these hybrids was checked using an apomictic specific primer (Apo #562 Q8M) and 12 out of these 27 hybrids were found apomictic type. These apomictic type hybrids are important for fodder and seed quality traits and will be subjected to station trial.

Napier germplasm evaluation

A collection of 65 exotic Napier (*Cenchrus purpureus*) germplasm was dissected for agro-morphological and molecular level variation. In the present study, 22 quantitative and qualitative traits related to yield and fodder quality were recorded. Further, 18 SSR markers showed a high degree of polymorphism among studied germplasm. These SSRs amplified a total of 74 alleles with an average of 0.64 PIC content. Based on the mean performance of genotypes and pooled morphological and molecular analysis, five genotypes *viz*., IGFRI-N11, IGFRI-N15, IGFRI-N30, IGFRI-N32 and IGFRI-N54 having high GFY per plant (>2.5 kg/plant) were selected for estimation of fodder values. As per forage quality traits, IGFRI-N11 and IGFRI-N30 may be recommended for fodder purposes while

IGFRI-N15, IGFRI-N32 and IGFRI-N54 for bioethanol production.

3.1.4 Genetic improvement of maize for high biomass and fodder quality

(CRSCIGFRISIL20200105)

Procurement and multiplication of maize germplasm

Eighty-nine germplasm lines were procured from NBPGR, New Delhi. The seeds of these lines were multiplied by bulk pollination. Twenty S4 inbreds were procured from CIMMYT Regional Centre, Hyderabad.

Evaluation of maize germplasm for fodder biomass and attributing traits

A total of 126 maize germplasm lines were evaluated for the second year and three lines (IG-01-703, IG-02-04-02 and IG-02-34) were identified for high fodder biomass. 89 maize lines received from NBPGR, New Delhi were evaluated and two lines *viz*. IC396864 (7.3%) and IC622330 (10.2%) were found superior over African Tall and J-1006. In addition, the silage quality of ten newly developed speciality maize hybrids (ABSH4-1, PSSC-1, PSSC-2, APCH-2, APCH-3, APH-1, PHM9I, PHM8I, PHQPM5I and PVQ9I) along with three checks (African Tall, J-1006 and CoHM-8) was determined. PHM9I recorded significantly higher CP (10.1%) and IVDMD (60.4%) and significantly lower NDF (67.1%) and ADF (33.2%), while APH-1 exhibited significantly lower ADL (2.66%) and ABSH4-1 possessed significantly higher total ash (10.04%) compared to African Tall and J-1006. The micronutrients concentration of Fe, Zn, Cu and Mn were highest in PVQ9I (38.94 ppm), J-1006 (151.7 ppm), PSSC-1 (9.94 ppm) and PSSC-2 (52.8 ppm), respectively.

Intra-specific hybridization

Selected plants in F1s of eleven populations (AT × J-1006, AT × J-1007, AT × KDFM-1, AT × TSFM-15-5, J-1006 × KDFM-1, J-1007 × KDFM-1, J-1006 × TSFM-15-5, J-1007 × TSFM-15-5, AT × IG-02-04-02, IG-01-703 × AT and AT × IG-02-31) were bulk pollinated to increase the frequency of superior alleles for fodder biomass. The bulk seeds were then grown in isolation to reach the populations in Hardy-Weinberg equilibrium.

Inter-specific hybridization

African tall and J-1006 were crossed with teosinte (Teo-1 accession) and the resultant F_1s were characterized for tillering habit (Fig. 3.1.1a). The F_1s plants with tillering habit were genotypes for Tb1 gene using molecular markers, which confirmed the heterozygous nature of F_1s at Tb1 locus (Fig. 3.1.1b).

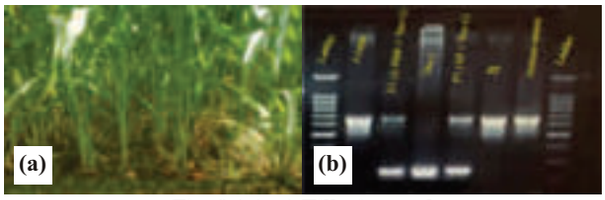


Fig. 3.1.1. a) Tillering and b) segregation pattern of Tb1 gene in F1 plants

Development of inbreds

Forty three S_3 inbreds were advanced to S_4 inbreds. Twenty inbreds were advanced from S4 to S5 generation. About 5-10 plants each were also selfed in African Tall, J-1006, J-1007, TSFM-15-5 and KDFM-1 to develop a fresh set of inbreds.

Station trial

A station trial of eleven advanced populations was conducted and four populations *viz*. AT × KDFM-1, J-1007 × AT, AT × IG-02-04-02 and TSFM-15-5 × KDFM-1 were found superior over both the checks (African Tall and J-1006).

AICRP trials

Three AICRP trials *viz.* IVTM (32), AVTM-1 (9) and AVTM-2 (7 entries) on fodder maize and four trials of IARI, New Delhi with 20, 37, 50 and 48 entries were conducted.

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

(CRSCIGFRISIL20200101)

Forage pearl millet inbred line development

A total of 50 S1, 133 S2, 93 S3 and 20 S4 generation forage pearl millet inbred lines have been developed through continuous selfing of different high biomass pearl millet germplasm and forage bajra varieties. Eighteen (10 lines of IGFRI and 8 lines from ICRISAT) were screened for blast resistance through artificial inoculation and other biochemical parameters. Two inbreds derived from landrace (Rajlocal-S1-S2-S3-34S4 and Rajlocal-S1-S2-S3-46S4-S5) were found highly resistant having a disease scale of 3.

Development of mapping populations

Two F2 mapping population for blast tolerance were developed crossing between ICMR 356 × ICMB99666 and ICMR 9333 × ICMB95444. Both the crosses had shown 3 (resistant): 1 (susceptible) segregation in F2 generation indicate a single

dominant gene control foliar blast resistance in pearl millet. Two bmr mapping populations were developed by crossing (bmr line) ICbmr07 × ICBP19 (non bmr line) and (bmr line) ICBbmr09 × ICBP 01(non bmr line). These populations will be utilized for mapping blast resistance and bmr genes in pearl millet. About 256 pearl millet association panels were evaluated for forage yield component traits.

Development of high biomass pearl millet genotypes

Three entries JHPM-22-1, JHPM-22-2 and JHPM-22-3 have been submitted to the initial varietal trial 2022 in AICRP on forage crops and utilization. Through phenotypic recurrent selection and pedigree breeding methods many high biomass lines and composites which are suitable for single cut and multicut nature have been developed.

Trials conducted in pearl millet

Three AICRP trials IVPTM, AVPTM-1 and AVTPM-2 on fodder pearl millet were conducted during *kharif* and one summer pearl millet multicut trial from ICRISAT were conducted in summer, 2022.

3.1.6 Developing erect type and multicut fodder cowpea with enhanced nutritional quality

(CRSCIGFRISIL20210103)

Rejuvenation of cowpea germplasm

A total of 200 cowpea accessions procured from NBPGR, New Delhi were rejuvenated for seed multiplication.

Evaluation of cowpea germplasm

A total of 159 cowpea genotypes including two checks, BL-1 and BL-2 were evaluated for 22 agro-morphological traits. Eleven genotypes performed (396.0-499.0 g/plant) better than checks (273.0-367.0 g/plant) for green forage yield. These eleven genotypes were then analyzed for forage quality. Genotypes IC20696 and IC240885-2 recorded significantly lower lignin, NDF and ADF content than checks. Genotype EC724773 had significantly higher CP content over checks. These genotypes can be used as potential donors for the forage quality improvement of cowpea.

Generation of crosses

Eight crosses were generated between nine selected genotypes of four groups' *viz*., high biomass (EC100094, BL-1, BL-2) × multicut (EC240891, IC402125, EC724773), high biomass (BL-1, 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 multi-cut trial consisting of 9 entries and two check varieties (BL-1 and BL-2) was conducted. Three entries (IC402125, EC240891 and EC724773) recorded higher GFY (41.39-51.23 t/ha) than checks (37.01-38.69 t/ha) across three cuts at 50, 80 and 110 days after sowing. Eight entries of cowpea along with three checks (BL-1, BL-2 and BL-4) were also evaluated in the station trial. Three entries EC107119, EC100094 and EC724773 (49.9-53.9 t/ha) performed better than checks (39.3-48.1 t/ha) for GFY.

Multiplication of promising cowpea genotypes and nucleus seed production

Seed multiplication of three multicut and two high biomass cowpea genotypes was carried out. Nucleus seed of four forage cowpea varieties *viz*., BL-1 (3), BL-2 (3), BL-4 (3) and MFC-09-1 (2 kg) was produced.

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

(CRSCIGFRISIL20160103)

The 112 lines procured from NBPGR, New Delhi were evaluated. A novel fodder sorghum genotype (identity IS 3260; EC 484238) with multiple gynoecia was identified (Fig 3.1.2a & b). Ten station trial entries were sown for seed multiplication purpose and HCN estimation. F_1 seeds of two crosses (IGS-1xIGS-114; MP-Chari x IGS-167) were confirmed for hybridity by morphological as well as molecular studies. The 27 sorghum lines were sown and evaluated. Three cuts were taken 1st cut at 55

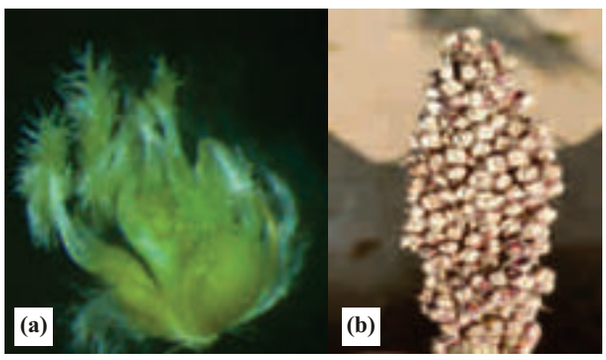


Fig 3.1.2 a) Microscopic view of multiple gynoecia b) Twin-triplet seeded panicle of novel fodder sorghum genotype IS 3260; EC 484238

days after sowing (DAS) and the next two cuts were taken at 40 days of interval. The average mean performance of three cuts for GFY and DMY ranged from 1.11 to 4.66 kg/m^2 and 0.3 to 1.33 kg/m^2, respectively. Sorghum lines (65) procured from IIMR, Hyderabad were evaluated for single cut, and found GFY ranged from 1.5 to 2.75 and DMY 0.25 to 0.66 kg/m^2. Three sorghum lines (IGS-1, IGS-141 and IGS-210) were evaluated for multiple foliar disease reactions at hot-spot multi-locations (Jhansi, Dharwad and Ludhiana). The application for registration of two lines (IGS-1 and IGS-141) for multiple foliar disease resistance was submitted.

3.1.8 Identification of oat lines for heat stress tolerance

(CRSCIGFRISIL20200103)

About 100 oat accessions were screened for heat stress tolerance in normal (NS) (last week of November; max./min. temperature <32/20 °C) and late sowing (LS) (first week of February; max./min. temperature >32/20 °C) conditions. Morphological traits *viz*. plant height (78.33-153.33 in NS and 59-110 cm in LS), fresh weight (1.52-4.8 in NS and 0.845-2.95 kg/plot in LS), dry weight (0.304-0.835 in NS and 0.122-0.740 kg/plot in LS), days to 50% flowering (81-114 in NS and 60-74 in LS), canopy temperature (19.3-27.9 °C in NS and 25-31.8°C in LS), no. of seed per panicle (55-120 in NS and 12-39 in LS) and SPAD values (35.26-57.40 in NS and 30.5-53.36 in LS) were recorded both in normal and late sowing conditions. The screening revealed some promising heat-tolerant genotypes based on the heat susceptibility index (HSI) which can be used in breeding program (Table 3.1.1).

3.1.9 Identification and characterization of genes involved in expression of apomixis component-traits in polyploidy series of guinea grass

(CRSCIGFRISIL20210101)

An expression study was conducted in guinea grass (*Megathyrsus maximus*) lines of varying ploidies and mode of reproduction by Real-time PCR analysis of the somatic embryogenesis receptor kinase (*SERK*) gene. Plants of the ploidy series representing eight ploidy levels (3x, 4x, 5x, 6x, 7x, 8x, 9x and 11x) and one obligate sexual plant SRP75 were used for this study. Expression study of *SERK* gene showed that the expression pattern differed in ploidies at premeiotic, meiotic and post meiotic stages as compared to the sexual line (Fig. 3.1.3)

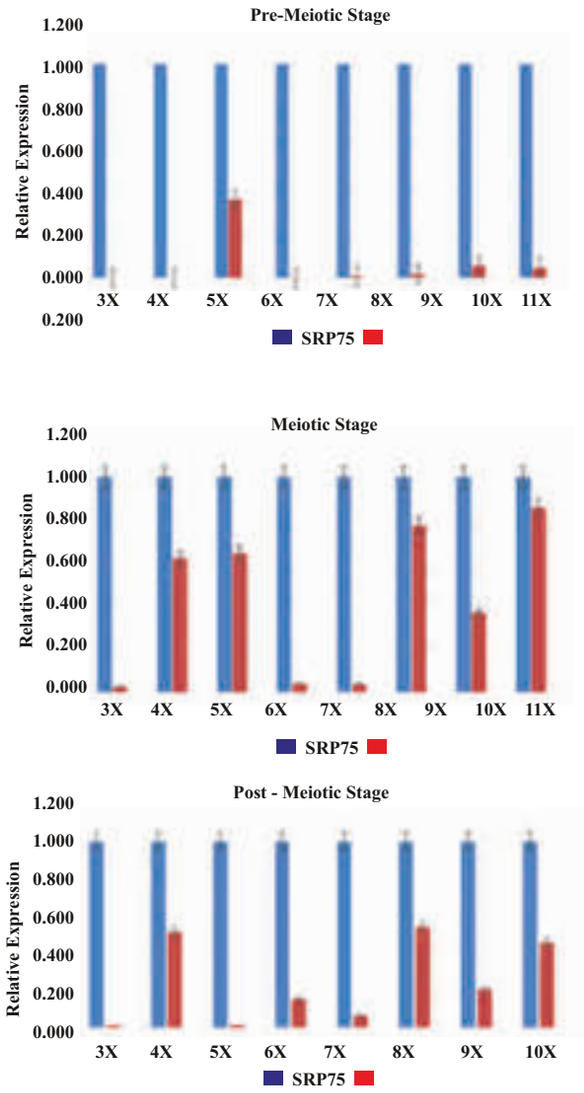


Fig. 3.1.3. Real time PCR analysis of somatic embryogenesis receptor kinase gene (*SERK*) in ploidy series of Guinea grass

Table 3.1.1 Details of promising genotypes for heat-tolerance

Category	Genotypes	Heat Susceptibility Index
Highly heat-tolerant	EC209390, EC096576, NGB-6372-1, NGB-6189, and EC-108656	0.26-0.43
Heat-tolerant	NGB-6202, NGB-6580, EC097520, EC-425112, and EC-10448	0.51-0.68
Moderately-tolerant	NGB-5118, EC-104472, EC-209416, and EC-13129	0.76-0.86

3.1.10 Genomic assisted breeding for zinc and iron biofortification in oats

(CRSCIGFRISIL20210102)

Phenotyping of diverse oat material for Zn, Fe and other fodder traits

Diverse oat germplasm comprising 400 accessions (oat core collection, different oat species, released varieties of oat and previously selected oat bio-fortified lines) were evaluated for zinc and iron content. In addition, various agro-morphological and physiological traits *viz*., days to 50% flowering, stem girth, panicle length, no. of spikelets per panicle, florets per panicle, leaf length, leaf number, leaf width, internode length, SPAD1 (at flowering) SPAD2 (20 days after flowering), plant height, canopy temperature, flag leaf length, flag leaf width, GFY, DMY and seed yield were also recorded. Based on mean zinc and iron content, a diverse association panel of 192 individuals was formed. This diverse 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; HRRS-IGFRI, Palampur, and CCSHAU, Hisar, in *rabi* 2022-23 for phenotyping of Zn and Fe content.

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

(CRSCIGFRISIL20190401)

Endophytic bacterial (19 no.) and fungal (12 no.) isolates were isolated from cowpea and berseem roots. Isolated endophytic microbes are evaluated against stem rot pathogen *i.e. Sclerotinia trifoliorum*. Further, zinc and iron-based nanoparticles were green synthesized by using cow urine as a reducing agent. Particle size characterization and evaluation against berseem stem rot pathogen are under progress.

3.1.12 Evaluation of berseem gene pool for herbicide tolerance

(CRSCIGFRISIL20200401)

Previously, nearly 180 mutant lines of berseem were selected which showed a varied level of glyphosate tolerance. During this year, these 180 mutant lines were again validated for their response against glyphosate tolerance with 0.8 kg a.i. /ha and 50 mutant lines were selected. Since no significant variations were observed with respect to the imazethapyr herbicide during the first year, so this treatment was excluded from the study.

3.1.13 Genetic improvement of temperate forage crops

(CRSCIGFRISIL20211002)

About 18 accessions of sainfoin (*Onobrychis viciifolia*) and 45 accessions of orchard grass (*Dactylis glomerata)* were evaluated at ICAR-IGFRI RRS Srinagar. Significant variations were observed for sainfoin plant height (103.5-136 cm), number of tillers per plant (14.2-30.3), green herbage yield (42.3-54.7 t/ha), dry herbage yield (12.19-18.3 t/ha). Significant variations in 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), dry herbage yield (10.3-16.8 t/ha) were also recorded in orchard grass. A non-conventional fodder legume, *Vicia faba* (13 collections) was evaluated for seed and plant biomass traits. Significant variation was observed for seed traits *viz*., seed length (12.2-20.5 mm), seed width (8-12.5 mm), seed thickness (5.1-6.7 mm) and 100 seed weight (35.6-119.6 g), while biomass traits such as height (40.3-75.5 cm), GFY (15.5-23.6 t/ha), and DFY (5.6-7.24 t/ha) were recorded. Whereas, the CP (16.8-22.3 %), NDF (33.1-45.5%), ADF (27.2- 38.7%), ADL (4.25-7.57%) and ash content (8.62-10.1%) were recorded and found significant variations in forage quality traits.

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

3.2.1 Establishment and evaluation of almond based hortipastoral systems in Karewa uplands of Kashmir

(CRSCIGFRISIL20141002)

Fig. 3.2.1. View of almond intercropped with *Phalaris aquatica* grass

Weed dynamics study in horti-pastoral systems has great significance by identifying and eradicating weed species unsafe for animal consumption, eg. *Anthemis cotula*, a common bad smelling obnoxious weed render foul odour in milk if consumed by lactating cows. Major weed flora found in field included *A. cotula, Sinapis arvensis*, *Chenopodium album, Rumex dentatus, Conyza canadensis, Carthamus lanatus, Capsella bursa-pastoris, Tragopogon dubius, Hypericum perforatum, Plantago lanceolata*. The intercropped treatment of *Phalaris* + red clover recorded minimum weed count of 10.64 m^{-2}, while as maximum weed density was observed in control plot (90.64 m^{-2}) followed by timothy (58.65 m^{-2}) and red clover (54.14 m^{-2}), when grown as sole. *Phalaris* + red clover recorded highest weed control efficiency (79.85%) followed by tall fescue + red clover (69.25 %) and *Dactylis* + red clover (68.64%). It is recommended that interspaces in almond orchards could be utilized for growing forage crops like, *Phalaris*, tall fescue and orchard grass in combination with red clover in 50:50 proportion for enhanced forage yield and effective weed control.

3.2.2 Forage yield and quality of grass-legume mixtures in mulberry based silvopastoral systems

(CRSCIGFRISIL20171001)

In mulberry based silvopastoral systems, maximum forage yield (74.23 t GFY and 20.93 t DM ha^{-1}) was observed under the tertiary mixture comprising *Phalaris* + orchard grass + sainfoin + mulberry which was followed by *Phalaris* + sainfoin + mulberry (Fig. 3.2.2; 66.2 t GFY and 17.80 t DM ha^{-1}), whereas minimum fodder yield (23.41 t GFY and 6.42 t DM ha^{-1}) was observed under the control treatment (natural vegetation). However, crude protein was found maximum (20.03%) under the treatment T_3 (sainfoin + mulberry) and minimum in the control treatment (4.41%). Maximum CP yield (3.21 t/ha) was observed in *Phalaris* + orchard grass + sainfoin + mulberry followed by *Phalaris* + Sainfoin + mulberry (2.82 t/ha).

Fig. 3.2.2. Sainfoin + *Phalaris* grass intercropped with mulberry

3.2.3 Canopy management in *Hardwickia binata* based silvipasture system

(CRSCIGFRISIL20180303)

In *Hardwickia binata* based silvipasture systems (Fig. 3.2.3a), *Chrysopogon fulvus* recorded maximum pasture yield (9.18 t/ha) followed by *Cenchrus ciliaris* (8.86 t/ha) and *Panicum maximum* (7.41 t/ha). In canopy management (Fig. 3.2.3b), 60% canopy pruning of *H. binata* resulted in significantly higher pasture yield (9.50 t/ha) than 30% pruning (7.60 t/ha) and 45% canopy pruning (8.36 t/ha). Top feed (3.27 t/ha) and fire wood yield (4.65 t/ha) also significantly increased with 60% canopy pruning of *H. binata* than 30% (2.08 and 2.84 t/ha) and 45% pruning (2.59 and 3.63 t/ha), respectively. *H. binata* recorded 23.04 t C/ha at 15 years age. In total carbon stock of *H. binata*

contribution of above and below ground carbon stock were 78.1 and 21.9%, respectively. Pooled data of two months showed that *C. fulvus* recorded higher moisture content (6.39, 7.21 and 7.81%) as compared to *C. ciliaris* (5.96, 6.83 and 7.52%) and *P. maximum* (5.43, 6.44 and 7.23%) at 0-15 cm, 15-30 cm and 30-60 cm soil depth, respectively. Similarly, light canopy pruning of *H. binata* (30%) resulted in maximum moisture content (6.50, 7.33 and 7.92%) followed by 45% pruning (6.01, 6.89 and 7.57%) and 60% canopy pruning (5.27, 6.25 and 7.07%) at 0-15 cm, 15-30 cm and 30-60 cm soil depth, respectively.

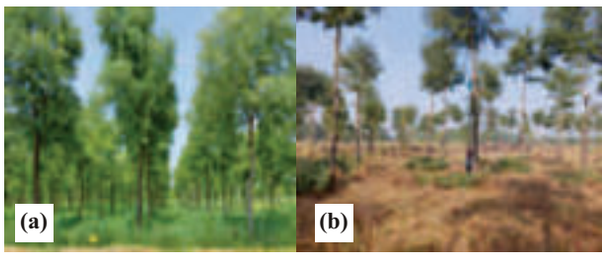


Fig. 3.2.3. a) *Hardwickia binata* based silvipasture system, b) Canopy management in *H. binata* based silvipasture system

Sustainable forage production through lopping management in three tier SPS

In three tier silvipasture system (SPS), planting of *H. binata* and shrub species in alternate row at 6x6 m spacing recorded significantly higher understorey pasture yield of *Cenchrus ciliaris* (9.35 t/ha) as compared to 6x4 m (8.01 t/ha) and 4x4 m spacing (6.16 t/ha). Among shrub species, *Ziziphus xylopyrus* recorded maximum top feed (2.84 t/ha) and fire wood (3.73 t/ha) followed by *Z. mauritiana* (2.51 and 3.37 t/ha) and *Acacia catechu* (2.01 and 2.86 t/ha), respectively. In total lopped dry yield of three tier silvipasture system (5.77 t/ha), contribution of top feed and fire wood were 42.5 and 57.5%, respectively. In lopping management (Fig. 3.2.3a), 70% lopping intensity of shrubs and tree resulted in higher top feed (2.81 t/ha) and fire wood (3.80 t/ha) as compared to 50% lopping intensity (2.09 and 2.84 t/ha). *A. catechu* based three tier SPS recorded maximum C stock (13.45 t/ha) followed by *Z. xylopyrus* (11.64 t/ha) and *Z. mauritiana* (11.27 t/ha). However, NDF, ADF and lignin content (75.1, 53.1 and 9.04%) increased with maturity of herbage during post growing season than growing season (67.1, 43.9 and 7.94%, respectively). Nutrient utilization study on goats and sheep (Fig. 3.2.3b) indicated that along with 1% concentrate supplementation, DM intake was 3.93% in goats and 3.84% in sheep. Digestibility of DM, OM, CP and NDF were 62.2, 65.3, 62.8 and 59.5% in goats and 60.9, 64.8, 61.5 and 58.2% in sheep, respectively. DCP and TDN intake (g/kg $w^{0.75}$) were 6.12 and 56.6 in goats and 5.87 and 54.6 in sheep. Nutrient content in terms of DCP and TDN content of the diet based on grazing plus supplementation was 7.22% and 66.50% in goats and 7.02% and 65.30% in sheep. Average daily gain was around 63 g in goats and 60 g in sheep from grazing and browsing in three-tier silvipasture system.

Fig. 3.2.4. a) Lopping management and utilization of top feeds by sheep and goats
b) Mixed herd grazing in three-tier silvipasture system

3.2.4 Evaluation of ecosystem productivity in grown up hortipastoral system for fruit and forage security with management practices

(CRSCIGFRISIL20180304)

Aonla based hortipasture ecosystem with micronutrient management

An experiment was conducted for improvement of ecosystem productivity in a 15 years old grown up aonla based horti-pastoral system (HPS) through foliar application of micronutrients (B & Zn). In the 5th year, tree growth except tree canopy spread was not influenced with foliar application of Borax and $ZnSO_4$. Micronutrient application significantly influenced the fruit yield as compared to control and it was highest (12.8 t/ha) with (T_3) followed by T_4 and T_2 (12.4 and 12.3 t/ha). Physico-chemical composition was significantly better with the application of foliar spray on trees over control. However T_3 and T_4 showed better performance than control in physico-chemical compositions of fruits. The under storey pasture production ranged from 5.2-5.5 t DM/ha and was not influenced with foliar application of micronutrients. Aonla based HPS stored 16.93-17.95 Mg C ha^{-1} in biomass (above + below ground) under various micronutrient regimes.

Guava based hortipasture ecosystem with pruning management

In a 14 years old grown up guava based HPS pruning management was employed for improvement of

ecosystem productivity. In the 5th year of experiment the guava tree growth [height, collar diameter (CD) and tree canopy spread] was not influenced with variety but significantly influenced with pruning treatment. The unpruned tree gave maximum height and canopy in cultivar *viz*., Lalit (6.3/6.0 m) and Shweta (6.2/5.8m), respectively. The tree CD was also influenced with pruning and maximum CD was recorded with maximum pruning. The fruit yield was also significantly influenced with cultivar. Lalit produced higher (8.6%) fruit (15.1 t/ha) as compared to Shweta (13.9t/ha). The pruned trees produced significantly higher fruit yield as compared to unpruned trees (Fig. 3.2.5). Medium pruned trees produced highest fruit production in both cultivars of guava (Lalit 17.5 & Shweta 16.7t/ha). The physical composition was performed significantly better in Shweta and chemical composition was found better in Lalit. Physico-chemical compostion was also influenced with pruning and medium pruned tree gave significantly better response. The reseeded understorey pasture (*C. ciliaris* + *Stylosanthes hamata*) for rejuvenation produced 2.9-3.9 t DM/ha and was not influenced by the pruning and tree cultivars. The total system stored 19.18- 25.15 Mg C/ha in biomass (above + below ground) under various pruning regime.

Fig. 3.2.5. Harvested guava in experimental plots

3.2.7 Studies on temperate pastureland for enhanced forage yield, quality and environmental sustainability

(CRSCIGFRISIL20201001)

Highest GFY with respect to pasture composition was recorded in T_2 (tall fescue$_{25\%}$ + orchard grass$_{25\%}$ + sainfoin$_{50\%}$) (36.30 t/ha), followed by T_3 (tall fescue$_{25\%}$ + orchard grass$_{25\%}$ + red clover$_{50\%}$) (31.80 t/ha) and T_1 (tall fescue$_{50\%}$ + orchard grass$_{50\%}$) (31.44 t/ha). Similarly highest DFY was recorded in T_2 (11.28 t/ha) followed by T_3 (10.67 t/ha). Among the cutting intervals, highest GFY (30.71 t/ha) and DFY (10.08 t/ha) was recorded in 40 days cutting interval after first harvesting. Combination of tall fescue, orchard grass and sainfoin sown in the proportion of 25:25:50%, respectively, harvested at the boot stage of grasses and subsequent cuts taken at an interval of 40 days resulted in highest fodder yield. Grass-legume combinations resulted in higher fodder yield compared to grass monocultures. Fodder yield also recorded an overall increase of 8.33-16.69% in GFY and 6.48-21.56% increase in DFY from the preceding year. Sown pastures also led to an increase of 152.3-202% in GFY and 96.1-119.9% in DFY over control. All the pasture types recorded low N availability. T_2 recorded highest available N (171.97, 170.19 and 168.41 kg/ha) at all cutting intervals. Available N decreased with increasing soil depth and also with increasing cutting interval.

3.2.8 Study of restoration ecology in silvipasture system for semiarid region

(CRSCIGFRISIL20200301)

Green forage biomass production was higher in *Panicum maximum* (33.1) followed by *Chrysopogon fulvus* (22.5) and *Stylosanthes seabrana* (4.62 Mg/ha) with different tree/shrub combinations of silvipastoral system. Crown lopping (30%) was imposed on tree species (Fig. 3.2.6 a & b) and pollarding on shrub species (Fig. 3.2.7 a & b) for obtaining top feed/fodder. Maximum edible green biomass production was obtained from *Ficus infectoria* (5.72) followed by *Leucaena leucocephala* (5.01), *Acacia nilotica* (3.93) and *Morus alba* (2.87 Mg/ha). Among tree species, maximum average height was observed in *A. nilotica* (6.27) followed by *F. infectoria* (6.08) and *M. alba* (5.01 m); maximum average diameter at breast height (DBH) was observed in *F. infectoria* (18.21) followed by *A. nilotica* (15.22) and *M. alba* (11.19 cm). At the age of 12 years, total biomass C stock (above & below ground) of silvipasture system ranged from 8.56 to 27.74 Mg C/ha with maximum under *A. nilotica* + *C. fulvus* combination. The annual leaf litter production among trees/shrubs was found to be maximum in *F. infectoria* (3.73) followed by *M. alba* (3.38), *A. nilotica* (3.21) and *L. leucocephala* (2.32 Mg/ha/year). Under different tree/shrub and grass/legume combinations, the SOC ranged from 5.74-10.09 g/kg with maximum under *M. alba* + *P. maximum* combination; total N content ranged from 170.6-272.2 kg/ha with maximum under *A. nilotica* + *P. maximum* combination; available P ranged from 8.21-10.83 kg/ha with

maximum under *M. alba* and *P. maximum* combination and available K ranged from 127.5-183.8 kg/ha with maximum under *A. nilotica* + *P. maximum* combination upto 0-15 cm depth.

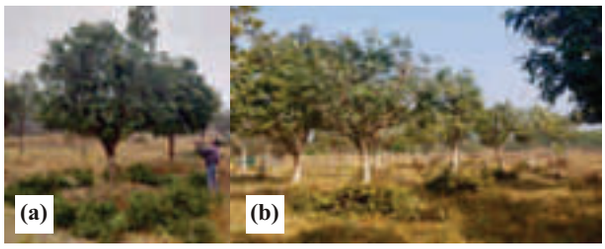


Fig. 3.2.6. a) Lopping of trees
b) Lopped trees of *F. infectoria*

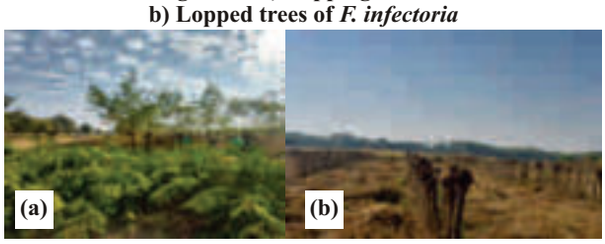


Fig. 3.2.7. a) Pollarding of *Leucaena*
b) Pollarded *L. leucocephala*

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

(CRSCIGFRISIL20200302)

An experiment was conducted to study the impact of different canopy architectures [central leader system, modified leader system, open centre and untrained bael tree (natural growth)] of bael (*cv.* CISHB- 2 and NB-9) in tree growth, yield, fruit quality and yield of understorey grass/legume on 12 years old bael orchard. Training and pruning operation in bale tree was done during summer to develop the desired canopy architecture. *M. maximus* grass with open centre system recorded more grass yield (17.0 t/ha GFY & 5.27 t/ha DM) than untrained tree (15.0 t/ha GFY& 4.35 t/ha DM), while *cv.* NB-9 recorded higher grass yield under central leader system (14.80 GFY & 4.44 t/ha DM) as compared to untrained tree (13.60 GFY & 3.95 t/ha DM). Bio-chemical attributes of bael fruit between the cultivars were not significant, however the highest TSS (34.91°Brix), ascorbic acid (21.64 mg/100 g), phenol content (34.73 mg GAE/100 g), TSS: acidity ratio (56.70), sugar: acidity ratio (26.35) and lowest acidity (0.63%) was recorded in *cv.* CISHB-2 than NB-9. All the bio-chemical attributes except acidity recorded higher values under canopy managed tree than untrained bael tree. Bael fruit harvested from tree trained under open centre system of canopy management recorded maximum TSS (36.91°Brix), ascorbic acid (23.84 mg/100 g), total sugar (17.34%), total phenol (36.91 mg GAE/100 g), TSS: acidity ratio (67.66), sugar: acidity ratio (31.77) and minimum acidity (0.55%). LAI showed no significant influence due to cultivar but, it showed significant variation under canopy architecture and its interaction with cultivars. The highest LAI value (6.0) was noticed in the central leader system followed by untrained bael tree with and without pasture (5.89 & 5.91) and lowest in modified leader system. Bael tree trained under different canopy management system observed more PAR than an untrained tree with highest value (244.97 μ mol m^{-2} S^{-1}) under central leader system .

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

(CRSCIGFRISIL20200303)

About 100 germplasm of *Morus* species were collected through exploration and procurement from various research Institutes and planted under semiarid conditions at IGFRI, Jhansi. About 66 germplasms of one year age were evaluated under nursery (Fig. 3.2.8a) for survival, growth performance and fodder traits. Survival after one year varied from 0-87%; length of the longest sprout varied from 22.5-190.9 cm; diameter of the thickest sprout varied from 2.17- 12.76 mm; number of leaves per plant varied from 10.2 to 98.7; fresh leaf yield per plant varied from 84.97-1257.44 g; and SPAD value varied from 28.5-43.3 among germplasms. Based on the nursery evaluation, germplasm MHP-15 was found better for height (190.90 cm), diameter of the sprout (12.76 mm), number of leaves (98.70), fresh leaf yield (1257.44 g) per plant and SPAD value 43.30. Other germplasm *viz*., MHP-7, MHP-8, Kanva-2 and China white seem promising based on nursery studies. Crude protein content in autumn collected leaves varied from 11.67-19.32 %. Under temperate conditions at IGFRI-RRS, Srinagar, 20 *Morus* germplasm species were evaluated for growth performance and length of the longest sprout varied from 62.2-98.5 cm whereas diameter of thickest sprout varied from 6.33-9.74 mm. Chatatul Mirgund showed maximum height and diameter growth which was found at par with Lajward, Zust & China white. In case of *Ailanthus excelsa*, plus tree selection (57 numbers) and collection of their seeds (germplasm) has been

carried out from Rajasthan (Fig. 3.2.8b), Madhya Pradesh and Uttar Pradesh.

Fig. 3.2.8. a) Nursery view of *Morus* species germplasm planted at ICAR-IGFRI, Jhansi
b) Plus tree of *A. excelsa* selected in Malpura, Rajasthan

3.2.11 Development of grassland assessment system using geospatial technology (CRSC\IGFRI\SIL20210301)

Generation of the base map and thematic layers of the Tikamgarh district grasslands spread over 5048 sq. km area allocated between 24.44°N-78.49°E' GPS location was done using a survey of India maps. Toposheets, Cloud-free satellite images (Landsat 8) of Tikamgarh district study area (Path/Row) were selected for assessment of grassland health in the region. USGS Earth Explorer in GeoTiff format (Ref: http://landsat.gsfc.nasa.gov) were georeferenced to UTM zone 43 projection based on datum WGS84. Images were processed for geometric and radiometric corrections using ERDASIMAGINE 2014. Soil and plant samples were collected and processed from the area for the assessment of soil health. Soil quality index was developed for the study area. Soil, climatic and production data were used for developing a grassland assessment system for the Tikamgarh district.

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

3.3.1 Effect of long-term use of sewage water irrigation on heavy metal accumulation in the soil-plant-animal continuum

(CRSCIGFRCISIL20180201)

Animal milk and blood samples were collected from the selected sites *i.e.* forage growing sites near peri-urban areas and long-term sewage water irrigated fields at Kanpur and Bhopal to determine its residual effect. Milk and blood samples of animals were analyzed for residues of heavy metals *viz*. chromium (Cr), nickel (Ni), cadmium (Cd) and lead (Pb) using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). The results showed that the mean concentrations of Cr, Ni, Cd and Pb in the milk samples ranged from 0.303 to 0.361, below detectable level, 0.189 to 0.201 and 0.293 to 0.296 mg L^{-1}, respectively. The Cr and Pb concentrations in milk samples were higher in Kanpur as compared to Bhopal, whereas, the Cd level was higher in Bhopal (Table 3.3.1). The mean concentrations of Cr, Ni, Cd and Pb in the blood of animals which consumed the contaminated forages ranged from 0.294 to 0.804, below detectable level, 0.086 to 0.251 and 0.547 to 2.435 mg L^{-1}, respectively. Higher residual levels of Cr, Cd and Pb in the blood of animals were reported in Kanpur as compared to Bhopal. The residue levels of Cr, Cd and Pb in milk and blood samples were found to be higher than the maximum permissible limit in Kanpur and Bhopal except for Cr in blood samples which were lower than the maximum permissible limit (1.0 mg L^{-1}). Hence, the proper monitoring of study sites will be necessary to prevent the excessive accumulation of heavy metals in animals in the near future.

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

(CRSCIGFRISIL20200201)

Genetic coefficients (Table 3.3.2) for five oat varieties (Kent, JHO-2010- 1, JHO 2009-1 2004-1 and JHO 99-2) were estimated based on detailed crop performance data of oat from field experiments during *rabi* for two consecutive years (2020-21 and 2021-22) under non-stress condition. Using a Glue estimator, the coefficient for genotype was estimated iteratively by initially running with the most appropriate matched value listed from the genetic coefficient file. The model output (date of anthesis, booting maturity, grain yield, tops weight, maximum leaf area index) is compared to actual data altering the genotype coefficient until the predicted and measured values matched. The simulated booting, anthesis and maturity from observed values were found within ±4 days sown under different environmental conditions. RMSE (3.47 to -4.9 days) and Bias (-1.67 to 4.3 days) values showed that the predicted values closely matched with measured values. The model performed satisfactorily, accounting for 94% of variation in top weight at maturity for oat cultivars. Their slope and intercept did not differ significantly from 1 and 0, respectively. Agreement between simulated and actual dry tops weight was reasonably good (bias =28.2 kg ha^{-1} and RMSE =83.3 kg ha^{-1}) for the oat cultivar irrespective

Table 3.3.1 Residues of heavy metals in milk and blood of animals reared in long-term sewage water irrigated areas

		Residues of heavy metals (mg/L)			
Location		Cr	Ni	Cd	Pb
Kanpur	Milk	0.361±0.081* (0.258-0.543)	BDL	0.189±0.011 (0.174-0.214)	0.296±0.168 (0.040-0.500)
	Blood	0.804±0.271 (0.383-1.173)	BDL	0.251±0.082 (0.139-0.409)	2.435±0.886 (1.330-3.580)
Bhopal	Milk	0.303±0.030 (0.238-0.333)	BDL	0.201±0.029 (0.159-0.239)	0.293±0.250 (0.025-0.780)
	Blood	0.294±0.160 (0.128-0.643)	BDL	0.086±0.025 (0.059-0.129)	0.547±0.093 (0.420-0.680)

*Mean±sd (Range); BDL-below detectable limit

Table 3.3.2 Genetic coefficient of different oat varieties (CERES-Wheat)

Varieties	P1V	P1D	P5	G1	G2	G3	PHINT
Kent	7	60	600	13	30	2.7	70
JHO 2010-1	6.9	65	740	11.7	29	3	70
JHO 2009-1	7.8	70	750	13.2	31	4.5	65
JHO-2004-1	7.5	65	560	11.5	30	2.5	70
JHO 99-2	8	55	600	10.5	28	2.5	68
Mean	7.44	63	650	12	29.6	3.04	68.6

of sowing date and cultivar. A similar trend was noticed for grain yield. In this study, the crop parameter of oat was estimated using the CERES-Wheat model and the calibrated model successfully simulated the development and growth aspects of the oat crop.

PHINT (phyllochron interval): Thermal time required between the emergence of two successive leaves.

P1V (Vernalisation coefficient): It describes the relative amount of slowing down the development of for each day of unfulfilled vernalisation assuming that 50 days of vernalisation is sufficient for all cultivar.

P1D (Photoperiodism coefficient): The coefficients govern the relative amount that development is slowed when plants are grown in a photoperiod 1 hour shorter than the optimum (16 hours).

P5 (Grain filling duration coefficient): It relates to thermal time in degree days above a base of 1°C where each unit increase above where each unit increases above zero adds 20 degree days to the initial value of 430 degree days.

G1 (Kernel number coefficient): The coefficients account for the kernel number per unit weight of stem plus spike at anthesis.

G2 (Kernel weight coefficient): It controls the kernel filling rate under optimum conditions (mg/day).

G3 (Spike number coefficient): It computes the non-stressed dry weight (g) of a single stem (excluding leaf blades and sheaths and spike when elongation ceases.

3.3.3 Precision nitrogen management in forage crops

(CRSCIGFRISIL20190202)

A field experiment was conducted during 2021-22 to test need-based N management approaches for fodder oats. The colour of the topmost fully opened leaf of fodder oats as expressed in terms of SPAD value and leaf colour chart (LCC) scores at different growth stages did not differ among the varieties (JHO-822 and JHO 2012-2). However, the oat variety JHO 2012-2 yielded 18.7% higher GFY than JHO-822 (40.2 Mg ha^{-1}). Applying 30 kg N ha^{-1} each time (in addition to 30 kg N ha^{-1} as basal dose) the SPAD value dropped below the 40 produced 49.4 Mg ha^{-1} GFY at 90 kg N ha^{-1} in three splits which were statistically at par with those with 100 kg N ha^{-1} applied in two splits. Similarly, fertilizer scheduling at LCC value of 4.5 recorded (Fig. 3.3.1) statistically similar fodder yields to those of SPAD value 40. Furthermore, scheduling of N at a higher SPAD value (<45) adds 30 kg more N in soil but their effects on GFY were not observed resulting in a reduction in the agronomic efficiency of applied nitrogenous fertilizer. Application of nitrogenous fertilizer when the SPAD value dropped below the 40 reduces N requirement of oats by 10% and recorded the highest agronomic efficiency (43.9 kg DM increase kg^{-1} N applied).

Fig. 3.3.1. Need-based N management approaches for fodder oats

3.3.4 Long term nutrient management strategies for sustainable forage production in guinea grass + (cowpea-berseem) cropping

(CRSCIGFRISIL20180202)

In a long-term (18 years) nutrient management study in guinea grass + (cowpea - berseem) cropping system it was observed that during 2021-22, T8 (withdrawal of nutrient application since 2010) recorded the lowest GFY (72.83 t/ha), which was at par with T1 (control), T7, T10 and T12 (withdrawal of nutrient application since 2018). However, the application of a 100% dose of nutrients through organic manure (T3: 80 t FYM/ha) gave the highest GFY (100.17 t/ha) and it was significantly superior over all the treatments. Similarly, application of 25% dose of nutrients through organic manure (T6:20 t FYM/ha) and 100% nutrient through inorganic fertilizers (T2: 200:50:50 kg NPK/ha during *kharif* and 20:80:0 kg NPK/ha during *rabi*) recorded 89.83 and 80.0 t/ha GFY, respectively during 2021-22. It was also observed that after withdrawal of nutrient application (since 2018) from the treatments T4, T5, T7, T9, T10, T11 and T12, except treatment T10 rest of the treatments recorded statistically at par total GFY with T2. Due to the lower production potential of treatment T10 than T2 during 2021-22, in *kharif* 2022 about 10 t FYM/ha along with biofertilizer consortia was applied in T10 and it recorded 39.64 t/ha GFY which was statistically at par with T2 (45.56 t/ha). During *kharif* 2022, the T3 treatment gave the highest GFY (76.73 t/ha) and was significantly higher than all the treatments.

3.3.5 Livestock-based Integrated Farming Systems (IFS) for sustaining livelihood of Bundelkhand farmer

(CRSCIGFRISIL20190201)

The on-station irrigated IFS model comprising of groundnut-wheat cropping system in 0.3 ha, green gram-wheat in 0.25 ha, BN hybrid + cowpea – berseem round the year green fodder cropping system in 0.2 ha, guava + seasonal vegetable-based agri-horticulture in 0.2 ha (Fig.3.3.2) and two cows, one buffalo and water harvesting - cum - fish pond (20 m × 25 m × 2 m) in 0.05 ha were continued during the year. The rainfed IFS model consisted of a green gram - barley cropping system in 0.3 ha, fodder sorghum - oat in 0.15 ha, Subabul + TSH + *Stylosanthes* silvopasture system in 0.3 ha, ber + sesame - gram based agri-horticulture in 0.2 ha, one cow, five goats and rainwater harvesting pond (20 m × 25 m × 2 m) in 0.05 ha. The irrigated model also had boundary plantation of subabul and spineless fodder cactus while the rainfed model had black currant, spineless fodder cactus, subabul and moringa at the boundaries. During 2021-22, the irrigated IFS model produced excellent wheat yield (2450 kg), green fodder (10500 kg berseem, 3000 kg cowpea 3050 kg BN hybrid), vegetables (450 kg potato, 150 kg spinach, 500 kg cauliflower and cabbage, 435 kg bhendi, 830 kg bottle gourd and 280 kg ridge gourd) and 16 kg fish. The rainfed IFS model produced 6500 kg fodder sorghum, 1710 kg green fodder from TSH, 1780 kg green fodder from subabul, 30 kg Stylo seed, 150 kg Stylo leaf meal, 1500 kg barley grain, 6550 kg fodder oat and 125 kg bengal gram.

Fig. 3.3.2. Vegetable block in irrigated IFS model

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

(CRCIGFRISIL20170201)

Nine cropping systems and three moisture conservation practices were evaluated in the field condition. TSH+*Sesbania*+(sorghum+ cowpea-chickpea) cropping system (CS) recorded the highest GFY and DMY (27.93 and 5.18 t ha^{-1}) in four cuts of TSH and the lowest being with TSH + *Leucaena*+ (sorghum+cowpea-barley) CS (25.24 and 4.66 t ha^{-1}). Among moisture conservation practices, integrated water management practices were at par with limited irrigation (26.99 and 5.31 t ha^{-1}) and recorded significantly higher GFY and DMY (28.61 and 5.56 t ha^{-1}) of TSH over rainfed conditions (24.16 and 4.67 t ha^{-1}). With respect to system economics, the highest net returns and benefit-cost ratio (Rs. 46466 $ha^{-1}yr^{-1}$ and 1.60) was recorded in TSH + *Sesbania* + (sorghum + cowpea - barley) CS (Fig.

3.3.3) and the lowest was with TSH + *Gliricidia* + (sorghum + cowpea - chickpea) CS (Rs. 32671 ha^{-1} yr^{-1} and 1.42). Integrated moisture management practices recorded 3.09% higher moisture content (v/v) in 0-15 cm soil profile, compared to rainfed conditions.

Fig. 3.3.3. TSH + *Sesbania* + [sorghum (f) + cowpea (f) - barley]

3.3.7 Manipulating the rhizosphere microbiome using plant growth promoting microbes to enhance soil and plant health

(CRCIGFRISIL20210201)

Oat rhizosphere microbiome was manipulated by seed inoculation with PGPMs and sowing in pots as well as in field. Two PGPMs (one bacterium and one fungus each) with 3 fertilizer doses (50, 75 and 100% RDF doses and 0% RDF control) combinations were used. In the *in vitro* experiment, all PGPM inoculated treatments recorded plant height (60.1-74.5 cm) and root length (19.3-25.2 cm) at par with or more than 100% RDF treatment (69.8 and 19.2 cm, respectively). Five PGPM treatments recorded shoot fresh weight (8.86-9.67 g) at par with 100% RDF (9.13 g) and two PGPM treatments recorded significantly higher root FW (2.75-2.87 g) over 100% RDF (2.49 g). Seven PGPM treatments (1.74-1.86 cm) recorded stem girth at par with 100% RDF (1.80 cm). There were no significant differences in number of leaves/plant, leaf length, leaf width between the treatments. In the field evaluation, all PGPM treatments recorded plant height (118.8-136.3 cm), leaf length (42.0-55.1 cm), leaf width (1.52-1.82 cm), green fodder yield (16.7-26.0 t/ha) and seed yield (1185.5-1730.0 kg/ha) compared with 100% RDF (124.5 cm, 54.2 cm, 1.77 cm, 23.3 t/ha and 1548.9 kg/ha, respectively) in the nutrient poor - light soil. Both PGPB and PGPF with 100% RDF recorded significantly higher GFY than 100% RDF. PGPM treatments for stem girth (6), number of leaves/plant (all), seed yield (8) chlorophyll SPAD value (7) recorded at par with 100% RDF. 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. The fabricated low cost aseptic growth chamber was used for the study of plant microbe interaction and root exudates collection. The 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. Also, there were some extra peaks formed in root exudates influenced by bacteria. These root exudates were also analysed using liquid chromatography-high-resolution mass spectrometry and the compounds will be identified by analysing this chromatogram.

3.3.8 Development of microbial inoculants for enhancing ensiling

(CRSCIGFRISIL20210202)

About 47 lactic acid bacterial (LAB) cultures were isolated from 55 different grasses/silage samples from institute. All the 47 LAB isolates were found Gram positive and catalase negative. They were screened for lactic acid production (0.08-0.71%) in liquid growth medium ranged from and pH reduction ranged from 6.54-4.07 in 24 h. About 9 lactic acid bacterial cultures were selected as inoculant additives to prepare silage of BN hybrid (Fig. 3.3.4a) and *Cenchrus ciliaris* (Fig. 3.3.4b) grasses. All the 9 LAB isolates were found positive for silage production. The prepared silage was evaluated for some quality parameters. The lactic acid content of BN hybrid silage ranged from 0.28-0.70% and pH 4-89-4.47 and LAB population ranged from $39x10^4$-$75x10^4$ cfu/g, while *Cenchrus* silage recorded 0.35-0.72% lactic acid, pH 5.04-4.38 and LAB population $38.8x10^4$-$63.3x10^4$ cfu/g. About four treatments had very pleasant aroma in both silages.

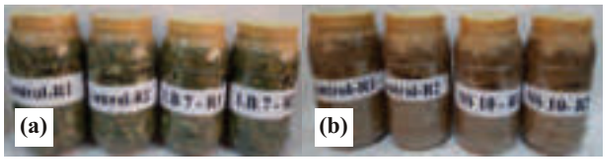


Fig. 3.3.4. Silage preparation using LAB additives in a) BN hybrid and b) *Cenchrus ciliaris*

3.3.9 Nutrient and water management in BN hybrid through drip irrigation in semi-arid region of India

(CRSCIGFRISIL20210203)

Crop was established in plots during 2021-22 as per requirement of treatment and a fertigation system was installed in April 2022. From *kharif* 2022 onward fertigation treatments were applied and it was observed that fertigation with 100% NPK and irrigation at 75% ASM with paired row planting (F3) treatment recorded significantly higher green biomass yield (88.34 t/ha) of BN hybrid than all the treatments. It was also observed fertigation with 67% NPK nutrients at 75% ASM and at 50% ASM gave 7.98% and 3.74% higher GFY than the control (F1: 100% NPK by conventional method and irrigation at 75% ASM application with normal planting). Fertigation with 33 % NPK and irrigation at 50% ASM with paired row planting (F8) recorded significantly lower GFY (49.10 t/ha) than all the treatments.

3.3.10 Studies on natural farming practices in forage crops

An experiment was initiated during *kharif* 2022 to study the effect of natural farming agro-inputs on yield and quality of forage crops, microbial and chemical composition of inputs and soil health. Two cropping sequences namely (1) sorghum (F) + cowpea (F)-oats (Fig. 3.3.5) and (2) Bajra Napier hybrid + (cowpea-berseem) were selected for testing five treatments *viz*., natural farming, improved natural farming, organic farming, conventional/ modern farming and Integrated farming with four replications and observations were recorded.

Fig. 3.3.5. Natural farming practices in sorghum (F) + cowpea (F)-oats cropping system

3.3.11 Standardization of agronomic practices in orchard grass (*Dactylis glomerata* L.) for enhanced forage yield and quality

(CRSCIGFRISIL20171302)

Among the harvesting stages, H3 (harvesting at the flowering stage) recorded the highest GFY (27.01 t/ha) and DFY (7.97 t/ha). Among the cutting intervals, CI 3 (cutting at 60-day intervals) recorded the highest green (26.58 t/ha) and dry fodder (8.31 t/ha) yield. Fodder yield increased as the harvesting was delayed from the vegetative to flowering stage (Fig. 3.3.6) due to longer duration and more accumulation of biomass. Fodder yield also increased as the cutting interval increased from 30 to 60 days. However, insignificant differences in fodder yield were recorded between cutting intervals of 45 days and 60 days. The highest crude protein content (11.89%) was recorded with harvesting at the vegetative stage (H1) which was significantly higher over harvesting at the flowering stage (H3). Crude protein content decreased as the harvesting was delayed to boot (11.51%) and flowering (10.82%) stages. H1 also recorded the lowest NDF (55.84%) and ADF (31.62%) contents which increased as harvesting was delayed till H2 and H3. NDF and ADF contents also increased as the cutting interval increased from 30-60 days. Based on fodder yield and quality, it was concluded that orchard grass should be harvested from the booting to the flowering stage and subsequent cuts may be taken at an interval of 45-60 days.

Fig. 3.3.6. Orchard grass at flowering stage in the experimental field of RRS Srinagar

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

(CRSCIGFRISIL20221101)

Soil samples were collected from the rhizosphere of forage crops during *kharif* 2022. Target crop plants were uprooted carefully without damaging root its root system using a clean farm tool which was washed with 70% ethanol. The rhizosphere soil (soil adhering to the roots) was collected and bagged in a labelled sterile plastic bag. A total of 21 rhizosphere soil samples were collected from different forage crop plants including grasses, cereals, legumes and millets.

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

3.4.1 Study of berseem (*Trifolium alexandrinum* L.) seed coat dynamics

(CRSCIGFRISIL20200104)

Berseem seed coat color is perceived as an indicator of seed quality. Change in seed coat color from yellow to red and dark red leads to poor acceptance by the farmers. In this study, seeds of three berseem varieties (Wardan, BB-3 and JBSC-1) were stored for 4 years under ambient and low-temperature conditions. It was found that storage in polythene bags under ambient and low conditions recorded better germination percentage (GP; 95.09-96.73%) and lower electrical conductivity (EC; 0.25-0.30 dS/m) than cloth bags (GP: 78.18-92.06% and EC: 0.31-0.38 dS/m). Seed of different storage intervals were categorized into three groups based on color (Yellow seed, Red seed and Dark red seed) using the RHS color chart. With an increase in storage period, the GP of different colors including yellow decreased i.e. 92.0%,91.33%, and 31.67% for 2019, 2018 and 2016, respectively and the GP of red and dark red seeds also showed a significant decrease (Fig. 3.4.1a). Loss of membrane integrity may be one of the major factors contributing to this variation in GP, which could lead to increased EC in seeds with more storage periods (Fig. 3.4.1b). The biochemical analysis revealed that despite the total tannin, phenol, and flavonoid content were higher in dark-colored seed than in yellow seed, the free radical scavenging activity and total antioxidant enzymes were lower in red and dark red seed as compared to yellow seed. Microflora study suggested the possibility of role of *Fusarium* spp. in deterioration of dark-colored seeds.

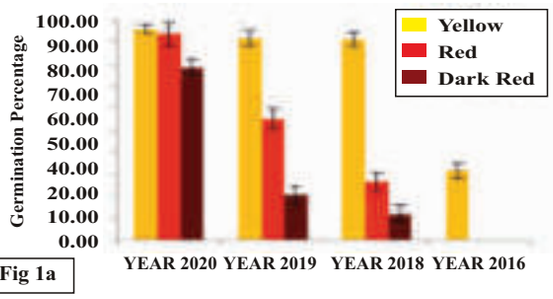


Fig 1a

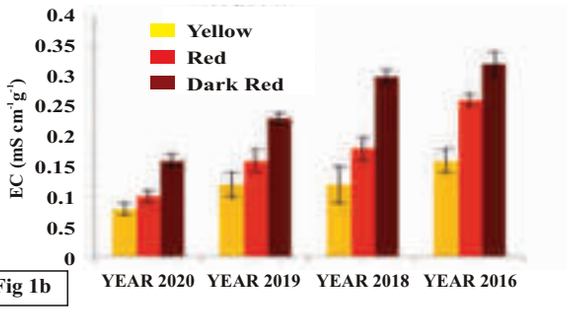


Fig 1b

Fig. 3.4.1. a) Germination percentage b) EC of different storage period colored seeds

3.4.2 Isolation and utilization of smoke-derived compounds in the early establishment of forages

(CRSCIGFRISIL20190402)

To study the effect of smoke water on early forage establishment, smoke water machine was fabricated. The overall size of the machine is 1100×400×1000 mm with a capacity of up to 150 l/h. The airflow control mechanism is regulated by an axial fan with a rectangular orifice sliding gate type and water is recirculated with a submersible pump (40 watt). The material used is stainless steel. The developed machine is more efficient, less time-consuming, and generates uniformly mixed smoke water with minimum loss.

Fig. 3.4.2. Modified smoke water machine

3.4.3 Stale seedbed technique for weed control in berseem seed production

(CRSCIGFRISIL20180401)

A field experiment was conducted during the year 2021-22 to test the efficacy of nine weed control treatments *viz*., T_1: Weedy Check (Fig. 3.4.3a), T_2: Weed Free Check, T_3: Mechanical Stale Seedbed, T_4: Pendimethalin + Imazethapyr @ 0.75 kg a.i./ha, T_5: Metribuzin @ 0.4 kg a.i./ha, T_6: Glyphosate @ 1.0 kg a.i./ha *fb* Imazethapyr + Imazamox @ 0.07 kg a.i./ha, T_7: Glyphosate @ 1.0 kg a.i./ha *fb* Bentazone @ 1.3 kg a.i./ha, T_8: Paraquat @ 0.5 kg a.i./ha *fb* Imazethapyr + Imazamox @ 0.07 kg a.i./ha and T_9: Paraquat @ 0.5 kg a.i./ha *fb* Bentazone @ 1.3 kg a.i./ha against the weed flora in berseem seed production. The results showed that among the pre-emergence applied herbicides pendimethalin + imazethapyr @ 0.75 kg a.i./ha was applied 2 days after seedbed preparation recorded the lowest (7.03 no./m^2 weed density and 5.03 g/m^2 weed dry weight)

before and (26.0 no./m^2 weed density and 8.81 g/m^2 weed dry weight) 20 days after berseem sowing. While in case of post-emergence, application of glyphosate @ 1.0 kg a.i./ha *fb* imazethapyr + imazamox @ 0.07 kg a.i./ha where glyphosate was applied 20 days after seedbed preparation and imazethapyr + imazamox was applied (Fig. 3.4.3b) 20 days after sowing of berseem recorded the lowest weed density (15.01 and 11.0 no./m^2) and dry weight (5.62 and 5.24 g/m^2) of weeds at first and second cut of berseem, respectively. Among all the nine weed control treatments, after weed-free check treatment glyphosate @ 1.0 kg a.i./ha *fb* imazethapyr + imazamox @ 0.07 kg a.i./ha applied treatment recorded significantly highest plant height at harvest (60.72 cm), no. of effective tillers (305.07/m^2), no. of heads (739.56 /m^2), green fodder (28.03 t/ha), straw (2.98 t/ha) and seed yield (525 kg/ha) of berseem.

Fig. 3.4.3. a) Weedy check b) Glyphosate @ 1.0 kg *fb* Imazethapyr + Imazamox @ 0.07 kg a.i./ha

3.4.4 Effect of elevated CO2 and temperature on growth, forage yield and seed quality of cowpea and oat

(CRSCIGFRISIL20190404)

This study was conducted to access the variations in the agro-morphological traits of oat under elevated CO_2 and temperature. Five forage oat varieties *viz*., Kent, JHO-2009-1, JHO-99-2, JHO-851, and JHO-2000-4 were subjected to the treatments *viz*., T1: Control at ambient temperature and CO_2, T2: Elevated temperature (3°C > ambient temperature), CO_2 (550+50 ppm), T3: Ambient temperature and elevated CO_2 (550+50 ppm). The treatments were started at elevated temperatures and were imposed 35 days after the crop was sown. The observations were taken 61 days after the imposition of elevated temperature (96 days after the crop sown). Traits included were plant height, tillers/plant, leaves/plant, flag leaf length, spike length, spikes/plant, seeds/spike, seed bearing spikes, root & shoot dry weight and root & shoot fresh weight. A slight increase in agro-morphological traits in T2 and a substantial increase in T3 as compared to ambient T1 were observed. The observations suggest that the symptoms of heat stress were marginally suppressed under elevated CO_2. The effect of elevated CO_2 and temperature on agro-morphological traits is indicated in Fig. 3.4.4.

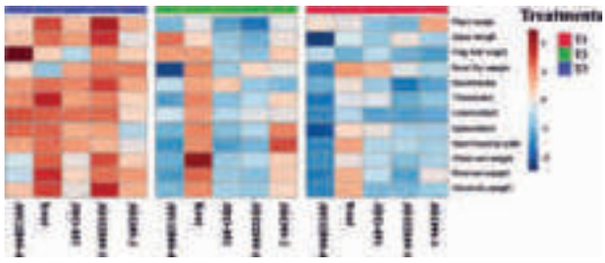


Fig. 3.4.4. Effect of elevated CO_2 and temperature on agromorphological traits

3.4.5 Effect of storage container and storage time on germination of Anjan grass (*Cenchrus ciliaris*) and Sewan grass (*Lasiurus scindicus*)

Three months old seeds of Anjan and Sewan grass (fluffed and defluffed) were 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. Observation for germination was recorded at 6 months interval from 6 to 30 months of storage (Fig. 3.4.5 a & b). At the time of packing germination of fluffed and defluffed seed was respectively 24 & 49.8% in Anjan grass, and 30 & 43% in Sewan grass. It is concluded that in both the grasses defluffed seed had less shelf life 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 minimise the cost of storage and transportation. Poly bag >700 gauge and Al bag were better storage containers than others for maintaining germination/ vigour of seed during storage.

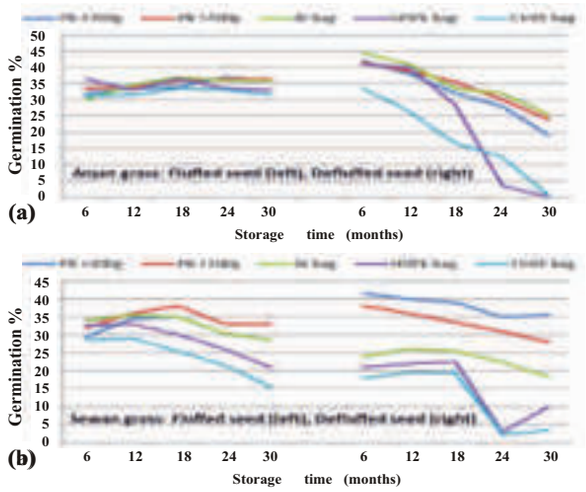


Fig. 3.4.5. Effect of storage container and time on germination of a) Anjan and b) Sewan grass

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

3.5.1. Development of economic ration for livestock production

(CRSCIGFRISIL20180703)

The effect of replacing mustard cake protein with berseem hay meal protein and the addition of non-protein nitrogen (NPN) @ 0.75% in the concentrate mixture was studied for nutrient utilization, milk yield and economics of production in crossbred cows. Crossbred cows weighing around 350±4.56 kg were fed with control concentrate mixture (G1) and concentrate mixtures in which 60% N of the mustard cake was replaced with berseem hay meal N containing 0.75% NPN (G2) along with wheat straw as basal roughage *ad libitum* for a period of two and half months. Dry matter intake was comparable in both groups (2.96% to 2.88%). Similarly, nutrient utilization in terms of DM, NDF and CP digestibility was (61.25, 58.45 and 59.60%) in G1, respectively and (59.46, 57.40 and 62.66%) in G2, respectively. N intake (g) per kg digestible OM was 28.74 in the control group and 29.21 in the treated group. N utilization efficiency (NUE) for milk production was 23.43 in G1 and 25.0 in G2. The nutritive value (%) in terms of DCP and TDN content was (6.43 and 65.60) in G1 and (6.48 and 63.86) in G2, respectively. Daily milk yield was comparable in both groups (7.01 *vs* 7.21 kg). Similarly, the composition of milk in terms of fat (3.53 *vs* 3.76%), protein (3.66 *vs* 3.67%) and SNF (8.15 *vs* 8.37%) was not significantly different. Feed cost per animal per day was Rs 109.12 in the control group whereas Rs 94.01 in the experimental diet. Cost of feed/kg (4% FCM-fat corrected milk) milk production was Rs 13.57 whereas, in treated group, the value was Rs 11.19 indicating the feed cost per kg milk production can be reduced by 17.53% using an economic diet. It may be concluded that mustard cake can safely be replaced by berseem hay meal (BHM) in the iso-caloric and iso-nitrogenous diet in formulating the least cost ration for economic milk production in small holders' dairy production without compromising the feed intake, nutrient utilization and milk yield of crossbred cows.

3.5.2. Screening of Bt genes in cottonseed cake

(CRSCIGFRI20180701)

Detection of Bt genes namely *Cry1Ac* and *Cry2Ab* in cotton seed cakes were carried out through ELISA (Enzyme-Linked Immunosorbent Assay) technique. For this purpose, 60 samples of cotton seed cakes from bulk purchase were screened for *Cry1Ac* and *Cry2Ab* genes. Out of these, 43 and 49 samples were found positive for *Cry1Ac* and *Cry2Ab* genes, respectively. Out of 60, 53 samples were found positive and only 7 samples were found negative to both genes which showed 88% cotton seed cakes were from Bt cotton origin.

3.5.3. Ensiling characteristics and feeding value of *Sehima* genotypes silage in sheep

(CRSCIGFRISIL20180705)

Silage prepared from selected *Sehima* grass genotypes IG-02-695-1 and BS-1 was evaluated with Napier (control) for silage quality and feeding value in sheep. Silage from IG-02-695-1 genotype and Napier had pH (4.16 *vs* 4.27) and lactic acid (0.95 *vs* 1.48% DM), respectively, while silage from BS-1 was relatively poor quality as evident from its pH (5.78) and lactic acid (0.31% DM). Twelve sheep (mean body wt. 21.6 kg) divided into three groups (G_1, G_2 and G_3) of four animals in each were offered silage (Fig. 3.5.1) prepared from BS-1, IG-02-695-1 and Napier in G_1, G_2 and G_3, respectively. Each sheep was also offered 250 g concentrate in all silage groups. Napier silage was low in CP (5.85) compared to BS-1 and IG-02-695-1 (6.83 and 7.17% DM), while NDF and cellulose contents were comparable among silages. Sheep fed IG-02-695-1 silage (G_2) had higher dry matter intake (2.86) than G_1 (BS-1 2.49) and G_3 (Napier grass 2.59%), respectively. The DM and OM digestibility was similar (P>0.05) and ranged between 49.46-52.29 and 54.1-55.6%, respectively among silage groups. The CP and ME (metabolisable energy) intake was relatively higher in sheep on IG-02-695-1 genotype silage based diet, while urinary N excretion was more in sheep fed BS-1 silage which resulted in lower N absorption in this group (61.92%). Rumen liquor collected before feeding had pH, total-N and NH_3-N ranged between 6.46-6.54, 70.0-81.2 mg/100 ml and 5.4-8.4 mg/100 ml, respectively. Results revealed that silage prepared from IG-02-695-1 was comparable to

Fig. 3.5.1. Digestion-cum metabolism trial in sheep fed Sehima genotypes silage

Napier, while that of BS-1 was poor in terms of fermentation quality, intake and digestibility.

3.5.4. Effect of grazing intensity/stocking rate on pasture yield and small ruminants performance

(CRSCIGFRISIL20130701)

The study was carried out in protected pasture (5 ha) where grazing was allowed at 3 stocking rates/grazing intensities on 4.5 ha and the remaining 0.5 ha was kept as un-grazed/control. Sheep and goats (90) were divided equally into 3 groups of 15 animals - 8 goats & 7 sheep (1 ACU-SR_1), 30 animals - 15 sheep & 15 goats (2 ACU-SR_2) and 45 animals - 22 goats & 23 sheep (3 ACU-SR_3) were grazed on pastures (Fig. 3.5.2a) from August 2021 to February 2022 during the post-growing season of herbages. After > 2 months of grazing a digestibility trial was conducted and herbage samples were collected daily during the trial. Animals were supplemented with a fixed quantity (250 g) of concentrates.

Before introducing grazing pastures herbage CP, NDF, ADF, cellulose and lignin varied between 5.64-7.27, 72.4-73.7, 46.1-48.7%, 38.2-38.6 and 5.72-6.71%, respectively, while TDN and DDM from 41.6-48.8 and 50.9-55.3%, respectively among pasture stands. After 6 months of grazing pasture herbage CP declined to 2.68-2.70%, while NDF 82.7-86.9, ADF 58.6-62.8, cellulose 43.0-46.5 and lignin increased to 11.9-14.1%. Grazing reduced herbage TDN and DDM by 10 and 15%. During the digestibility trial herbage samples collected from goat mouth had higher CP (12.9-13.3%) than sheep (6.83-9.97%), while NDF, ADF and cellulose were low in herbage samples collected from goat mouth than sheep. Irrespective of the stocking rate, goat consumed higher biomass than sheep, sheep had a lower biomass intake at SR_3 while goats had a relatively lower biomass intake at SR_1. Herbage intake (% body wt) was lower in sheep (2.02-2.51) than in goats (2.76-3.14%). Goats had higher DM and OM digestibility than sheep, while for CP, NDF, ADF and cellulose differences were inconsistent. Rumen TVFA, total-N and NH_3-N were relatively higher in SR_1. During September to November weight gain in animals increased in all. Stocking rates were decreased from December onward but rate of decrease was less in SR_1 than in SR_2 and SR_3.

Fig. 3.5.2. a) Mixed herd grazing in natural pasture
b) Tying of fecal collection bags

3.5.5 Bundelkhandi goats: conservation and improvement of the breed

(CRSCIGFRI20180701)

AICRP on goat improvement (Bundelkhandi unit) is working since 2018 at IGFRI, Jhansi, with the major objective of conservation and improvement of Bundelkhandi goats, characterization of their production systems and capacity building of goat keepers. Under the project 3 villages (Parasari, Sersa, Bajni) were adapted in Datia district. Information on distribution, prevailing management practices, production reproduction performances and socio-economic profile of goat keepers were collected. Ear tagging (Fig. 3.5.4a) was started for the identification of registered goats. Blood samples were collected (Fig. 3.5.4b) from the field for genetic studies of these goats in CIRG, Mathura laboratory. Vaccination was completed for PPR and FMD diseases. De-worming against endo-parasites, health check-ups at regular intervals *etc*. were performed in adapted villages regularly. For capacity building of goat keepers Animal health camp cum *Kisan gosthis* were organized in the adopted villages.

Fig. 3.5.3. a) Ear tagging in field goats
b) Collection of blood samples for genetic study

3.5.6. Cold stress management in local goats

(CRSCIGFRI20180704)

The harsh winter season may affect goat productivity by causing cold stress. To devise feeding and management strategies to improve goat productivity experiment was carried out on 20 male goats (10 in each group). Supplementation of berseem hay (300 g/head/day) was given in the treatment group to alleviate cold stress. Meteorological variables, feed intake, nutritional status, physiological parameters and body weight were recorded. THI (temperature humidity index) in December and January was near to lower critical limit and avg. monthly temperature in January was 14.9 °C, indicating some degree of cold stress. However physiological parameters did not differ between groups. In both the groups, lower rectal temperature was recorded in January. Supplementation of berseem hay (300 g/h/d) in male Bundelkhandi goats resulted improvement in protein

(8.07 *vs*. 10.05) consumption with a positive impact on body weight gain. However, there was no significant effect of treatment on physiological parameters.

3.5.7 Performance evaluation and improvement of Bhadawari buffaloes

A herd of pure bred Bhadawari buffaloes is being maintained under the project to produce superior breeding bulls. During the reporting year, average lactation milk yield, lactation length, standard lactation milk yield and peak yield were 1563.23±69.86 kg, 316±11.09 days, 1476.65±52.48 kg and 8.34±0.29 kg, respectively. Average milk fat, SNF, protein and lactose were recorded as 8.20, 9.70, 3.50 and 5.34%, respectively. The average age at first calving was recorded as 46.68 months. The conception rate was 59.5% and 32 calvings during the year. The average birth weight of the calves was 27.97±0.64 kg and the dam's weight at calving was recorded as 425.28±12.13 kg. A total of 4300 semen doses were frozen from the selected breeding bulls and 3100 semen doses were supplied for artificial insemination in the Bhadawari breeding tract.

3.5.8 Ensiling of temperate grasses/ legumes for increased livestock productivity

(CRSCIGFRISIL20211001)

Apple leaves as a nutritious fodder in Himalayan region

Leaves of ten apple cultivars collected from apple orchards had CP contents between 10.30-12.41%. Fibre fractions *viz*. NDF, ADF, cellulose and lignin contents were low and ranged between 31.3-35.8, 17.4-19.2, 12.7-22.1 and 4.11-7.23% of DM amongst the leaves of evaluated apple cultivars. *In vitro* dry matter digestibility (IVDMD%) varied widely from 64.0-77.5% among cultivars. Leaves had adequate Ca (1.01-1.77%), Fe (382-1077 ppm), Mn (71.8-191 ppm), Zn (8.12-60.9 ppm), Cu (4.96-12.97 ppm) and Co (5.10-6.02 ppm), respectively. Palatability parameters in terms of dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were quite high and ranged from 3.21-3.85, 66.2-75.4 and 174-213%, respectively. These palatability attributes are comparable to any high quality forage crop. Leaves had high energy value as total digestible nutrients (TDN) and metabolisable energy (ME) values varied between 66.98-82.37% and 2.42-2.97 Mcal/kg DM, respectively. The results on nutritive value of apple leaves revealed that CP contents are comparable to green cereal fodder crops, while fibre contents are low. Adequate mineral, higher digestibility, TDN, energy and RFV substantiate apple leaves as a good to medium quality forage source for feeding ruminants. Apple trees can be a promising alternate fruit tree for temperate horti-pasture systems.

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

(CRSCIGFRISIL20180601)

Performance evaluation of defluffing machine for dinanath grass seeds

Defluffing machine was tested for dinanath grass seeds at two levels of moisture content (6.7 and 7.8%) and the processing time was 30 and 34 minutes/5 kg batch, respectively. Defluffing capacity and the percent true seed recovery recorded was 9.67 kg/h and 16.46% in single pass at 6.7% moisture with the machine. Defluffing cost using machine was Rs. 10.75 per kg with 83.9% saving in processing cost as compared to manual defluffing. Defluffed seed recorded highest germination (65-71%) with mean value of 69.7% whereas fluffy seed showed lowest germination (14-33%) with average of 25%. Seedling length in defluffed seed ranged from 6.64-7.28 cm (avg. 6.97 cm) whereas in fluffy seed from 5.98-6.50 (avg. 6.31 cm).

Development and evaluation of cylindrical drum type seed pelleting machine

Increasing the size and weight of small and lighter grass seeds is useful for enhancing germination in field. A prototype of seed pelleting machine (cost: Rs. 90,000) was developed (Fig. 3.5.4) which consists of pelleting chamber (PC) assembly, speed regulator, motor, belt & pulley power transmission unit, gear mechanism (upward/downward movement of PC) and water application system. Test trials for pelleting of fluffy deenanath grass seeds were conducted. Samples of 10 kg (soil + fluffy seed) were fed into the pelleting chamber which was converted into pellet form in 8-10 minutes followed by drying and different sized seed pellets were separated *viz*., above 10 mm (15%), between 5-10 mm (45%) and below 5 mm (40%). The machine capacity was 65-70 kg pellets/h.

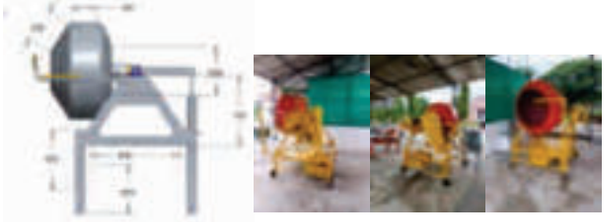


Fig. 3.5.4. Cylindrical drum type seed pelleting machine

3.5.10 Development and evaluation of evaporative cooling based hydroponic fodder production unit for semi-arid region

(CRSCIGFRISIL20190603)

An experiment was conducted to produce maize biomass in trays (Fig. 3.5.5) under Evaporative Cooling based Hydroponic Structure (ECHS) with two treatments: (i) GA1: seed treated with gibberellic acid (GA) @ 1 ml (0.001%), (ii) GA0: control (without GA); and fixed seed rate: 300 g/sq. ft. The size and weight of tray were 2.5 sq. ft. and 635 g, respectively. Biomass improved with the seed treated with growth regulator over control. The biomass and plant height increased up to 10th day, and then the curve took plateau on 11th day. Productivity and plant height of GA treated fodder maize was observed as 6.03 kg biomass/kg seed and 30.6 cm, respectively as compared to 3.38 kg biomass/kg seed and 24.5 cm under control.

3.5.11 Development of forage based feed for commercial goat farming

(CRSCIGFRISIL20190602)

Assessment of fodder leaves and wood mass productivity in *Moringa oleifera*

Supplementation of protein rich fodder tree leaves or its leaf meal could be a potential alternative for increasing the quality of livestock diet. A study was conducted to assess Moringa plantation (10,000 plants/ha) with respect to leaves and wood production per unit area to quantify precise biomass production. Plant base diameter to leaf biomass and wood mass yield had high correlation coefficients (R^2) ranged from 0.80 to 0.87. Mean leaf fodder yield of 22.7 t/ha, wood yield of 98.4 t /ha with leaf stem ratio of 18.8:81.2 were observed on fresh harvesting basis. Dried leaf and wood mass production were recorded 6.6 t/ha and 65.9 t/ha, respectively. Crude protein (19.5%) yield from Moringa leaves was 1292 kg/ha on dry matter basis. A process methodology was also developed for the preparation of Moringa leaf meal.

3.5.12 Development of automatic seed coating machine

(CRSCIGFRISIL20190605)

A seed coating machine for treatment of fodder seeds was developed (Fig. 3.5.6). The main components of the machine were seed treatment chamber, chemical mixer (material - plastic, volume - 2 l), hopper and control system. Overall dimension of fabricated machine was 1040×700×1350 mm. A treatment chamber (volume 137 l) was developed that could treat 15-20 kg seeds in one batch depending upon the type/density of seeds. It was fabricated using stainless steel sheet of 2.5 mm thickness. A seed disc (58.5 cm diameter and 2 mm thickness) was provided at the base of chamber so that the disc could rotate freely inside the chamber. Fabric material was used for sealing the gap between seed disc and hollow cylinder of chamber. Two rectangular baffle plates (350×150×2 mm) were incorporated inside and over the periphery of chamber for uniform mixing of chemical with seeds. A liquid atomizer plate was incorporated over seed disk for splashing out the chemical liquid coming from chemical mixer. Cast iron (CI) frame (1040×640×550 mm) was used to assemble different components of machine. Frame was fabricated using square hollow CI section (38×38×2 mm) and covered with 3 mm thick CI sheet to accommodate other components. A motor (A.C. induction, 2 HP, 1440 RPM, 230 V, 1 P) was fitted below the frame to transmit power to seed disc of treatment chamber. V belt pulley (D 5") was installed over motor shaft (D 1") and two brackets (P206) arrangement was made for installing different pulley according to required different gear ratio over seed disc shaft (D 1"). V-belt was used for transmitting the power from motor to seed disk in treatment chamber. The seed disc speed and angle of inclination of baffle wall (ɵ) for berseem were found optimum at 200 RPM and 30°, respectively. Machine output capacity was 600 kg/h for berseem seed.

Fig. 3.5.6. Developed seed coating machine

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

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

In addition to four already selected farmers, additional eight farmers were identified during the period and necessary activities for the development and assessment of new IFS models has been initiated and the progress of existing models (Fig. 3.6.1) was recorded. Training and capacity building of farmers in the area of improved fodder and livestock technologies was given through exposure visits to innovative mushroom and vermicompost units and nearby research institutes. Under the forage technologies, BN hybrid/ Guinea grass/ TSH based round the year fodder production systems, non-traditional fodders (*Azolla*, cactus, fodder beet, moringa, subabul), hydroponic fodder, fodder conservation through silage and hay, animal feed balancing, mineral mixture supplementation *etc*. were transferred and adopted by the IFS farmers. The productivity and profitability analysis of four IFS models [Model I: Semi medium (3 ha, livestock specialized), Model II: Semi-medium (3 ha, crop specialized), Model III: Medium (5 ha), Model IV: Goushala (5 ha) was done and the B:C ratio was 1.95, 1.67, 1.61 and 1.38 for model I, II, III and IV, respectively.

Fig. 3.6.1. Components of livestock based integrated farming system

3.7 All India Coordinated Research Project on Forage Crops and Utilization

Kharif 2022

3.7.1 Forage crop improvement

In *kharif* 2021, a total of 17 multi-locational trials (13 annual and 4 perennials) were conducted at 34 locations. The annual crops include fodder maize, fodder pearl millet, fodder cowpea, fodder rice bean, and Dinanath grass, whereas the perennial system consists *Cenchrus ciliaris, C. setigerus*, BN hybrid and *Stylosanthes*. A total of 88 entries including 57 annual and 31 perennial along with national and zonal checks were evaluated. The success rate for all trials was 97.1%.

In Initial Varietal Trial in forage maize (IVTM), fourteen entries with three national checks were evaluated at 23 locations including 4 each in hill, south and 5 each in the north-west, north-east and central zones. For green fodder yield (GFY) and dry matter yield (DMY), entries CMH-12-686, PJHM-1, MFM-18-2, IIMFC-2 and ADFM-2 showed superiority over the best check by ~5% in one zone or at the national level. For crude protein yield (CPY), at all India level, entry CMH-12-686 (800 kg/ha) was best followed by PJHM-1 (780 kg/ha). For crude protein (CP), entry PJHM-1 ranked first in the hill, entry CMH-12-686 in CZ, and entry IIMFC-2 in NEZ. Entry CMH-12-686 was the best performer for IVDMD followed by ADFM-2.

In First Advance Varietal Trial in forage maize (AVTM-1), six entries with three national checks were evaluated at 23 locations comprising 4 locations each in hill, south and 5 each in the north-west, north-east and central zones. For GFY, entry HQPM-28 in HZ, CZ and entry PFM-13 in CZ and for DMY, entry HQPM-28 in HZ, NWZ and CZ; entry DFH-2 in NWZ showed superiority over the best check. For CPY, entry DFH-2 ranked first for NW, HQPM-28 for central, south as well as at all India level. For CP, entry PMC-11 was the best performer in NE zone, and entry HQPM-28 for the south zone.

The second Advance Varietal Trial in Forage Maize (AVTM-2) comprising one entry PFM-12 with three national checks was conducted at 11 locations (5 in northwest and 6 in the central zone). For GFY, DMY and CPY, national check J-1006 was top ranked. For CP (%), national check African Tall was top-ranked. **AVTM-2 seed** comprising of one entry PFM-12 along with three national checks was conducted at 6 locations (2 in the northwest and 4 in the central zone). National check African Tall was top ranked in NW zone whereas Check COHM-8 was top ranked for the central zone as well as combining both zones.

An **IVTPM (pearl millet)** comprising eight entries with two national checks (Giant Bajra and RBB-1 and respective zonal checks) was conducted at 19 centres (5 in NW, 4 in NE, 4 in SZ and 6 in CZ). For GFY, entry JPM 18-71 in NWZ, NEZ, SZ; entry AFB-54 in NWZ; entry ADV175020 in NWZ, NEZ, SZ; entry FSB2021-1 in NWZ, NEZ, SZ, entry FBL-7 in NEZ, entry FBL-6 in NEZ showed superiority over the best check by a margin of > 5%. The above mentioned entries also showed superiority (>5%) over the best national check at all India level. For DMY, entry JPM 18-71 in NEZ; entry AFB-54 in NWZ; entry ADV175020 in NWZ, NEZ, CZ; entry FSB2021-1 in NWZ, NEZ, SZ. Entry FBL-7 in SZ. Entry FBL-6 in NEZ, SZ showed superiority over the best check by a margin of more than 5%. The same entries also showed superiority (>5%) over the best national check at all India level. For CPY (q/ha), AFB-54 in NWZ, JPM-18-71 in NEZ, ADV175020 in CZ and SZ were best performers. At all India level, entry ADV175020 was best (760 kg/ha) followed by JPM-18-71 (710 kg/ha) and check RBB-1 (700 kg/ha). For CP, AFB-45 and ADV175020 in NWZ, FBL-7 in NEZ, ADV175020 in CZ, entry JPM-18-71 in SZ were best performers. At all India level, entry JPM-18-71 (820 kg/ha) was best followed by check Giant Bajra (8.0%). Entry AFB-45 for ADF, check Giant Bajra for NDF and FBL-7 for IVDMD were superior.

In **AVTPM-1,** five entries with two national checks (Giant Bajra and RBB-1) and respective zonal checks were evaluated at 19 locations comprising 4 each in NE and SZ, 5 in NW, and 6 in CZ. For GFY, entry 16ADV0111 in NWZ, NEZ, CZ, SZ, at all India level; entry JPM-18-37 in NWZ, SZ, at all India level; entry FBL-4 in SZ, at all India level; entry TSFB-1610 in SZ, at all India level; entry PHFB-5 at all India level showed superiority over the best check by a margin of >5.0%. For DMY, entry 16ADV0111 in NWZ, NEZ, CZ, SZ, at all India level, entry JPM-18-37 in NWZ, NEZ, CZ, SZ, at all India level; entry FBL-4 in SZ; entry TSFB-1610 in NWZ, SZ, at all India level; entry PHFB-5 at all India level showed superiority over the best check by a margin of >5.0%. For per day productivity entry

JPM-18-37 ranked first for both green and fodder production. For CPY, entry TSFB-1610 in CZ, entry 16ADV0111 in NEZ, SZ and at all India level were best performers. For CP, zonal check AFB-9-1 top ranked in NWZ, BAIF bajra in CZ, Moti Bajra in SZ, whereas national check Giant Bajra top ranked in NEZ and at all India level. Entry FBL-4 ranked first for ADF and IVDMD whereas RBB-1 ranked first for NDF. In **AVTPM-2,** four entries with two national checks *i.e.* Giant Bajra and RBB-1 and respective zonal checks were evaluated at 19 locations comprising of 4 in SZ, 5 in NW, 4 in NE, and 6 in CZ. For GFY, entries 16ADV0055 and JPM-18-7 in NWZ, and at all India level, entry Dev-1 in NWZ, SZ, and at all India level were superior over the best check by a margin of >5.0%. For DMY, entries 16ADV0055 in NWZ, CZ, and at all India level; entry JPM-18-7 in NWZ and at all India level; entry Dev-1 in SZ, CZ and at all India level were superior over the best check by a margin of >5.0%. For CPY, entry JPM-18-7 in NWZ, Dev-1 in NEZ, CZ, SZ and at all India level ranked first. For CP, zonal check AFB-3 in NWZ, APFB-9 in NEZ, entry Dev-1 in CZ, national check Giant Bajra at SZ and at all India level ranked first. Entry Dev-1 followed by 16ADV0055 for ADF and IVDMD; 16ADV055 followed by Dev-1 for NDF performed better. In **AVTPM-2 Seed,** four entries with two national checks *i.e.* Giant Bajra and RBB-1 and respective zonal checks were evaluated at 9 locations (3 in SZ and 2 each in NW, NE, and CZ). For seed yield, zonal check AFB-3 in NWZ, entry 16ADV0055 in NEZ, JPM-18-7 in CZ, Dev-1 in SZ and JPM-18-7 at all India level ranked first. The superiority in SZ over the best check was 26.1% for Dev-1, 23.6% for JPM-18-7 and 11.6% for 16ADV0055. At all India level also entries JPM-18-7 (13.2%), Dev-1 (7.8%) and 16ADV0055 (2.4%) were superior over the best check.

In **IVTC (forage cowpea),** eight entries with two national checks and respective zonal checks were evaluated at 26 locations (3 in HZ, 4 in NW, 6 in CZ and 6 in SZ while 7 in NE). Entry UPC-21-1 was superior by a margin of 6.0 % for GFY and 6.7% for DMY over the best check in NEZ. For DMY, MFC-18-8, MFC-18-10 and PFC-40 were superior over the best check a margins of 11.5%, 14.0% and 7.9% respectively in CZ. For CPY, entry UPC21-1 in NWZ, and NEZ, MFC 18-10 in SZ were top ranked. For CP, at all India level, entry MFC-18-8 was best performer (16.2%) followed by entry PFC-40 and national check UPC-5286 (15.5%). In **AVTC-1,** two entries with two national checks (Bundel Lobia-1 and UPC-5286) and respective zonal checks were evaluated at 6 locations in SZ and 7 in NEZ. National or zonal checks showed superiority for GFY, DMY, per day productivity. For CPY, entry HFC-17-9 in SZ, and national check UPC-5286 in NEZ ranked first. For CP, entry HFC-17-9 ranked first in SZ (20.7%) while national check UPC 5286 ranked first in NEZ. Combining both zones, entry HFC 17-9 ranked first (17.1%) as compared to best check UPC 5286 (16.7%). For ADF, NDF and IVDMD, national check Bundel Lobia-1 was best performer.

In **IVTRB (rice bean),** four entries with two national checks (Bidhan-3 and Bidhan-2) were evaluated at 10 locations. Entry JRBJ 12-9 ranked first showing superiority of 12.3 % for GFY and 12.4% for DMY as compared to best check. For leafiness, entry JRBJ-12-9 ranked first. For CPY, entry JRBJ-12-9 ranked first followed by entry BRB1-L13P5 and JOR-21-1. For CP, entry BRB1-L13P5 was best (16.2%), followed by entry JRBJ-12-9 (15.9%), JOR-21-1 (15.6%) as compared to best check Bidhan -2 (14.9%).

AVT-2 Dinanath grass comprising of four entries with one national check was conducted at 8 locations. Check Bundel Dinanath-2 performed best for both GFY and DMY as well as per day productivity. In quality parameters, for CPY (kg/ha), check Bundel Dinanath-2 ranked first followed by JHD 19-4. For CP, entry BAU-DN-103-18-2 ranked first with value of 8.3 % followed by BAU-DN-110-18-2 (8.1%) as compared to 7.1 % in check Bundel Dinanath-2. Entry BAU-DN-109-8 ranked first for ADF, NDF and IVDMD. **AVT-2-seed-Dinanath Grass** comprising of four entries with one national check was conducted at 5 locations. Entry JHD-19-4 showed superiority over the best check by a margin of 7.7% for seed yield.

For *Cenchrus ciliaris* (perennial), trial was established in 2019 with 6 entries along with 3 checks in three zones. National check IGFRI-67-365 performed best for GFY in all zones and also at all India level. For DMY, entry IG-96-414 and RCCB-05 were superior over the best check by a margin of >8% in NWZ, and SZ, respectively. In CZ and at all India level, the national check IG-67-365 was best.

For CPY, check IGFRI-67-365 was best whereas for CP, entry RCCB-06 was best (7.9%) followed by RCC-2016-8 (7.6%). For ADF, national check CAZRI-75 was best whereas entry RCCB-06 performed best for NDF and IVDMD.

***Cenchrus setigerus* (perennial)** trial was established in 2019 with four entries and three national checks at 12 locations. For GFY and DMY, national checks performed best in all zones and at national level. National check TNCS-265 in NWZ, IG-96-706 in SZ and CAZRI-76 in CZ and at all India level were top ranked. For CP, entry RCSB-08 ranked first (7.4%) followed by entry IG-97-447 (7.2%) and entry RCSB-09 (7.0%) and national check CAZRI-76 (6.9%). For CPY, national check TNCS-265 ranked first.

Bajra Napier hybrid (perennial) trial was established in 2019 with fourteen entries and two national checks at 19 locations. It included 2 locations in HZ, 3 in NW, 3 in NE, 5 in central 4 in south zone. The entries are in coded form and will be decoded after completion of trial.

3.7.2 Forage crop production

The programme on forage crop production was conducted at 42 locations during *kharif* 2022. In total 10 experiments were conducted, out of which 4 in coordinated, 3 AVT trials and 3 in location specific mode.

K-20-AST-1a-Response of fodder crops to micronutrient management trial was conducted at five locations (Rahuri, Bikaner, Imphal, Ranchi and BUAT Banda) to study the effect of PGRs and micronutrients on growth, yield and quality of Maize. In Rahuri and Banda, testing material was maize, whereas BxN hybrid was at Bikaner, Imphal and Ranchi. The results indicated that 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 recorded significantly yield.

K-20-AST-1b -Yield enhancement and bio-fortification of *kharif* forages with PGRs and micronutrients was conducted at four locations to study the effect of PGRs and micronutrients on growth, yield and quality of sorghum. On location mean basis soil application of 5 kg Zn + 2 kg B/ha + triacontanol (10 ppm) as foliar spray at 30 DAS recorded significantly higher green fodder, dry matter and crude protein yield.

K-21-AST-7 -Effect of nitrogen and cutting management on performance of forage pearl millet varieties trial was conducted at Hyderabad, Raipur, Pusa, Ludhiana, Jabalpur and Varanasi to study the effect of nitrogen and cutting management on yield and economics of new pearl millet varieties for prolonged quality fodder availability. Moti Bajra with 120 kg/ha nitrogen and taking three cuts (first at 50 days after sowing, second at 35 after first cut and last cut at 50% flowering proved best.

K-20-AST-3 Optimizing the feedstuffs for air evacuating method of silage production in polybags field experiment was conducted at Coimbatore to identify suitable fodder crops and additives for polybag method of silage production. Higher quality silage with acetic acid content of 2.5% and lactic acid content of 9.0% was produced from fodder maize by air evacuation method with 1%molasses.

In K-20-AST-6 Precision nitrogen management for enhancing fodder yield and nitrogen use efficiency in forages, **p**roduction of fodder maize was better with 150 kg N/ha (40% N basal) + remaining based on LCC 5. It recorded 47.91 t GFY and 13.75 t DMY/ha.

K-20-AST-5 Evaluation of promising fodder grass varieties under shade was laid out at Vellayani center to assess the influence of different shade levels on the growth, quality and yield of promising fodder varieties. Highest GFY (241.9 t/ha) and DFY (60.5 t/ha) were recorded by CO-5 under open condition. Under 25% and 50 % shade levels, highest GFY and DFY were recorded by guinea grass var. Sulabha.

R-19-AST-5 Standardization of magnesium nutrition in BN hybrid experiment was laid out at Vellayani to assess the impact of varying doses and frequency of application of magnesium on the growth, yield and quality attributes of BN hybrid. Significantly superior values of GFY (189.13 t/ha) and DMY (47.3 t/ha) were recorded with application of 100 kg $MgSO_4$/ha once in 6 months.

K-21-AST-1 AVTPM-2-1 was conducted at ten locations in four zones to find out the response of four promising entries and three checks of pearl millet under three level of nitrogen application *i.e.* 30, 60 and 90 kg/ha. In NW and NE, entry Dev-1 proved superior. In SZ, JPM-18-7 produced maximum GFY, DMY and CPY. In CZ, entry

16ADV0055 proved higher yielder. Herbage yield and CPY increased consistently with increasing level of nitrogen up to 90 kg N/ha.

K-21-AST-2- AVTM-2 **on forage maize** was conducted at three locations in NW and two locations in CZ to find out the response of one promising entry and two checks of maize under four level of nitrogen application *i.e*. 40, 80, 120 and 160 kg/ha. In CZ, the entry PFM-12 (66.17 t GFY/ha) out yielded checks COHM-8 and J-1006. In NW, entry PFM-12 did not perform well. Herbage and CPY increased consistently with increasing level of N up to 160 kg N/ha.

K-21-AST-3 AVTD-2 on **Dinanath grass** was conducted to find out the response of four promising entries of Dinanath grass to three graded doses of nitrogen (30, 60 and 90 kg N/ha). On locational mean basis the national check produced maximum GFY and DMY of 26.24 and 5.26 t/ha, respectively. Herbage yield, CPY and CP increased consistently with increasing level of nitrogen up to 90 kg N/ha.

3.7.3 Forage crop protection

The programme on forage crop protection was conducted at 6 locations. In total, 11 trials were conducted.

PPT 1: Monitoring of diseases and insect pests in *kharif* forage crops: In *kharif* 2020, study of population dynamics of important diseases and insect pest in *kharif* forages (sorghum, maize, bajra, rice bean, cowpea and BN hybrids) was carried out. At Ludhiana**,** major disease in pearl millet were leaf blast and downy mildew; grey leaf spot and anthracnose in sorghum and leaf blight in maize. At Palampur**,** major disease were wilt-root rot complex in cowpea; leaf bight in maize; zonate leaf spot in sorghum and leaf blast in bajra was observed. At Rahuri**,** fall army worm infestation and Maydis leaf blight infection was high in maize; incidence of yellow mosaic virus and aphids infestation was low to moderate in cowpea. At Bhubaneswar, wilt-root rot complex and yellow mosaic virus in cowpea; leaf bight and banded leaf and sheath blight and fall armyworm in maize; leaf blast in pearl millet; leaf defoliators, root rot and yellow mosaic in rice bean. At Coimbatore**,** the major pests were anthracnose in sorghum; fall armyworm in maize and aphid in cowpea. At Jhansi**,** defoliators were major insect-pests of cowpea; fall armyworm in maize; leaf blast in bajra and zonate leaf spot in sorghum.

PPT-2: Evaluation of *kharif* breeding materials for their resistance to diseases and insect-pests under natural conditions - IVT in pearl millet: At Rahuri and Jhansi, all the entries were resistant to moderately resistant against blast disease. At Ludhiana, all entries were found susceptible to leaf blast. At Bhubaneswar, all the entries were resistant to moderately resistant against blast and defoliators except AFB-54 and RBB-1. **AVT–1 PM:** At Rahuri and Jhansi, all the entries were resistant to moderately resistant against blast disease. At Ludhiana, all entries showed susceptible disease reaction to leaf blast. **AVT–2 PM:** At Rahuri, Bhubaneswar and Jhansi, all the entries were resistant to moderately resistant against blast disease. At Ludhiana, all entries showed susceptible disease reaction to leaf blast.

IVT in cowpea: At Rahuri, entries HFC 17-7, MFC-18-10 and PFC 40 were resistant to aphids, whereas PFC 36, UPC-5286 and TSFC-20-06 were moderately resistant. The entries TNFC 1910, MFC-18-8 and PFC 40 were found resistant to the yellow mosaic virus. At Palampur, entries PFC 40 and TSFC-20-06 were found moderately resistant to root rot and wilt complex At Ludhiana, all the entries were found resistant to cowpea mosaic virus except HFC 17-7, PFC 40 and TSFC-20-06. At Coimbatore, all the entries were resistant to moderately resistant to aphids and yellow mosaic virus infestation. **AVT-1 (cowpea):** At Bhubaneswar, all the entries were found resistant to moderately resistant to aphid, root rot and mosaic except MFC-16-8. At Coimbatore, all the entries were resistant to aphids and yellow mosaic virus infestation.

IVT in maize: At Rahuri, all the entries were found resistant to moderately resistant to fall armyworm except IIMFC 1, ADC-2 and PJHM-1 which were moderately susceptible. At Palampur, all the entries were resistant to moderately resistant against *Turcicum* leaf blight. At Ludhiana, all entries showed resistant to moderately resistant disease reaction to *Maydis* leaf blight. At Bhubaneswar, all the expressed resistant to moderately resistant reaction to leaf blight except Hybrid - FSM2021-1, IIMFC 2, CMH-12-686 showed moderate susceptibility to leaf blight. At Jhansi, the entries ADFM-3, IIMFC 1, IIMFC 2, ADFM-2, MFM-18-27, CMH-12-686, HPFM-11, and MFM-18-2 were found resistant to *Spodoptera frugiperda*.

AVT–1 in maize: At Rahuri, all the entries were found resistant to moderately resistant to fall armyworm. At Ludhiana, all entries showed moderately resistant disease reaction to leaf blight of maize. At Palampur and Bhubaneswar, all the entries were resistant to moderately resistant against *Turcicum* leaf blight. At Jhansi, the entries PMC-13, PMC-11, COHM-8 were found resistant to *Spodoptera frugiperda*. At Coimbatore, all the entries were found resistant to *Spodoptera frugiperda.* **AVT–2 in maize:** At Rahuri, all the entries were found resistant to moderately resistant to fall armyworm and *Maydis* leaf blight. At Ludhiana, all entries showed moderately resistant disease reaction to leaf blight of maize. At Jhansi, all the tested entries were found resistant to *Spodoptera frugiperda*.

AVT-2 in Dinanath grass: At Bhubaneswar, all the entries were resistant to moderately resistant to leaf spot and defoliators except BAU-DN-103-18-2 which was found moderately susceptible to both leaf spot and defoliators.

VTCC- *Cenchrus ciliaris*: At Rahuri, entries CAZRI 75, IGFRI 3108, RCCB-05 were resistant while entries RCCB-06 and IG-96-414 were moderately resistant to leaf blight.

VTCS- *Cenchrus setigerus*: At Rahuri, IG-96-706 (NC) was resistant to leaf blight.

PPT-25: Validation treatments on non-chemical management of *Helminthosporium* leaf blight in fodder maize: At Ludhiana, leaf blight severity was observed very less in plots treated with two foliar sprays of chitosan @ 0.05% at 10 days interval with 19.21% respectively with 55.64% disease control as compared to check (43.31% severity). A higher benefit-cost ratio of 3.69 was obtained in two foliar sprays of chitosan @ 0.05% at 10 days.

PPT-26: Management of leaf blast in forage pearl millet was conducted at Ludhiana, Bhubaneswar, Palampur and Jhansi. Among 11 treatments, at Jhansi, Palampur and Ludhiana, best treatment was Seed treatment with tebuconazole + trifloxystrobin @ 1 g/kg seed + foliar spray of tebuconazole + trifloxystrobin @ 0.4 g/l]. At Bhubaneswar, best treatment was seed treatment with tricyclazole @ 0.6 g/kg seed and two sprays of the same fungicide @ 0.3 g/l.

PPT-27: Management of invasive insect-pest fall army worm, *Spodoptera frugiperda* L. on forage maize was conducted at Rahuri, Ludhiana, Bhubaneswar and Jhansi. at all the locations foliar spray of Emamectin benzoate 5 WG @ 0.5 g/l was the most effective in reducing the infestation of fall army in maize at 10 days after spray.

PPT-28: Assessment of crop losses due to diseases and insect-pests in forage cowpea was conducted at Ludhiana, Bhubaneswar, Palampur, Rahuri and Jhansi. Losses to the tune of 19.25, 32.98, 73.02, 32.14 and 22.94% in GFY were recorded at Ludhiana, Bhubaneswar, Palampur, Rahuri and Jhansi, respectively.

PPT-29: Eco friendly management of zonate leaf spot of sorghum was conducted at Palampur. Three foliar sprays of propiconazole @ 0.1% were most effective. Among the non-chemical methods, three foliar sprays of Tamarlassi @ 10% recorded 49.19% disease control with a 12.35% increase in the yield over control.

PPT-30: Management of root rot and wilt in cowpea was conducted at Bhubaneswar. The chemical seed treatment with tebuconazole 2 DAS @ 1 g/kg seed along with basal soil application of *T. viride* @ 4 kg/ha enriched in FYM @ 250 kg/ha was best which reduced the disease by 58.1% and increased the yield by 17.6% compared to control. Among nonchemical treatments, seed treatment with *T. viride* along with basal application of the same bio-agent was found superior recording followed by *P. fluorescens*.

PPT-31: Estimation of yield losses due to insect-pests in fodder sorghum was conducted at Rahuri and Coimbatore. At Rahuri, overall yield losses in sorghum were estimated to be 43.10%. Yield losses due to shoot fly alone were estimated to be around 25.62%. Yield losses due to fall armyworm were estimated to be around 5.22%. Yield losses due to aphids were estimated to be around 20.97%. At Coimbatore, overall yield losses in sorghum were estimated to be 32.23%. Yield losses due to shoot fly alone were estimated to be around 15.68%. Yield losses due to fall armyworm were estimated to be around 6.14%

PPT-32: Estimation of yield losses due to foliar diseases (anthracnose, gray leaf spot and zonate leaf spot) in fodder sorghum was conducted at Ludhiana, Palampur and Jhansi. At Palampur, the maximum GFY loss recorded due to zonate leaf spot was 19% while 16.2% at Jhansi. At Ludhiana, the maximum

GFY loss due to grey leaf spot and anthracnose was 30%.

3.7.4 Breeder seed production (*kharif* 2021) [Indent year *kharif* 2022]

In *kharif* 2021, a total indent of 7.81 t for breeder seed production (Indent year *kharif* 2022) was received from DAC, Govt. of India for 20 varieties of 6 forage crops *viz.,* fodder maize, fodder pearl millet, fodder cowpea, fodder guar, hedge lucerne and Sewan grass. The indent was allotted to twelve SAUS/ICAR/NGO institutes. In forage maize, 04 varieties were indented and total production was 8.148 t as against the indent of 6.02 t making a surplus of 2.13 t (35.34%). In forage pearl millet, 6 varieties were indented and total production was 765 kg as against the indent of 155 kg thereby making a surplus of 610 kg (393.55%). In forage cowpea, 7 varieties were indented and total production was 2275 kg as against the indent of 1590 kg, thereby making a surplus of 685 kg (43.08%). In Sewan grass, 10 kg was indented for one variety RLS-11-50. Production was 1100 kg thereby making a surplus of 1090 kg (10900%). In fodder guar, an indent of 25 kg was received for one variety Bundel Guar-3 and production was nil as crop was reported to be damaged due to heavy rain. In the case of hedge lucerne, an indent of 10 kg was received for one variety TDN 1308 which was produced by TNAU, Coimbatore. ICAR-IGFRI Jhansi also reported the production 20 kg seed of Guinea grass variety PGG 518 which was not indented. Thus variety wise scenario indicates that production was equal or more in 18 varieties and deficit in 2 varieties as compared to indented quantity. The overall breeder seed production in forage crops was 12318 kg as against the indent of 7810 kg indicating that surplus production was 12318 kg or 4508 kg (57.72%) higher than the indented quantity.

Rabi 2022

3.7.5 Forage crop improvement

In *rabi* 2021-22 and summer 2022, multi-location trials were conducted across the country to identify the suitable entries for different zones and at national level. A total of 24 multi locational trials comprising test entries along with their respective checks were conducted at 34 locations in the country. It included 20 trials under annual (berseem, oats, lucerne, *Lathyrus*, bajra (multicut, summer) and 4 under perennial (lucerne, sainfoin, orchard grass, tall fescue) crops. A total of 127 entries including 99 annual and 28 perennial along with national and zonal checks were evaluated.

In IVTB (berseem), five entries with one each national and zonal check in respective zones were evaluated at 17 centres comprising 2 locations in HZ, 5 each in NWZ, NEZ and CZ. For hill zone, entries BM-13, PC-115, HFB-18-3 were better than the best check (19.3%) for CP %. For NWZ, entries BM -13, PC-115 were better than the best check (17.7%) in CPY, whereas entries HFB-18-3, JB-08-19, BM-13 performed better than the national check Wardan (19.1) in CP%. For CZ, entries PC -115, BM-13, HFB -18-3, HFB-18-9, JB-08-19 performed better than the best check for GFY, DMY and CPY. Entries HFB-18-9 and PC-115 performed better than the best zonal check BL-44 (18.5%) in CP%. In NEZ, national check Wardan performed best for GFY, DMY as well as CP% and CPY. For other quality parameters, entry BM-13 top ranked for ADF%, national check Wardan for NDF% and entry BM -13 for IVDMD. **In AVTB-1,** four entries with one national and one zonal check were evaluated at 17 centres, 3 in HZ, 5 each in NW and CZ, and 4 in NEZ. In HZ, for CPY and CP%, entry PC-114 ranked first. In NWZ, entry PC-114 for GFY and entries JB-08-17 and PC-114 for DMY were more than 5% superior over the best check. For NEZ, entry JB-08-17 showed superiority for GFY and DMY over the best check. For CZ, entries performing better than the best check for GFY, DMY, CPY and CP% included JB-08-17, PC-114, JHB-20-1 and JHB-20-2. At all India level, PC-114 was best performer. For DMY and CP%, entries JB-08-17 and PC-114 performed better than the national check. Entry PC-114 was the best performer for NDF%, ADF% and IVDMD%. **In AVTB-2,** two entries along with one national and one zonal were evaluated at 17 centres, 3 locations in Hill, 5 each in NW and CZ, 4 in NEZ. In HZ, NWZ and NEZ, national or zonal checks showed superiority over the entries for desirable traits. In CZ, entry JB-07-15 followed by entry BM-14 showed superiority over the best check for GFY and DMY, CPY, CP%. At all India level, entries BM-14 and JB-07-15 showed marginal superiority over the best check. National check Wardan ranked first for NDF%, ADF% as well as IVDMD%. In **AVTB-2 (seed)** conducted at 11 centres, 1 in Hill, 3 each in NW and NE and 4 in CZ. In HZ, entry JB-07-15 performed better than the national check. In NWZ,

entry BM-14 was the best performer followed by JB-07-15 showing higher seed yield by margins of 39.4% and 15.3% respectively over the best zonal check. In NEZ, entries JB-07-15 and BM-14 performed better. At all India level, entries JB-07-15 and BM-14 showed higher seed production by margins of 11.8% and 3.0% over the national check Wardan. **In IVTO (single cut; SC),** thirteen entries with one national and one zonal check were evaluated at 27 locations in HZ (3), NWZ (6), NEZ (6), SZ (4) and CZ (8). In HZ, for GFY, entries UPO-21-1, BAUO-105 and HFO-1113 were superior over the best check. Entries BAUO-105, JO-08-41, OL-1988, and UPO-21-1 showed superiority over the best check for DMY. For CPY, BAUO-102 top ranked followed by BAUO-105. For CP%, entries NDO-1925, SKO-245 and BAUO-102 showed superiority over the best check. In NWZ, CZ and NEZ, none of the entries could perform better than the best check for GFY or DMY. In NEZ, for CPY, entries OL-1988, BAUO-105, JHO-21-1 and UPO-21-1 showed superiority over the best check. For CP%, entries OL-1988 and OL-1967 performed better than the best check. In SZ, entries JHO-21-1, JO-08-41, and OL-1931-1 were found superior over the best check for GFY. Entries OL-1931-1 and JO-08-41 were the best performers for DMY. For CPY, entry JO-08-41 and for CP%, NDO-1925 were the best performers. At all India level, entries JHO-21-1, OL-1931-1, HFO-1113, and OL-1967 performed better than the best check for GFY. For other quality parameters, entry OL-1931-1 top ranked for NDF%, national check OS-6 for ADF, and entry OL-1988 for IVDMD%. **In AVTO (SC)-1,** eight entries with two national and one zonal check were evaluated at 26 locations i.e., 3 in HZ, 5 in NWZ, 6 in NEZ, 8 in CZ and 4 in SZ. In HZ, entry JO-08-37 for DMY, JO-08-37 and OL-1980 for CPY, JHO-20-1 and zonal check for CP% were superior over the best check. In NWZ, entry SKO-244 for GFY, OL-1977, SKO-244, HFO-1003 for DMY showed better performance than the best check. In NEZ, SZ and CZ, none of the entries showed substantial improvement over the best check. At all India level, for GFY, DMY and CPY, entries SKO-244, OL-1977, HFO-1009, and HFO-1003 showed superiority over the best national check. Entry OL-1980 for CP%, JO-08-37 for NDF% and IVDMD%, and national check for ADF% were best.

In **AVTO (SC)-2,** three entries with two national and one zonal checks were evaluated at 26 locations, 3 in HZ, 5 in NWZ, 6 in NEZ, 8 in CZ and 4 in SZ. In HZ, entries JO-07-28 and HFO-904 for DMY, HFO-904 and check OS-6 for CP% were superior over the best check. In NWZ, entry HFO-904 for DMY was superior over the best check. In NEZ, SZ for GFY and DMY as well as CPY, national check OS-6 was the best performer. In CZ, for GFY entry HFO-906 showed marginal superiority. For DMY, CPY, CP %, the checks were best. At all India level, entries HFO-904, HFO-906 for GFY, HFO-904 for DMY showed superiority over the best check. In **AVTO (SC)-2 (seed),** the same three entries were evaluated at 11 locations, 2 in HZ, 2 in NWZ, 3 in NEZ, 2 in CZ and 2 in SZ. Entry HFO-906 was top ranker in CZ, while JO-07-28 was best performer in SZ. At all India level, entry HFO-904 and national check were joint first.

In **IVTO-(multi cut; MC),** fourteen entries were evaluated against two national checks at 15 locations, 2 in HZ, 3 in NWZ, 5 locations each in NEZ and CZ. In HZ for GFY, all entries performed better than the checks. For DMY, entries FO-21-2, HFO-1121, FO-21-1, JHO-21-3, OL-1969, and HFO-1123 performed better than check. For CPY, almost all the entries performed better than the national checks. In NWZ for GFY and DMY, entries OL-1969, OL-1931-2, and FO-21-1 showed superiority over the best check. In NEZ for GFY, DMY and CPY, national check RO-19 ranked first. In CZ, national check RO-19 for GFY, entry JO-08-335 for DMY, JO-08-335 for CPY and OL-1975, FO-21-2, OL-1931-2 for CP% were found superior over the best check. At all India level, national check RO-19 ranked first for GFY, DMY and CPY. For other quality parameters, the best ranking entries were PLP-29 for NDF%, JHO-21-4 for ADF% and IVDMD%**.** In **AVTO (MC)-1,** six entries were evaluated against two national checks at 7 locations, 3 in HZ and 4 locations in NWZ. In HZ, HFO-915 for GFY, PLP-27, HFO-915, OL-1949, JO-08-329 for DMY were better than the best check. Other entries were either inferior or marginally superior over the best check in HZ and NWZ for GY and DMY. Entries JHO-20-3 and JO-08-329 for CPY, entries JO-08-329, JHO-20-3, OL-1949, PLP-27 for CP%, national check RO-19 for ADF%, UPO-20-2 for ADF%, JHO-20-3 for IVDMD were best over the best check. In **AVTO (MC)-2,** two entries JO-07-310 and PLP-24 were evaluated against two national checks at 3 in HZ and 5 locations in CZ. Entry PLP-24 for DMY in

HZ, national check for GFY and DMY in CZ were superior over the best check. National check RO-19 ranked first for NDF%, ADF% and IVDMD%. In **AVTO (MC)-2 (seed),** the same two entries were evaluated at 2 locations in HZ and 3 locations in CZ. Entry JO-07-310 was top ranked for hill zone and NWZ.

In **IVTO (dual),** nine entries along with two national checks were evaluated at 13 centres including 4 each in NWZ, NEZ and 5 locations in CZ. In NWZ for GFY and DMY, entry OL-1874-2 showed superiority over the best check. For CP% and seed yield, national check JHO 822 was the best. In NEZ, for GFY and DMY, entries HFO-1008, JHO-21-6, OL 1967-1, UPO-21-3, OL-1982-2, OL-1874-2, were superior by more than a 5% margin over the best check UPO-212. Entries HFO-1108, UPO-21-3, OL-1967-1, JHO-21-6, JO-13-518, OL-1874-2 for CPY, and JHO-21-5 and OL-1982-2 for CP% showed superiority over the best check. For seed yield, entries HFO-1108 and HFO-1119 were the best performers. In CZ, national check JHO-822 for GFY, Check UPO-212 and entry JHO-21-5 for CP% were found superior over the check. Check JHO-822 ranked 1st for seed yield. Entries OL-1967-1 and JHO-21-5 for NDF%, JHO-21-5 and UPO-21-3 for ADF%, and JHO-21-5 for IVDMD% ranked first. In **AVTO-1 (dual),** five entries were evaluated against two national checks at 8 locations comprising 4 each in NWZ, NEZ. In NWZ, entry JO-03-513 for DMY; HFO-1014, JHO-20-2, HFO-917, OL-1931, and JO-03-513 for CP% and HFO-1014 for seed yield showed more than 5% better yield than the best check. In NEZ, entries JO-03-513 and HFO-917 were superior over the best check for GFY, DMY and CPY. Entries JHO-202, HFO-1014, HFO-817, OL-1931, and JO-03-513 for CP%, and HFO-1014 and HFO-917 for NDF%, ADF% and IVDMD% were best performers.

In **VT lucerne perennial (2nd year),** A trial was established in 2020 with 5 entries. The data for this year was reported from seven locations including 2 locations in NWZ, 2 in CZ and 3 in SZ. The trial will continue in coded form. In **AVT-2 lucerne annual,** single entry LLC-6 along with two national checks were conducted at 6 centres, 2 in NWZ and 4 locations in SZ. In NWZ, entry LLC-6 was superior for GFY and DMY. In SZ, the national check RL-88 was best for GFY as well as DMY. For quality parameters, entry LLC-6 was best for CPY and IVDMD%. In **AVT-2 (seed),** single entry LLC-6 was evaluated against two national checks at 4 locations, 2 each in NWZ and SZ. National check Anand-2 was best for both zones for seed yield.

In **IVT *Lathyrus*,** nine entries were tested against the two national checks at seven locations. Best performing entries were JCL-21-3, IPLa-2021-01, JCL-21-1, BL-3, IPLa-2021-03, BL-5, JCL-21-2, BL-3, and BL-1. In **AVT-1 *Lathyrus*,** one entry KL-5 was evaluated against 2 national checks at seven locations. The entry KL-5 performed better than the two national checks for GFY, DMY, CPY, CP% and per day productivity.

In **IVT bajra (multicut),** ten entries were evaluated against three checks at 4 locations in CZ and 3 in SZ. In CZ, none of the entries could surpass the national check for GFY and DMY. In SZ, entries Alamdar-12, BAIF Bajra-9, ADV 2184, IIMR-FB-MC-2022-2, SBH-104, BAIF Bajra -10, HTBH-4904 showed superiority over the best check for GFY and DMY. However, for CPY and CP%, Check Moti Bajra top ranked. In **AVT-1 bajra (multicut),** two entries SBH-103 and 16-ADV175020 were evaluated along with 3 checks at 4 locations in CZ and 3 in SZ. None of the entries could beat the best check by a substantial margin in either of the two zones for desirable parameters.

Varietal trials including seven entries each in **VT orchard grass** and **VT sainfoin**, and ten entries of **VT tall fescue grass** were established at different centres of HZ. The year being the establishment year, the data will be reported from next year onwards. These are perennial trials and will continue in coded form.

3.7.6 Forage crop production

The forage crop production programme was executed at 61 locations in five zones. In total 17 experiments were conducted, out of which 11 were in the network (9 coordinated and 4 AVT based) and 6 were in location specific mode.

An experiment on the effect of cutting and splitting of nitrogen doses on growth, yield and quality of fodder oat cultivars was conducted at Raipur, Ranchi, Ayodhya, and Pantnagar. Maximum GFY at Ranchi, Raipur and Ayodhya was obtained with oat cultivar RO-19 and at Pantnagar with UPO-06-1. Nitrogen application and cutting management as three cut + 50% basal+25% at 1st cut+25% at 2nd cut At Raipur; three cut + 40% N as basal+30% at 1st

cut+30% at 2nd cut at Ayodhya and at Pantnagar with two cut + 50% N as basal+50% at 1st cut at Pantnagar proved better. An experiment on the effect of different potassic fertilizer sources on green fodder production and quality of fodder maize was conducted at Anand and Hyderabad centres. At Anand, 75% RDK through potassium schoenite + 1 % schoenite foliar spray (at 30 and 45 DAS) recorded maximum GFY and DFY. Whereas, at Hyderabad, 100 % RDK through potassium schoenite was better. Trial studies on the organic source of nutrients on forage yield and quality of Fodder cowpea-maize system under irrigated situation was conducted at Mandya, Coimbatore, Vellayani and Hyderabad. On a locational mean basis, application of 100% RDN through inorganic fertilizer recorded higher GFY and DFY of cowpea, maize as well as higher system productivity, net returns and B:C ratio. Experiment on studies on the organic source of nutrients on green forage yield and quality of rice bean-oat under irrigated situation was conducted at Kalyani, Imphal, Pusa and Ranchi. The highest GFY and DMY recorded with 50% RDN through FYM + 50% RDN through vermicompost at all centres except Ranchi where 75% RDN through FYM + 25% RDN through vermicompost proved better. An experiment on the efficacy of plant growth regulators on forage yield and quality of maize-oat cropping system was conducted at Urulikanchan, Srinagar, Pusa, Raipur, Hisar and Ranchi. Application of mepiquat chloride at 300 ppm produced the highest green forage yield over locations but the highest DM and CP yields were recorded with the application of GA_3 at 400 ppm. Precision N management for enhancing fodder yield and nitrogen use efficiency in forages was conducted at Mandya and Dharwad. On the location mean basis application of 150 kg N/ha (40% N basal + remaining based on SPAD meter critical value of 50) recorded significantly higher GFY, gross returns, Net returns and B:C ratio. Organic nutrient management for soil health and sustainability of round the year fodder production system was conducted at Palampur. Application of FYM @ 10 t/ha resulted in significantly higher GFY and DFY of system. Studies on the performance of organic nutrient management practices on soil health and sustainability of sorghum-oat cropping system was conducted at Ayodhya. Significantly higher GFY, DMY, CPY, net return and B:C ratio were recorded with FYM 5 t/ha basal + natural farming with mulch or FYM 10 t/ha. Optimizing production technology for sustainable organic fodder production and soil health was conducted at Pantnagar. Higher GFY was recorded under vermicompost application and rishi krishi system. BN hybrid +cowpea/berseem/ rice cropping system produced the highest GFY and DFY, gross return, net return as well as B:C ratio. Enrichment of BN hybrids and maize silage quality by amalgamation with legume tree and fodder crops was initiated at Hyderabad. Silage prepared from fodder maize showed lower pH levels than APBN 1 silage. The highest crude protein content was observed with the APBN-1+hedge lucerne. Evaluation of hedge lucerne for optimum seed rate and spacing for seed production was initiated at Hyderabad. Planting at 100 cm spacing along with 9 kg ha^{-1} seed rate was superior. Intensive fodder based cropping system for year round fodder supply was carried out at Hyderabad. In 1st year, annual based cropping system sorghum (MC) + cowpea (4:2) – maize + cowpea (4:2) – bajra (MC) + cowpea (4:2) was more productive and remunerative.

AVT-2 trials

The effect of P levels on forage yield of promising entries of berseem (AVTB-2-MC) was conducted at 10 locations. In Hill, North West, and Central zone as well as on the national level, entry JB-07-15 proved significantly superior. The effect of N levels on forage yield of promising entries of single cut oat (AVT-2 SC) was conducted at 10 locations in all five zones. In NE and Central and South zone, entry JO-07-28 yielded maximum green fodder and dry matter yields. On an overall mean basis, linear response to N application was noted up to 120 kg N/ha. Effect of N levels on forage yield of promising entries of multi cut oat (AVT-2 MC) was conducted at five locations in two zones. In the Hill zone, both the entries (PLP-24 and JO-07-310) proved higher yielders than checks. On an overall mean basis, linear response to N application was noted up to 140 kg N/ha. Effect of P levels on forage yield of promising entries of annual lucerne was conducted at five locations in North West and South zones. In both zones, LLC-6 proved superior and responsive up to 100 kg P_2O_5/ha.

3.7.7 Forage crop protection

Disease and pest occurrence during *rabi* 2021-22

During *rabi* 2021-22, the occurrence and abundance of major diseases and insect-pests in berseem,

lucerne and oats were recorded at six locations. At Ludhiana, 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%. At Rahuri, pea aphids and oat aphids were recorded in the range of 76-143 and 0.80-320 aphids/tiller, respectively. At Palampur, highest incidence of powdery mildew was observed in oats (45%). At Bhubaneswar, in oat, maximum leaf blight recorded was 50.6%, root rot incidence was 24.4% and berseem leaf spot and blight severity was 38.4%. At Jhansi, the incidence of stem rot in berseem and the severity of oat leaf blight started was 27.8 and 71.5%, respectively. At Coimbatore, in lucerne, the major pests observed were leaf folder, leaf miner, aphids and stink bug.

Disease management

At Ludhiana, for the ecofriendly management of *Helicoverpa* larvae, soil application of *Trichoderma viride* @ 1 kg/25 kg FYM/acre + foliar spray of NSKE @ 5%+ chickpea as trap crop on border row + bird perches exhibited the least disease incidence of stem rot, lower *Helicoverpa* larvae and higher GFY. At Ludhiana, for the management of stem rot of berseem, seed treatment + foliar spray with chitosan @ 0.05% showed the least stem rot incidence. At Palampur and Bhubaneswar, seed treatment with carbendazim @ 0.2% + foliar spray of chitosan @ 0.05% showed the least root rot incidence and leaf blight severity increase in green fodder yield. At Jhansi, seed treatment + foliar spray with carbendazim @ 0.2% showed least stem rot incidence and high GFY. At Ludhiana, plant extracts and organic inputs showing strong antifungal activities against (*Sclerotinia trifoliorum in vitro* were screened in pot experiments. the lowest disease incidence was provided by panchgavya, *Aegle marmelos* and *Cymbopogan citratus* at 10% concentration. At Rahuri, average yield loss due to aphids, rust, *Spodoptera litura, Helicoverpa armigera* were 6.84, 12.21, 6.15, 14.1% and cumulative average yield losses in control were 37.3%. At Ludhiana, cumulative average yield loss due to downy mildew, weevil recorded was 10.4 and 6.6% and cumulative average yield losses in control were 16.7%.

During 2021-22, leaf blight infected leaf samples of oat were collected from Ludhiana, Palampur, Bhubaneswar, Rahuri and Jhansi. A total of 18 isolates of *Drechslera avenae* (3 from Ludhiana, 2 from Jhansi, 7 from Palampur, 4 from Rahuri and 2 from Bhubaneswar) were isolated, purified and maintained. Biointensive management of defoliator insect pests in lucerne was conducted at Rahuri, 14 days after spraying, *HaNPV* and S*lNPV* 500 LE/ha was highly promising against defoliator larvae.

Germplasm evaluation programme against diseases and insect pests in *rabi* forages

In oat, a total of 122 germplasm lines were tested against different diseases and insect-pest. OGP-2 was found moderately resistant against powdery mildew at Palampur, resistant (against leaf blight) at Jhansi, Bhubaneswar and mesothetic against leaf blight at Ludhiana and thus can serve as an effective source of resistance against both powdery mildew and leaf blight diseases in oat. In berseem, a total of 72 germplasm lines were tested against different diseases and insect-pest at various locations. Germplasm lines *viz.*, BM-14, PC-114, BL-22, BL-1, BL-10, HFB-20-3, HFB-20-4, JB-06-1, JB-06-2, JB-06-6, JB-15-3, JB-15-4, JBSC-1 were found moderately resistant against stem rot; resistant to moderately resistant against leaf blight as well as root rot and thus can serve as an effective source of resistance against stem rot, root rot and leaf blight disease in berseem. In lucerne, a total of 27 lines were tested against different diseases and insect-pest at various locations. Against downy mildew, all the lines were moderately susceptible. Against weevil, all the lines were resistant or moderately resistant. Against aphids, all lines were susceptible at Rahuri. Against rust, 4 lines were categorized as resistant; 23 lines were moderately resistant.

3.7.8 Breeder seed production

During *rabi* 2021-22, breeder seed production indent was received from DAC, GOI for 38 varieties in four forage crops *viz*., oat (22), berseem (10), lucerne (4) and hedge lucerne (2). The total quantity allocated was 52.6 t and production was 53.65 t which was a 1.05 t surplus (an increase of 1.99%). In oat, the production was 48.51 t against the allocation of 43.88 t making a surplus of 4.62 t. In berseem, the total production was 4.81 t against the indent of 8.09 t making a deficit of 3.29 t. In lucerne, the total production was 233 kg which was 77 kg lower than the indent of 310 kg. In hedge lucerne, there was an indent of 300 kg seed of two varieties. In variety THSL-1 the target was achieved whereas in TND 1308 there was deficit production.

DAPSC/SCSP activities: Under the SCSP activities during 2022, AICRP coordinating centres had conducted on farm demonstrations of improved fodder varieties, distribution of quality seeds/root slips/inputs/implements and also conducted training programs at the different districts across the country and almost 550 farmers had benefited by the intervention of improved technologies.

NEH activities: Under the NEH activities, AICRP coordinating centres located at Jorhat and Imphal had conducted training programs, distributed literature on fodder crops in local languages and also quality seeds/root slips/inputs/implements at the different villages near their centre and 217 farmers had benefited by the intervention of improved technologies.

DAPSTC/TSP activities: Under the TSP activities, 2198 farmers benefitted from the training programs, FLDs, awareness camps, exhibitions and distribution of fodder inputs or related literature in local languages conducted by AICRP FCU centres in 12 states of the country.

3.7.9 Varieties identified for release

Lucerne (annual) entry LLC-6: Developed by PAU, Ludhiana, the entry was identified for release in the lucerne growing areas in Punjab and Rajasthan for cultivation in multicut irrigated system in *rabi* season.

Berseem entry BM 14: Developed by PAU, Ludhiana, the entry was identified for release in the NW, NE and Central zones comprising West Bengal, Jharkhand, Bihar, Odisha, Maharashtra, Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Uttarakhand, Haryana, Punjab, and Rajasthan for cultivation in multicut irrigated system in *rabi* season.

Berseem entry JB-07-15: Developed by JNKVV, Jabalpur the entry was identified for release in the Eastern- North Eastern and Central zones comprising West Bengal, Jharkhand, Bihar, Odisha, Maharashtra, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh for cultivation in multicut irrigated system in *rabi* season.

Forage oat (single cut) entry HFO-906: Developed by CCSHAU, Hisar the entry was identified for release in the NW zone comprising Rajasthan, Haryana, Punjab and *terai* part of Uttarakhand for cultivation in single cut irrigated system in *rabi* season.

Forage oat (multi cut) entry PLP-24: Developed by CSHHPKV, Palampur the entry was identified for release in the Hill zone comprising states of Himachal Pradesh, Uttarakhand and UT of J&K for cultivation in multicut irrigated system in *rabi* season.

Forage pearl millet entry JPM-18-7: Developed by JNKVV, Jabalpur, the entry was identified for release in Punjab, Haryana, Rajasthan, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka.

Forage pearl millet entry Dev-1 (Milkon): Developed by Crystal Crop Protection Ltd, Delhi, the entry was identified for release in Tamil Nadu, Telangana, Andhra Pradesh, and Karnataka.

Forage pearl millet entry BAIF Bajra-7: Developed by BAIF, Uruli Kanchan, the entry was identified for release in Tamil Nadu, Telangana, Andhra Pradesh, and Karnataka.

Forage pearl millet entry 16ADV0055: Developed by UPL Limited, Hyderabad, the entry was identified for release in Punjab, Haryana Rajasthan, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka.

Dinanath grass entry JHD 19-4: Developed by ICAR-IGFRI, Jhansi, the entry was identified for all the Dinanath grass growing areas of the country.

Forage crop production technologies

1. Air evacuation method of silage production in poly bags
2. Precision nitrogen management in fodder maize
3. Fodder productivity of moringa
4. Cutting and nitrogen management in multi cut fodder oat

Forage crop protection technologies

1. Non chemical management of *Helminthosporium* leaf blight in fodder maize
2. Eco-friendly pest management techniques in berseem ecosystem
3. Integrated disease management in berseem

3.8 Externally funded projects

3.8.1 DST-SERB-EMEQ project: Bioprospecting of abiotic stress tolerance genes in grasses

(CRSCIGFRICOL20200104)

The plants of Bundel deenanath 2 cultivar of *Pennisetum pedicellatum* were grown in pots and plants were induced to drought stress by withholding the water considered as treatment and control plants were continued with watering to maintain soil moisture at field capacity. The plants were sampled at 48 and 96 hours after inducing drought stress. The transcriptome sequencing and metabolic profiling revealed that phospholipase, chalcone synthase, ABA, calcium dependent protein kinase, syntaxin, phenylalanine amonia lyase, coumarate and flavonoid play important role in drought tolerance mechanism in deenanath grass. Similarly, *Chloris gayana* plants were induced to drought stress by withholding water 48 and 96 hours and salinity stress by exposing 300 and 400 mM NaCl. The leaf samples were collected and subjected to transcriptome sequencing and metabolic profiling.

3.8.2 DST-SERB-CRG project: Synthetic seed production in sterile Bajra Napier hybrid via encapsulation of somatic embryos

(CRSCIGFRICOL20220101)

Highly efficient *in vitro* plant regeneration protocol utilizing somatic embryogenesis pathway has been standardized in BN hybrid. For mass multiplication of somatic embryos under *in vitro* conditions, suspension culture protocol was standardized and newly developed somatic embryos were characterized under microscopic conditions. The somatic embryos generated were then transferred to regeneration medium for development to complete plant. The regeneration protocol was standardized, however, its efficiency needs to be improved.

3.8.3 NAD project: Study on productivity of fodder and grasses

An attempt was made to revisit the area and forage productivity data, both from range grasses and cultivated fodder. As per the DAC report, permanent pasture including other grazing lands is 3.39% of the total reported area. It is lowest (0.03%) in West Bengal and maximum in Himachal Pradesh (32.94%). This estimate of DAC is purely based on the Land-use data compiled by the Statistical Department. In the present study, Geospatial technology was used to generate the area under grasslands/ pasturelands and other grazing lands. This study provides a precise estimate about the area under different states (Fig. 3.8.1). That total area under grasslands is 3.5% (11.5 million ha) of the total geographical area. The maximum area (16.38%) under grasslands was observed in Himachal Pradesh and minimum in Delhi (0.33%), Punjab (0.48%) and Haryana (0.52%).

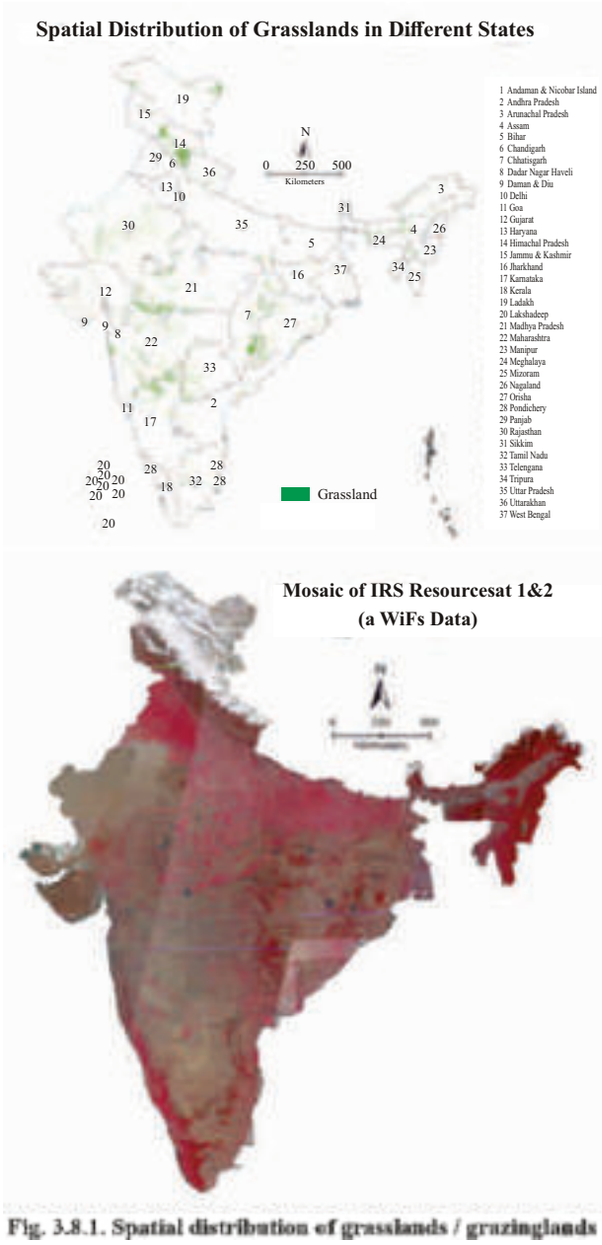


Fig. 3.8.1. Spatial distribution of grasslands / grazinglands

The distribution pattern of grassland and other grazing lands clearly shows that in central western part except for Kerala and AP uniformly distributed (3-5%) whereas in the northern plain, it ranges between 0.48-1.54%. The western Himalayan zone (except Ladakh) grasslands range between 3.0-

16.38%. The average forage productivity in metric tonnes of dry matter per hectare (t DM/ha) from grasslands including other grazing lands of the country was assessed as 3.22 t DM/ha; at the state level it ranged from 1.4 t DM/ha in Ladakh followed by Andhra Pradesh (2.1 t DM/ha) to 7.65 t DM/ha in Meghalaya followed by Kerala (7.2 t DM/ha). Efforts were made to estimate the total range of fodder in the country and it is estimated as 36.99 million tonnes of dry matter. Agro-climatic conditions affect the distribution pattern of grasslands; so grassland data were also extracted using the ACZ *shapefile.* It is evident from the study that the maximum area (5.03%) under grasslands is found in ACZ-1 (Western Himalayan Zone) whereas the minimum (0.82%) is in Trans Gangetic Plain.

3.8.4 NTPC project: Use of fly ash in agriculture for sustainable crop production and environmental protection

This project is funded by National Thermal Power Corporation ltd. to study the impact of long-term coal ash application on soil quality and food/fodder quality under different agro ecological zones of India and to formulate policy related guidelines for safe and maximum use of coal ash in agriculture. Under this project field experiment was laid out in the Randomized Complete Block Design consisting twelve treatments and three replications. Under this experiment perennial components *Leucaena leucocephala* and *Acacia nilotica* in combination with grasses - *Cenchrus ciliaris*, *Panicum maximum*; legume - *Stylosanthes seabrana* and annual components *viz*., sorghum-lathyrus, cowpea-oat based cropping system have been established in more than two hectares area. In the *rabi* season 2022, the highest green fodder yield (GFY) was observed in T11 treatment for all the perennial grass and legumes under *Leucaena* and *Acacia* based systems. The highest GFY and DFY was observed in T11 treatment for both the annual crops cowpea and sorghum, *Leucaena* and *Acacia* based systems. Application of fly ash had no significant effect on the soil pH, EC and OC content. However, it increased available phosphorus content significantly in the treatment T11 in sorghum based system. The application of fly ash increased the alkaline phosphatase concentration in T11. Penetration resistance and infiltration rate was found lowest in the T11 treatment for *Acacia* based system. Bulk density was found lowest in T11 treatment for both the soil layer in *Leucaena* and *Acacia* based systems.

3.8.5 UPCAR project: Development and evaluation of annual moringa for food, fodder and nutritional content in Uttar Pradesh

Study on feeding of Moringa) foliage as alternate feed for Jalauni sheep

This study was carried out at small ruminant unit of IGFRI Jhansi. Sheep (male) of Jalauni breed were used for the study. A total of 12 animals with average body weight of 20.6 kg were divided into three groups (4 in each) for the trial. All the animals were dewormed with broad spectrum antihelmintic before trial. Three types of diets were prepared each having roughage: concentrate ratio of 60:40 of dry matter requirement. Control group (T1) was fed with Guinea grass (*Panicum maximum*) + Concentrate mixture; while second group (T2) was fed with Guinea grass + Concentrate mixture (20% of DM req) + Moringa (*Moringa oleifera*) leaves (20% of DM req.) and third group (T3) was fed with Guinea grass + Moringa leaves. The sheep were allowed 10 days of adjustment period during which they were gradually introduced to the experimental diets. During the period, the animals were introduced to the control diet in order to adjust their rumen bacteria to the feed. Digestion trial was conducted for 7 days. Moringa leaves were freshly harvested (Fig. 3.8.2) for feeding and guinea grass was chaffed before feeding. Dry matter intake was significantly higher ($p \leq 0.05$) in T1 followed by T2. Dry matter intake per 100 kg body weight was almost similar in T1 and T2 group. Similar results were found for the DMI per metabolic body size. T1 group showed significantly higher ($p \leq 0.05$) DCP and TDN intake. Crude protein digestibility was significantly different among the group. T1 group showed highest digestibility of CP. Total digestible nutrient (TDN) and CP content of all the three diets were not significantly different

Fig. 3.8.2. Feeding trial on fresh moringa leaves

3.8.6 Developing cheaper nutrigel for improving water and nutrient use efficiency in degraded lands of Bundelkhand

The developed nutrigel from agro-wastes was used for field evaluation under a sorghum (*Sorghum bicolor*)-oat (*Avena sativa*) based cropping system (Fig. 3.8.3). Experiment was conducted using 25% NPK through nutrigel + 50% NPK through mineral fertilizer, 50% NPK through nutrigel + 50% NPK through mineral fertilizer, 50% NPK through nutrigel + 25% NPK through mineral fertilizer, 100% NPK through nutrigel and compared with 100% NPK through mineral fertilizer application. Biomass yield of sorghum and oat under 50% NPK through nutrigel + 25% NPK through mineral fertilizer was atleast 50 and 63% greater than 100% NPK application through mineral fertilizer, respectively. Thus, using 50% NPK through nutrigel + 25% NPK through mineral fertilizer, sorghum (8085 g/m^2) and oat (4766.7 g/m^2) biomass yield can be increased significantly. Soil properties like, soil organic carbon, nitrogen, phosphorus, potassium content was significantly improved by nutrigel application. Hence, 25% fertilizer can be saved, leading to reduction of cost of cultivation and boost in economic profit..

Fig. 3.8.3. Performance of nutrigel under sorghum-oat based cropping system

3.8.7 IGFRI-CIAT_Bioversity International project: Use and conservation of agrobiodiversity for food and nutrition security, increased agricultural sustainability, and resilience to climate change in India

Subproject 4: Develop methods for restoring degraded grazing lands

Application of drone for degraded land restoration and grassland development was initiated at the central research farm of the institute. Keeping in view of the climatic condition, soil type, and survivability, three grasses (*Cenchrus ciliaris*, *Megathyrsus maximus* and *Pennisetum pedicelletum*) were selected. For spreading through a hexacopter drone, seed pellets were prepared using a suitable combination of nutrient material, binding agent, and grass seeds. These pellets were spread over about 2 ha land using the drone (Fig. 3.8.4) for land restoration/grassland development and good grass seed germination (Fig. 3.8.5) was recorded. This application of aerial seed sowing technology made developing vast grasslands a possibility. It saved time besides reduced labor dependency. This work of ICAR-IGFRI would lead to addressing the target of restoration of degraded land as well as the shortage of fodder for livestock.

Fig. 3.8.4. Utilizing hexacopter drone for degraded land restoration and grassland development

Fig. 3.8.5. Grass seed germination after utilizing hexacopter drone based sowing

3.8.8 AMAAS project: PGPR inoculant bioformulations for rhizosphere management in enhancing biomass of fodder crops

Twenty three PGPR which enhance plant growth with reduced nutrient application were screened for their drought tolerance using PEG6000 in liquid medium *in vitro*. About six PGPR were used for *in vitro* drought tolerance in fodder cowpea and

sorghum (Fig. 3.8.6a) with 100%, 50% and 25% irrigation based on weight basis. Plant height in PGPR treated fodder cowpea seedlings ranged from 27.2-30.5 cm, shoot fresh weight (0.55-0.81 g/plant), root length (2.45-4.5 cm), root fresh weight (0.1-0.19 g/plant) compared to uninoculated control (28.2 cm, 0.56 g, 1.85 cm and 0.13 g, respectively) in 100% water applied treatments, while 50% watered treatments recorded 26.6-31.7 cm, 0.50-0.81 g, 2.1-4.2 cm and 0.08-0.21 g, respectively and 25% watered treatments recorded 24.9-33.3 cm, 0.50-0.89 g, 20-5.5 cm and 0.11-0.17 g, respectively. In fodder sorghum, plant growth ranged from 18.0-22.8 cm, shoot fresh weight (0.07-0.11 g), root length (1.7-4.0 cm) and root fresh weight (0.01-0.04 g) compared to uninoculated control (18.8 cm, 0.06 g, 1.55 cm and 0.02 g, respectively) in 100% watered seedlings for 10 days, while 50% watered treatments recorded 19.1-26.0 cm, 0.07-0.11 g, 1.45-2.50 cm and 0.01-0.03 g, respectively and 25% watered seedlings recorded 18.2-24.7 cm, 0.08-0.10 g, 1.1-2.5 cm and 0.01-0.04 g, respectively. The proline content in the PGPR treated sorghum seedlings ranged from 0.13-0.23, 0.15-0.25 and 0.16-0.26 µmol/g, respectively in 100%, 50% and 25% watered treatments compared to uninoculated control (0.15 µmol/g). While the proline content in the PGPR treated cowpea seedlings ranged from 0.30-0.34, 0.29-0.45 and 0.29-0.40 µmol/g, respectively in 100%, 50% and 25% watered treatments compared to uninoculated control (0.30 µmol/g).

In another experiment, eight bacterial cultures were used to evaluate oat production (Fig. 3.8.6b) in pots with 50% RDF and 50% water application on weight basis. All PGPR treatments recorded shoot (76.2-82.4 cm) and root length (10.8-14.1 cm), number of leaves/plant (8.3-10.7) at par with 100% RDF and 100% moisture treatment (83.0, 12.8 cm and 10.2, respectively). However, shoot and root fresh weight recorded in 50% RDF and 50% water application treatments were comparatively lesser than the 100% RDF and 100% moisture treatment (14.46 and 2.04 g). Proline content ranged from 0.58-3.56 µmol/g, malon dialdehyde from 0.27-0.46 µmol/g in PGPR treated 50% RDF and 50% water applied plants.

Fig. 3.8.6. Screening PGPR imparting drought tolerance in fodder a) sorghum and b) oat

3.8.9 NABARD project: Community fodder interventions for dairy development

About 112 self help groups were formed involving 1117 farmers in two cluster blocks Baiznath and Rait in District Kangra HP. A baseline survey was completed among 150 farmers. High percentage of farmers were unaware about the cultivation of improved varieties of fodder and grasses, mineral mixture feeding, scientific animal feeding, and management of common livestock diseases. Six hectares land infested with *Lantana* and other weeds were rehabilitated by the introduction of perennial grasses *viz. Brachiaria*, *Setaria*, *Paspalam*, BN hybrid. Improved fodder crop oats (JHO 822 and Kent) seed propagation in individual farm fields benefitted 628 farming families.

Rehabilitation of weed infested common grassland: One ha of common land was selected for fodder cultivation in one village cluster. An user group of 16 women farmers was formed in the village to take up the fodder development (Fig. 3.8.7) in the *Lantana* weed infested land with the support of MGNREGA, Himmotthan Society and Rural Technology and Development Centre. User groups contributed in the form of labour, transplantation, maintenance, manuring and fencing of the land. 10,000 grass rootslips of BN hybrid, *Setaria*, *Paspalum* and *Brachiaria* were transplanted.

Fig. 3.8.7. a) Members uprooted *Lantana* infested in common land b) life saving irrigation work c) fodder growth in common land d) harvesting of grasses

3.8.10 KISAN MITrA project: Doubling farmers' income in Bundelkhand region (IGFRI-ICRISAT collaborative project)

Under 'KISAN MITrA, a total of 2248 demonstrations on fodder production, conservation and utilization technology (sorghum- 575, cowpea-132, guar- 131, BN hybrid- 149, berseem- 501, oat-760) were conducted in Jalaun, Jhansi and Lalitpur districts. Besides crop demonstrations, 85 livestock based demos were also conducted. As per the results, improved multi-cut fodder sorghum and berseem recorded 38 and 19%, respectively more fodder yield over farmers practice. BN hybrid (Fig. 3.8.8), fodder oats, cowpea and guar were newly introduced fodder crops which were the most promising intervention and were liked and adopted by farmers very well. As per the impact analysis, the adoption of fodder and grasses technology improved cow milk yield by around 58% and buffalo milk yield by around 27%.

Impact

Regarding factors influencing adoption decisions of improved fodder technologies, it was found that adoption is positively associated with longer formal schooling of the household head. The learning chances of educated farmers from exposure to technical advice, training and farm demonstrations may be higher. Additionally, households with large farm sizes were 4% more likely to adopt the improved forage technologies. Households with higher livestock units and having more buffaloes in their herd are more likely to adopt improved forage based interventions on their farm- the probability increases by 0.099 and 0.132, respectively for the present study area. Moreover, a positive and significant association between off-farm income activities by households and the probability of adoption of improved forage technologies was observed in the present study. All three instructional factors considered in this study *viz*., training, credit and market access clearly have a positive and significant effect on adoption of forage technologies. Exposure to training and demonstrations on improved forage practises increases the probability of adoption by 0.23. Training and demonstrations boost credibility among farmers towards new technologies and counter balance the negative effect of lack of formal education in the adoption decision. With regard to annual milk production, adopter households had a higher annual milk yield than non-adopters. While daily milk yield of cows significantly increased by 1.15 to 1.97 l; and by 1.23 to around 2 litres for buffaloes. These findings are indicative of year round availability of quality feed and fodder in the treated villages. Project interventions are associated with increased feed availability, particularly during feed stress periods and compared to non-adopters, daily time spent by adopters in sourcing feed significantly reduced by around 2 hours during the *zaid* season and about an hour during *kharif* season. In monetary terms, feed sufficiency due to project interventions benefited adopters by reducing the imputed labour cost. Impact of improved forage technology adoption on the milk yield of dairy animals is less sensitive to unobserved bias.

Fig. 3.8.8. Demonstration on improved fodder production

3.8.11 Network project: Ecosystems, agribusiness and institutions

Component 1: Impact of agricultural technology (crop science technologies)

Sub title: Impact analysis of grassland and fodder technologies

(CRSCIGFRISIL20210501)

The economic impact of Wardan variety of berseem was preliminarily estimated to the tune of Rs. 2640.50 crores. Soil samples from 5 cultivated grassland sites developed by ICAR-IGFRI, Jhansi were collected for estimating the ecological impact of grassland technologies. Preliminary analysis revealed that soil organic carbon of developed grasslands was in the range of 4.05-4.75 g/kg in 0-15

cm soil layer, while that of barren land was around 3.31 g/kg.

3.8.12 Farmer FIRST project: Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity and livelihood security in Bundelkhand region

Under Farmer FIRST programme, the institute had done many interventions under different categories at farmer's fields since 1st November, 2016 in the selected cluster of villages *i.e*. Palinda, Pali, Dhimarpura, Datar nagar and Parwai in Jhansi district. From *kharif* 2022, this project is being implemented in newly selected cluster of villages *i.e*. Ganeshgarh, Ramgarh, Nayakheda, Dhikoli, and Kanchanpur in Jhansi district.

Rabi 2021-22

Wheat

Demonstration of improved variety of wheat (Raj 4079) procured from BUAT, Banda was conducted on farmers' fields. Besides improved variety, line sowing, chemical weed control, and application of nano urea were also advocated to farmers for higher productivity. The grain yield of Raj-4079 was 13.2% higher over the farmers' variety or local one (3.70 t/ha). Higher economic returns and B:C ratio were also computed in improved variety.

Fodder crops

During *rabi* 2021-22, improved variety of oat (JHO-822) and berseem (BL-10) were demonstrated. Mean GFY of oat variety was 51.9 t/ha and recorded higher net returns (46732 Rs/ha) and B:C ratio (2.53). Improved variety of berseem produced 79.1 t/ha GFY which was 25.7% higher in comparison to local ones (62.9 t/ha). Improved varieties were also recorded higher economic returns and B:C ratio.

Kharif, 2022

Green gram

Greengram is an important *kharif* pulse crop of the Bundelkhand region. Demonstrations (Nos. 154) of improved varieties of green gram (*cv*. IPM 2-3) were conducted (Fig. 3.8.9) and compared with their local variety. Greengram (IPM 2-3) procured from BUAT, Banda gave 23.4% higher seed yield over local variety resulting in higher economic returns. Continuous rains at the grain filling stage led to low yield levels.

Fig. 3.8.9. Demonstration of improved variety of green gram (*cv*. IPM 2-3)

Fig. 3.8.10. Demonstrations of improved varieties of food and fodder crops

Groundnut

Groundnut is a widely grown *kharif* oilseed crop in Bundelkhand region. About 1000 kg groundnut seed (*cv*. TG 37A and HNG 123) was procured from SKRAU, Bikaner and was demonstrated (Fig. 3.8.10) at 44 farmers' fields. White grub was a major problem of groundnut cultivation in the area. Hence, seed treatment with chlorpyriphos and application of phorate were advocated to farmers. This intervention helped farmers to get good harvest. Average pod yield of groundnut (TG 37A) under demonstration was 1750 kg/ha which is 23.2 and 25.9% higher over HNG-123 and local varieties, respectively. This variety also fetched higher economic returns.

Fodder sorghum

Demonstrations of improved variety of fodder sorghum (*cv*. MP chari) were conducted (Fig. 3.8.10) under Farmer FIRST project in *kharif* season. All the demonstrations of improved variety were conducted with standard package of practices including seed treatment. Sorghum is an important fodder crop for the adopted villages. MP chari produced 58.8 t/ha green fodder which was 25% higher than the local ones (46.9 t/ha). This variety is multi-cut in nature, so farmers were able to harvest 3-4 cuts. Due to higher yield, improved variety of sorghum fetched higher economic returns and benefit to cost ratio.

Vegetable production

Under Farmer FIRST project, an effort was made to

replace local vegetable varieties with improved high yielding cultivars during the *zaid* & *kharif* 2022 (summer & rainy season vegetables). Performance of improved bottle gourd (*cv*. Pusa Naveen) was demonstrated (Fig. 3.8.11) in the farmers' field (45 nos.) of adopted villages. Bottle gourd (*cv*. Pusa Naveen) recorded higher yield (31.25%) and B:C ratio (6.38) as compared to local variety B:C ratio (4.50). The use of neem-based insecticide along with fruit fly trap as plant protection measures reduced the pest management cost by 43.92% as compared to chemical pesticides. In case of vegetable cowpea (*cv*. Pusa Dharani) recorded 35.27% higher yield and B:C ratio (6.2) as compared to local variety B:C ratio (4.0).

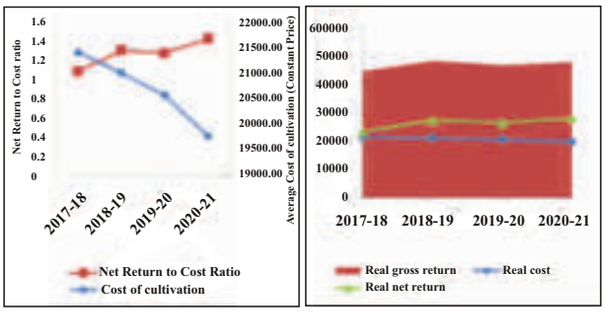
Fig. 3.8.11. Demonstrations of improved vegetable varieties

Minor millets

During this year institute tried to promote minor millets *viz*., ragi (*cv*. GPU -97) and barnyard millet (*cv*. DhBM-93-2) in the adopted villages. A total of 48 demonstrations (31 - ragi and 17 - barnyard millet) were conducted. In general, the performance of ragi was not good but farmers got an average harvest of barnyard millet. On an average, the grain yield level of barnyard millet was 560 kg/ha under demonstrations. The late rains at the grain filling stage hampered the grain filling and crop maturity resulting in lower yield levels. Farmers also faced the problem of marketing as these crops are not grown in the region.

Impact

Impact analysis of improved agricultural technologies disseminated under Farmer FIRST Programme on production costs of major crops showed (Fig. 3.8.12) that average real cost during the period 2017-18 to 2020-21 declined leading to an increase in net return to cost ratio from farming. Technological interventions at farmer's field resulted in a gradual decline in the share of seed from 13 to 8%, fertilizer from 12 to 7 % and plant protection chemicals from 5 to 2% in the cost of cultivation during 2017-18 to 2020-21. The panel data analysis revealed that productivity growth due to technological interventions played a vital role in absorbing the increase in the production cost of farmers. Price elasticity of factors was estimated by fitting the translog function, suggesting that policies for controlling input price inflation, particularly wage rate, will be imperative in reducing the cost of farming. Results on elasticity of technical substitution between labour and machinery highlight the need for devising suitable farm mechanization strategies which may be affordable in a small farm situation.



Source: Author's estimate based on field data

Fig. 3.8.12. Changes in average cost of cultivation and returns at constant price

Chapter 4

Forage Seed Production

4.1 Seed production 2021-22

4.1.1 Variety-wise seed production of fodder crops

Rabi 2021-22

Crops	Variety	Nucleus seed - NS (kg)	Breeder seed - BS (kg)	Truthfully labeled seed - TFL (kg)	Total (kg)
Oat	JHO-822	702	8172	3775	12649
	Kent	600	1671	342	2613
	JHO-99-2	124	50	51	225
	JHO-99-1	60	200	295	555
	JHO-2009-1	300	1205	1144	2649
	JHO-2000-4	100	300	496	896
	JHO-851	75	-	100	175
	JHO-2010-1	50	200	216	466
	BJ 2012-2	40	-	249	289
	JHO-2015-1	75	300	128	503
	Sabzar/SKO 96	-	-	1000	1000
	Total	**2126**	**12098**	**6796**	**22020**
Berseem	Wardan	65	1150	65	1280
	JBSC-1	15	480	60	555
	BB-3	50	207	50	307
	BB-2	50	200	20	270
	Total	**180**	**2037**	**195**	**2412**

Kharif 2022

Crops	Variety	NS (kg)	BS (kg)	TFL(kg)	Total (kg)
Maize	African Tall	50	450	25	525
Sorghum	MP chari	75	1200	841	2116
	CoFS 29	0	0	600	600
Bajara	AVKB 19	25	290	25	340
Cowpea	BL-2	10	20	0	30
	EC 4216	35	150	165	358
	Kohinoor	15	40	0	55
	BL-4	10	25	0	35
Guar	BG 1	15	0	90	105
Total		**235**	**2175**	**1746**	**4164**

4.1.2 Grasses and legumes seed production

A. Grasses	Variety	TFL (kg)
Brachiaria brizantha	NS	100
Brachiaria ruziziensis	NS	28
Chrysopogon fulvus	BDG 1	10
Heteropogon contortus	BLG 1	05
Cenchrus ciliaris	IGFRI 67-365	10
Cenchrus setigerus	IGFRI 97-706	326
Pennisetum pedicellatum	BD/BD2	310
Dichanthium annulatum	-	5
Panicum maximum	BG 2/BG 4, DGG 1, Grazing guinea	320
Panicum antidotale	Non-Specific	5
Chloris gayana	Non-specific	4
Sehima nervosum	Non-specific	5
Tall fescue	Non-specific	38
Orchard grass	Non-specific	80
Red fescue grass	Non-specific	40
Total (A)		**1286**
B. Legumes		
Desmanthus virgatus	Non-specific	4
Stylosanthes seabrana	Non-specific	10
Dolichos lablab	Bundel Sem 1	2
Sesbania sesban	Non-specific	1
Red clover	Non-specific	80
White clover	Non-specific	2
Sainfoin	Non-specific	8
Total (B)		**107**
Total (A+B)		**1393**

4.2 Seed/planting material sale (2022)

4.2.1 Grass root slips sale (2022)

Grass name	Variety	Number of root slips
Bajra Napier hybrid	IGFRI 3, 6, 10, DBN1	723150
Guinea grass	BG 2, DGG1, BG 1	240820
Brachiaria spp.	Non-specific	23000
Chloris gayana	Non-specific	1850
Cenchrus ciliaris	IGFRI 67-365	1850
Phalaris hybrid		20000
Total		**1010670**

4.2. Seed sale (2022)

4.2.1 Grass root slips sale (2022)

Grass name	Variety	Number of root slips
Bajra Napier hybrid	IGFRI 3, 6, 10, DBN1	723150
Guinea grass	BG 2, DGG1, BG 1	240820
Brachiaria spp.	Non-specific	23000
Chloris gayana	Non-specific	1850
Cenchrus ciliaris	IGFRI 67-365	1850
Phalaris hybrid		20000
Total		**1010670**

4.2.2 Seed sale (2022)

4.2.2.1 Total seed sale 2022

Class of fodder seed	Value in Rupees
Breeder seed (BS)	14,65,360.0
Truthfully labelled seed (TFL)	67,19,187.0
Total	**81,84,547.0**
Perennial grasses root slips (no.)	11,12,800.0
Grand Total	**92,97,347.0**

Chapter 5

Outreach Programmes

5.1 Scheduled Castes Sub-Plan (SCSP)

Under SCSP program, ICAR-IGFRI, in collaboration with KVKs of six states (UP, West Bengal, Punjab, HP, J&K, Karnataka), has initiated its implementation. In different states, twenty three trainings were organized for 720 farmers; fodder technologies related demonstrations (1450) were conducted in an area of 35.5 ha; livestock technologies related demonstrations on 475 animals of 180 farmers were conducted; other agricultural technologies related demonstrations were conducted with 345 farmers.

Demonstration under SCSP

In five villages (Khajraha Bujurg, Khajraha khurd, Mathurapura, Rampura and Chamraua) of Jhansi district demonstration of improved farm implements including sprayer-65; chaff cutter-15; groundnut decorticator.-19; spiral seed separator -10; hand hoe-01; hasiya-100; khurpi-60; fork- 50 and seed drill-2 had been done besides improved Buck-2; Ram-10; chicks -1000. The demonstration of improved varieties of sorghum (162), ragi (119), fodder cowpea (135), kondo (101), fruit plants (90) and oat (120) were conducted. Four training/ extension programme were conducted in which 160 farmers participated.

Awareness programmes (2 nos) were organised under SCSP at Samba and RS Pora regions of Jammu by RRS, ICAR IGFRI Srinagar. More than 200 SC farmers including women farmers participated. Mineral mixture and berseem seed *var.* Mescavi were distributed among the farmers along with drudgery reducing farm implement kits for their use.

Fig. 5.1. Glimpses of awareness programmes in Jammu region under SCSP

5.2 Tribal Sub-Plan

As a part of Tribal Sub-Plan (TSP), ICAR-IGFRI is collaborating with KVKs/ SAUs of five states (Maharashtra, Rajasthan, Madhya Pradesh, J&K, and Himachal Pradesh). Tribal Sub-plan interventions were implemented at Dausa (Rajasthan), Nandurbar and Dhulle districts (Maharashtra), Anantnag, Baramula, Kulgam, Bandipore district (Srinagar) and Badwani, Alirajpur, Dhar, Khargoan and Khandwa district (Madhya Pradesh), Singhbhum and Lohardaga district of Jhanrkhand, Chamba and Kinnour district (H.P.).

FTDs conducted

During summer 2022, bajra (cv. AVKB-19) seed (400 kg) was demonstrated with 182 tribal farmers in villages - Thikaria, Dharanvas, Lavan, Chudiavas and Hapavas, Dausa District. The seed of oat JHO-822 (1800 kg) was demonstrated with 285 farmers, seed of mustard variety Giriraj (430 kg) was demonstrated with 195 tribal farmers in village-Khanvas, Dausa. Demonstration of mineral mixtures (1314 kg) for milch animals was done with 285 tribal farmers in villages of Chudiavas, Malvas, Dharanvas, Khanvas, Lavan, Nayavas, Nangal Rajavatan, Udaypura, Thumadi, Chandpur and Toda Meena in Dousa and 2076 kg with 300 tribal farmers in villages of Thumdi, Khanvas, Chudiavas, Malvas, Dharanvas and Nayavas in Rajasthan. A total of 662 FTDs were conducted in district Dousa.

Fig. 5.2. Trainings cum awareness programme and Pearl millet, oat seed and mineral mixture distribution to tribal farmers, Hapavas, Dousa

Two training programmes (one day) were organized in Dousa district on "*Rabi mausam ki chara falson me beej utpadan taknik*" and "Importance of good quality seed in higher fodder production". About 781 farmers including women farmers attended the training programme. More than 150 tribal farm women from Thikaria, Dharanvas, Lavan, Chudiavas and Hapavas villages from Dousa district attended the programme.

In collaboration with KVK, Nandurbar and Dhule, demonstration of perennial fodder sorghum- (CoFS-29; 800 kg) and mineral mixtures (273 kg) were done

with 300 tribal farmers of six villages in Nandurbar & Dhule districts. Perennial fodder sorghum seeds (200 no. in Nandurbar and 100 no. in Dhule district), mineral mixture (300 no.) demonstrations were conducted in tribal farmers village of Nimburni, Shravani, (Tq. Navapur) and Bhujgaon (Tq. Dhadgaon and Junwani (Tq. Akkalkuwa), district Nandurbar during rabi 2022. Four, one day training programmes were organized in Nandurbar & Dhule district and 100 farmers attended the training programme.

Fig. 5.3. Inputs distribution at Nandurbar district of Maharashtra

Two training/ awareness programs on "Fodder production, utilization and conservation, enhancing livestock productivity through Fodder technologies and agroforestry for forage production" were organized in Anantnag, Shopian, Bandipore and Rajouri Ganderwal district, Srinagar. About 150 farmers including women farmers attended the training programme, seeds/mineral mixture were also distributed to tribal farmers. About 2200 FTDs were conducted in Anantnag, Shopian, Bandipore and Pulwama district, J&K, Srinagar.

Fig. 5.4. TSP Trainings programme in Rajori & Gandewal, Pulwama district, J&K

In collaboration with KVK, East Singhbhum, Lohardaga and Saraikela-kharsawan district (Jharkhand), FTDs were conducted in *rabi*. Goat, pig & poultry distributed to 60 farmers in selected village of East Singhbhum. Berseem (20 hectare) FTDs demonstration were conducted in Lohardaga and & East Singhbhum in Jhanrkhand. Three training programmes were as organized on, "Introduction of improved fodder production technology of crops and livestock management". Total 135 farmers including women farmers attended the training. Total 80 FTDs were conducted in East Singhbhum, Lohardaga and Saraikela-kharsawan district in Jharkhand during *kharif/rabi* 2022. In collaboration with KVK, Karbi Anglong & west Karbi angling district (Assam), FTDs conducted in *rabi*; cultivation of annual/ perennial fodder crops, maize and oats & hybrid napier and congo signal grass; 12 nos. demonstrations were conducted in both district of Aasam during *rabi* 2022.

FTDs of 25,000 rooted slips of BN hybrid, guinea grass were conducted with 280 tribal farmers. 10 kg seed of tall fescue and 10 kg of white clover was demonstrated with 120 beneficiaries. Commercial broiler chicks (1800 no.) were demonstrated with 110 tribal farmers. Kodo millet, bhindi, bottle gourd, carrot, french bean, tomato, onion, radish, cauliflower, capsicum, methi, coriander and turnip was demonstrated with 03 tribal farmers in Chamba, Kinnour & Lahul and Spiti of Himachal Pradesh during 2022. Ten, one to four days, training cum awareness programmes were conducted; a total 700 farmers and women farmers attended the training programme.

Fig. 5.5. Distribution of Kodo millet, rooted slips to tribal farmers, Chamba district

5.3 National Initiative for Accelerating Fodder Technology Adoption (NIAFTA)

Under "National Initiative for Fodder Technologies Adoption (NIAFTA)" All India Fodder Production Officers *kharif* workshop (online) was conducted by ICAR-IGFRI, Jhansi, during 28-30th June, 2022, (260

participants). Fodder resource development plans were developed for 25 states, out of which 20 had been published including 09 states *viz.* Nagaland, Sikkim, Maghalaya, Manipur, Mizoram, Arunachal Pradesh, Punjab, Jharkhand and Bihar during 2022.

5.4 Mera Gaon Mera Gaurav (MGMG) Programme at RRS, ICAR-IGFRI Srinagar

Trainings cum exposure visits were made to Pulwama and Budgam districts under MGMG program by ICAR-IGFRI Srinagar.

Fig. 5.6. Various exposure visits to RRS Srinagar under MGMG

Fig. 5.7. Demonstration of Golden Jubilee Forage Garden under MGMG, RRS Srinagar

5.5 Agricultural Technology Information Centre (ATIC)

Kisan Chaupal/ Telecast on DD Kisan Channel

1. **Kisan Chaupal:** Held at village Ramgarh on 6.12.2022 with DD Kisan channel coverage – 60 participants - programme was telecasted on 20.12.2022
2. **Kisan Chaupal:** Held at village Nayakhera on 6.12.2022 with DD Kisan channel coverage – 50 participants – programme was telecasted on 29.12.2022
3. **Kisan Chaupal:** Held at village Kanchanpur on 7.12.2022 with DD Kisan channel coverage (Mahila krishak from Balinee Milk Producer organisation) - 55 participants - Programme was telecasted on 09.01.2023
4. **Kisan Chaupal:** Held at village Ganeshgarh on 7.12.2022 with DD Kisan channel coverage - 65 participants- Programme was telecasted on 02.01.2023
5. **Kisan Chaupal:** Held at village Dhikoli on 8.12.2022 with DD Kisan channel coverage – 40 participants- Programme was telecasted on 24.12.2022
6. **Kisan Chaupal:** Held at village Palinda on 8.12.2022 with DD Kisan channel coverage – 45 participants- Programme was telecasted on 03.01.2023

Krishi Mela/exhibition organized/Goshthis organized

1. Interactive meeting with Shri Narendra Singh Tomar, Hon'ble Min. of Agri. and Farmers Welfare, GoI on 28-01- 2022.
2. Tech. & Mech. Demo Mela on 16-03-2022 at IGFRI Jhansi - 175 farmers participated.
3. International Women's Day on 08th March 2022 at IGFRI- 50 candidates participated.
4. Anna Data Devo Bhava Gosthi on biofortified crops and millets on 24 & 25-04-2022 at IGFRI - 110 candidates participated.
5. Anna Data Devo Bhava - training on Natural and Organic farming on 24 & 25-04-2022 at IGFRI - 32 farmers participated.
6. Kisan Gosthi - at DFI Kisan Mitra-Singar Sulta on 30-06-2022 - 120 farmers participated.
7. Anusuchit Jati Kisan Labharthi Sammelan on 28-05-2022 at IGFRI - 100 SCSP farmers Participated.
8. Labharthi Samwad by Prime Minister on 31-05-2022 at Jhansi - 100 farmers participated.
9. Rastriya Jagrukta Abhiyan Goshthi on balance fertilizer on 21-06-2022 at IGFRI - 55 farmers participated.
10. IGFRI-Chara Diwas on 09-09-2022 - 50 farmers, 40 students and 50 staff participated.
11. Kisan Diwas on 23 December 2022 – 55 farmers participated; nano-urea was distributed to 40 farmers and weed control mixture was distributed to 15 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 (January to December 2022), 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, 21 scientists, 04 technical officers and 08 administrative, finance & account officers received various specialized training organized by different national institutes and agencies on a wide spectrum of topics including finance management (Table 6.1). Human resource development programmes 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. Suheel Ahmad	January 28 - February 17, 2022	ICAR-NDRI	Advances in Agricultural Extension Research	Online
2	Dr. Edna Antony	February 7, 2022	ICAR- IASRI New Delhi	Prediction of Non-coding RNA	Online
3	Dr. Amit Kumar Singh	February 15 - March 7, 2022	ICAR- IASRI New Delhi	Artificial Intelligence in Agriculture	Online
4	Dr. Manjanagouda S. Sannagoudar	February 21 - March 02, 2022	ICAR-CCARI, Goa	Ecosystem service analysis in diversified coconut, areca nut gardens	Online
5	Dr. Purushottam Sharma	February 21-23, 2022	ICAR-NAARM, Hyderabad	Competency Enhancement programme for effective implementation of training functions	Online
6	Dr. Kamini	February 22 - March 3, 2022	ICAR-CSSRI, Karnal	Recent developments in agroforestry dimensions for managing salt affected ecologies	Online
7	Dr. S.S. Bhat	February 22-26, 2022	NAARM, Hyderabad	Recent advances in organic farming research	Online
8	Dr. Gaurendra Gupta	February 22-26, 2022	NAARM, Hyderabad	Recent advances in organic farming research	Online
9	Dr. Purushottam Sharma	March 7-12, 2022	NAARM, Hyderabad	National facilitators development programs	Online
10	Dr. Shahid Ahmad	June 27-28, 2022	NIDM, Rohini, Delhi	Face to Face two days Sensitization Workshop	Physical
11	Dr. S R Kantwa	June 27-28, 2022	NIDM, Rohini, Delhi	Face to Face two days Sensitization Workshop	Physical
12	Dr. Mukesh Choudhary	September 13-19, 2022	Galilee International Management Institute, Israel	New Agricultural Innovation Programme	Physical

13	Dr. R.K. Agrawal	July 25-29, 2022	Centre for Disaster Management, LBSNAA, Mussoorie	Role of Technology in Community Level Disaster Mitigation	Physical
14	Dr. S.S. Bhat	August 1-5, 2022	ICAR-IGFRI & MANAGE	Fodder technology innovations for sustainable livestock production	Online
15	Dr. Srinivasan R	August 18-20, 2022	ICAR-NAARM, Hyderabad	Response Surface Methodology	Online
16	Dr. Nagaratna Biradar	October 10-14, 2022	Extension, UAS, Bangluru	Empowerment and entrepreneurship development in agriculture	Physical
17	Dr Pooja Tamboli	November 9-29, 2022	ICAR-IGFRI, Palampur and NADCL, Baramulla	Role of science : Retrospective and perspective	Online
18	Dr R Srinivasan	November 15-24, 2022	NAARM, Hyderabad	Application of bioinformatics in agricultural research and education	Physical
19	Dr Indu	November 18, 2022	ICAR-IASRI New Delhi	CAFT training programme	Physical
20	Dr VK Yadav	December 12-23, 2022	ICAR-NAARM, Hyderabad	MDP on Leadership Development (a Pre-RMP Programme)	Physical
21	Dr Purushottam Sharma	December 12-23, 2022	ICAR-NAARM, Hyderabad	MDP on Leadership Development (a Pre-RMP Programme)	Physical
22.	Dr Pooja Tamboli	December 19-21, Phase I and: December 26-28 Phase II, 2022	NAARM, Hyderabad	Analysis of experimental data	Physical
Technical Category					
1	Sri Deepak Chaudhary	February 7, 2022	New Delhi	Prediction of Non-coding RNA	Online
2	Dr RK Sharma	February 22-26, 2022	NAARM, Hyderabad	Recent advances in organic farming research	Online
3	Mr. Shailendra Sinha	May 18-24, 2022	ICAR-IISWC, Dehradun	Motivation, positive thinking and communication skills for technical officers (T-5 and above)	Physical
4	Dr. Ratnakar Singh Patel	May 18-24, 2022	ICAR-IISWC, Dehradun	Motivation, positive thinking and communication skills for technical officers (T-5 and above)	Physical
Administrative Category					
1	Sh. Kripa Ram	March 21-23, 2022	IISTM New Delhi	Workshop on Handling of CAT Cases	Online
2	Sh. Rakesh Kumar	March 21-23, 2022	IISTM New Delhi	Workshop on Handling of CAT Cases	Online
3	Sh. Rakesh Kumar	April 6-8, 2022	IISTM New Delhi	Knowledge Management	Online
4	Sh. Prashant Saxena	February 14-15, 2022	IISTM New Delhi	Workshop on Income Tax	Physical
5	Sh. H. P. Khaddar	February 14-15, 2022	IISTM New Delhi	Workshop on Income Tax	Physical
6	Sri Rakesh Kumar	June 16-18, 2022	ICAR-NRRI, Cuttack	National Pension Scheme	Online

7	Sri VK Paliwal	June 16-18, 2022	ICAR-NRRI, Cuttack	National Pension Scheme	Online
8	Sri VK Paliwal	November 15-19, 2022	ICAR-NAARM, Hyderabad	Capacity Building Programme	Physical

6.2 Capacity building for forage resource development

Five sponsored training courses were organized in various areas related to engineering interventions, grazing and pasture management, climate resilient forage and livestock production. The details are as in Table 6.2.

Table 6.2 Sponsored and institutional capacity building programmes

S.No	Programme /Training	Sponsored by	No. of Participants	Duration	Category of participants
1	Collaborative online training programme of ICAR-IGFRI, Jhansi & MANAGE, Hyderabad on "Agripreneurship development on value added fodder products"	MANAGE, Hyderabad	50	January 17-20, 2022	Extension officials of state/ central animal husbandry departments, veterinarians, faculty of SAUs/ KVKs/ICAR institutes
2.	Fodder Production, Conservation and Utilization	ATMA Begusarai,	36	March 7-11, 2022	Farmers
3	Improved technology of fodder production, utilization & conservation	Sub Mission on Agriculture Extension under ATMA, Shivpuri	40	March 21-25, 2022	Farmers
4	Online workshop on National Initiative for accelerating fodder technology adoption (NIAFTA) for *Kharif*	ICAR-IGFRI, Jhansi	95	June 28-30, 2022	All India Fodder Production Officers
5	Summer School on "Recent trends in sustainable livestock and crop production technologies vis-à-vis climate change"	ICAR-IGFRI, RRS, Srinagar, BVC, Patna and NADCL Baramulla	125	June 18 - July 8, 2022	Staff of SAUs, state governments
6	Training programme on "Fodder technology innovations for sustainable livestock production"	ICAR-IGFRI, RRS Srinagar and MANAGE, Hyderabad	123	August 01-05, 2022	Staff of SAUs, state governments
7	FDP on "Role of science and technology in sustainable agriculture, horticulture, animal husbandry and allied sectors: retrospective and prospective"	ICAR-IGFRI, RRS, Srinagar and NADCL Baramulla,	144	November 3 to 23, 2022	Staff of SAUs, state governments

6.3 Training cum exposure visits at IGFRI, Jhansi

Indian Grassland and Fodder Research Institute, Jhansi has kept its doors always open for all those who have 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 6.3.

6.4 Teaching cum dissertation work at IGFRI, Jhansi

IGFRI offers trainings and dissertation programme to students from various universities. During this financial year 21 students of B.Sc. and M.Sc. registered themselves at this institute.

Table 6.3 Training cum exposure visits

S. No.	Date	Department	Category	No. of visitors
1	19.01.22	Project Director, ATMA, Damoh (MP)	Farmers	20
2	22.2.22	Project Director, ATMA, Vidisha (MP)	Farmers	21
3	24.02.22	Sh. Mishra, Jhansi (UP)	N G O	6
4	24.2.22	Farmers from CAFRI, Jhansi (UP)	Farmers	20
5	11.03.22	Sh. Saurabh Gupta+2, Bhopal	N G O	3
6	24.03.22	Project Director, ATMA, Damoh (MP)	Farmers	30
7	24.03.22	Ms. Akansha+2, SR College, Ambabai, Jhansi	Student	3
8	26.03.22	Staff+ Student from BU, Jhansi	staff+student	54
9	27.03.22	Staff+ Student from BU, Jhansi	staff+student	29
10	27.03.22	Forest Training Academy, Haldwani (UK)	Govt. Employee	45
11	30.03.22	Agri. College, Powerkheda, Hoshangabad	staff+student	39
12	13.05.22	Swam Vivekanand University, Sagar (MP)	Student	35
13	19.05.22	Sh. Vivek Tiwari+3 CARD NGO, Lalitpur	N G O	4
14	26.5.22	Sh. Atul+2 Axis Bank, Jhansi	Pvt. Company	3
15	1.06.22	Sh. Sahi Ram Bishnoi+4, DDA, Delhi	Govt. Employee	5
16	16.06.22	Visitors from CARD NGO, Lalitpur	NGO	55
17	17.06.22	Agri. Deptt. Hamirpur (UP)	Farmers	22
18	29.06.22	Mr. Vansh Narayan+2, BAIF, Banda	NGO	3
19	14.07.22	Trainees from CAFRI, Jhansi	Farmers	25
20	14.7.22	Proff. From BBC College, Jhansi	Govt. Employee	3
21	19.07.22	Sh. Mohan Singh rajawat+2, Bhind	Farmers	3
22	25.07.22	Sh. Shrivastava, Sai Jyoti NGO, Lalitpur	NGO	5
23	24.08.22	Sh. Janardan Dubey+2, Hamirpur	Farmers	3
24	26.08.22	Sh. Sandeep+2, Kanpur	Farmers	3
25	27.08.22	Sh. Harsh Samadhiya+2, Moth, Jhansi	Farmers	3
26	15.09.22	Sh. Yatesh Yadav, IBTADA NGO, Alwar	NGO	4
27	28.09.22	Sun International School, Jhansi	staff+student	119
28	09.11.22	Ms. Wasnik+6, BU, Jhansi	Student	7
29	10.11.22	Md. Khalid+3, Action Aid, NGO, Jhansi	NGO	4
30	16.11.22	PD, ATMA, Tikamgarh	Farmers	30
31	16.11.22	Student from BU, Jhansi	Student	10
32	16.11.22	Input dealer from Up	Input Dealer	19
33	21.11.22	Input dealer from Chhatpur, MP	Input Dealer	17
34	25.11.22	Sh. Satyaveer Tomar, Bhind	Farmers	4
35	28.11.22	PD, ATMA, Shyopur, MP	Farmers	25
36	14.12.22	Students from BUAT, Banda	Student	30
37	16.12.22	Govt. H S School, Kadvaya, Ashoknagar	Staff + students	79
38	17.12.22	Forest Training Academy, Haldwani (UK)	Govt. Employee	55
39	19.12.22	Forest Training Academy, Haldwani (UK)	Govt. Employee	66
40	26.12.22	Sh. Prabhu Dayal+3,	Contractor	4

Chapter 7

Infrastructure Developed

Seed Processing Unit at IGFRI, Jhansi

Seed Processing Unit at IGFRI RRS Dharwad

Construction of Seed Processing Unit at IGFRI RRS Srinagar

Animal Shed

Nursery at IGFRI Central Research Farm

Open GYM

Main Gate

Irrigation Channel

ABIC Building

Chapter 8

List of Publications

8.1 Research articles

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8.5 Lecture

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8.6 Compendium/ Lectures/ Souvenirs

अमित कुमार पाटील, चन्द्रशेखर सहाय, प्रभाकांत पाठक , संजय कुमार सिंह एवं प्रकाश नारायण द्विवेदी (2022) कृषि में फार्म मशीनरी की महत्ता in a compendium of training on "Fodder Production, Conservation and Utilization" organized at ICAR-IGFRI Jhansi and sponsored by Agriculture Technology Management Agency (ATMA) Begusarai (Bihar) during 07-03-2022 to 11-03-2022.

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Chapter 9

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

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

(CRSCIGFRISIL**2020**0101): Breeding of pearl millet for driving multi-cut and dual purpose genotypes with high forage yield and quality.

(CRSCIGFRISIL**2018**0101): Development of Genetic and Genomic Resources for low moisture stress tolerance in Berseem.

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

(CRSCIGFRISIL**2016**0102): Development of fertile variants of Bajara Napier Hybrids through *in vitro* plant regeneration.

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

(CRSCIGFRISIL**2017**0101): Development of *Trichoderma*-Chitosan for combination management of root and stem rot disease in berseem.

(CRSCIGFRISIL**2019**0101): Studies on epidemiology and assessment of avoidable yield loss due to major pests and diseases in fodder sorghum and cowpea.

(CRSCIGFRISIL**2021**0101): Identification and characterization of genes involved in expression of apomixes component traits and polyploidy series in guinea grass grass (*Panicum maximum* Jacq.).

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

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

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

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

(CRSCIGFRISIL**2019**0401): Endophytes consortium as bio-control for effective management of pest and diseases in fodder legumes.

(CRSCIGFRISIL**2020**0401): Evaluation of berseem gene pool for herbicide tolerance.

Genetic Improvement in Temperate Forage Crops.

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

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

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

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

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**2021**0301): Development of Grassland Assessment System using Geospatial Technology.

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

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

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

(CRSCIGFRISIL**2020**0303): Evaluation of *Ailanthus excelsa* and Morus species germplasm for growth performance, fodder yield and nutritional traits under various agro climatic-zones.

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

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

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

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

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

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

(CRSCIGFRISIL**2020**0201): Development of decision support system for fodder crops with a special reference to climate change.

CRSCIGFRISIL**2019**0202): Precision Nitrogen Management in forage crops.

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

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

(CRSCIGFRISIL**2019**0203): Above and below ground biodiversity in different forage production systems.

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

(CRSCIGFRISIL**2021**0201): Manipulating the rhizosphere microbiome using plant growth promoting microbes to enhance soil and plant health.

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

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

(CRSCIGFRISIL**2019**0201): Livestock based integrated farming systems for sustaining livelihood of Bundelkhand farmers.

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

(CRSCIGFRISIL**2022**0301): Sustainable forage production from different densities of shrubs and tree through lopping management in three tier silvopasture systems.

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

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

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.

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

(CRSCIGFRISIL20200104): Study of berseem (*Trifolium alexandrinum* L.) seed coat dynamics.

(CRSCIGFRISIL20190402): Identification and utilization of smoke derived compounds in early establishment of forages.

(CRSCIGFRISIL20210401): Development of near-infrared spectroscopy (NIRS) based prediction models for the assessment of seed viability and vigour in tropical grasses.

(CRSCIGFRISIL20190901): Investigations on seed yield and quality enhancement techniques in *Brachiaria ruziziensis.*

(CRSCIGFRISIL20190801): Effect of different packaging materials on storability of seed of range grasses.

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

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

(CRSCIGFRISIL20180701): Nutritional evaluation, improvement and utilization of newer feed resources for livestock production.

(CRSCIGFRISIL20130701): Long term effect of different grazing intensities on soil health and pasture-animal productivity.

(CRSCIGFRISIL20180704): Feeding and management strategies to improve goat productivity under semi arid conditions.

(CRSCIGFRISIL20180705): Screening and evaluation of tropical grasses diversity for yield, nutritive value and ensiling potential.

(CRSCIGFRISIL20211001): Ensiling of temperate grasses/legumes for increased livestock productivity.

(CRSCIGFRISIL20190602): Development of forage based feed for commercial goat farming.

(CRSCIGFRISIL20190603): Development of evaporative cooling based hydroponic fodder production unit for semi-arid region.

(CRSCIGFRICIL20180601): Development and evaluation of defluffing machine and pelleting machine for forage grass seeds.

(CRSCIGFRISIL20190605): Development of automatic seed coating machine.

(CRSCIGFRISIL20190604): Design and development of Solar powered self-propelled multipurpose machine for agricultural operations.

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

(CRSCIGFRISIL20220702): Phytochemical nano-formulations to control aflatoxins in animal feeds.

(CRSCIGFRISIL20220703): Foraging behaviour of small ruminants under natural grassland in Bundelkhand region.

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

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

(CRSCIGFRISIL20210501): ICAR-NIAP – 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.

(CRSCIGFRISIL20200901): Participatory fodder production in fruits and plantation crops.

(CRSCIGFRISIL20210502): Impact of fodder and livestock technologies on livelihood of farmers of SCSP- IGFRI.

(CRSCIGFRISIL20210503): Ex Post development impact evaluation of Adarsh Chara Gram Project (Scaling up of fodder technologies at farmer's field).

Chapter 10

Success Stories

10.1 FTD on Sainfoin hay improves milk productivity: story of a peri-urban farmer in Kashmir

Introduction

Mohamad Ayub son of Haji Ghulam Nabi, Resident of Baghi Mehtab, Srinagar, who owns three HF cows and six sheep. He is having 2.5 acres of land. Earlier, he used to grow fruit trees and vegetable crops.

Awareness & training

He came in contact with ICAR-IGFRI Regional Research Station Srinagar in 2021. He had interaction with station scientists about various temperate perennial grasses/ legumes and technologies like hortipasture and silvipasture.

Achievements

He started cultivating forage crops and diversification in fruit orchards for increasing availability of fodder production. The station established a Fodder Technology Demonstration of sainfoin in his farm. We also provided him sainfoin hay for a small feeding experiment. *Onobrychis viciifolia,* locally called as sainfoin (French word meaning holy hay) is a perennial legume which grows from 40 to 130 cm in height with many hollow stems, arising from basal buds, forms a branched crown. Dry matter biomass productivity of sainfoin is up to 16 tonnes ha^{-1} and is known to have valuable characteristics such as palatability, higher protein availability (up to 23 %) and digestibility, anti-helminthic properties due to its unique tannin and polyphenol composition that also prevents bloating in the animals. There is huge scarcity of fodder during the winter months in Kashmir valley, especially in the urban areas, where land availability is a limitation. We supplied sainfoin hay to a local farmer namely Mohamad Ayub son of Haji Ghulam Nabi, Resident of Baghi Mehtab, Srinagar, who owns three Holstein cows and six sheep. As per record, he fed 15 kg sainfoin hay daily to the cows instead of oats of the same quantity. The cows on average yielded 12 kg milk per cow per day when fed on oat hay. The milk yield increased by 1.3 kg per day (an increase in milk yield of 10.8 per cent). He further observed that the health of his cows as well as sheep improved and reported no bloating in his livestock. The farmer hailed the station for such a wonderful initiative.

Importance to other farmers

He works as an efficient pruner of fruit crops and has acted as an efficient facilitator for various horticulture programmes. He gives information to the farmers about fodder crops, use of interspaces in fruit orchards for increasing fodder availability.

10.2 Revolutionizing livelihood of Tribal farmers though fodder production

Nandurbar located in Khandesh region of Maharashtra is a tribal district (70 % tribal population) bestowed with abundant natural resources. Utilizing these resources to bring about socio-economic development of people is quintessential need of the hour. Livestock plays an

important role in the rural economy as a major source for livelihood. In Nandurbar district almost every household has livestock. With a view to create self-employment for these tribals, the state government has focused on promotion of cattle, sheep, goat rearing and intensive poultry development. However, the area under fodder crops in the district is almost negligible. The farmers are largely dependent on crop residue and fodder from nearby forest areas to meet daily fodder requirement. Under Tribal Sub Plan, systematic effort was made to improve the area and production of fodder crops by careful application of improved technologies by IGFRI, Southern Regional Research Station, Dharwad in collaboration with Krishi Vigyan Kendra, Nandurbar. The programme was started in 2012-13. Initially the focus was on conduct of field demonstrations of improved technologies at farmer's fields through introduction of improved perennial fodder crops, seed/planting material distribution, knowledge dissemination, capacity building and entrepreneurship development. Till now, around 750 tribal farmers have been trained. Demonstrations were conducted in the farmers field keeping in view their herd size, water availability and land holding. The tribal farmers and villages were selected from all six Tehsils *viz.,* Navapur, Akalkua, Taloda, Shahada, Nandurbar and Dhadgoan of the district. In total, 200 demonstrations on newly improved varieties of fodder crops, 10 livestock health camps, 10 silage making programmes were carried out. Apart from these, improved breeds of poultry birds and fodder tree saplings were also distributed. As a result of all these activities, the area under fodder crops has increased drastically in the district, many commercial dairy units have come up, the milk production by the tribal farmers has gone up and farmers are purchasing the fodder seeds from KVK, Nandurbar for increasing the area under fodder crops by paying huge amount. About 300-400 farmers are now cultivating the improved varieties of fodder crops.

Most importantly, around 15-20 farmers are producing the seeds of forage grasses in participatory mode on commercial scale in collaboration with KVK, Nandurbar and the KVK is intern purchasing the seeds at Rs. 300/kg from the farmers. The introduction of these crops took some time to penetrate the cropping pattern of the district, since these tribal farmers were initially reluctant to adopt these technologies. But, now with continuous efforts both by IGFRI and KVK, the farmers are convinced about the benefits of these crops and they are cultivating it on large scale and reaping the benefits out of it. Further, the farmers were advised to use non competitive land of orchard crops for improved fodder production which not only alleviated fodder scarcity but also brought multiple benefits to the livestock farmers. Looking at the success of fodder technologies in the district, KVK Nandurbar is getting huge indent for supply of quality seeds from the neighboring districts and other line departments. *(Source: ICAR-Indian Grassland and Fodder Research Institute, Southern Regional Research Station, Dharwad-580 005, Karnataka)*

10.3 Leveraging Artificial Intelligence for grassland development - A pilot initiative

Animal husbandry has great potential to contribute to the agriculture GDP. Fodder scarcity is one issue which is hindering the growth of this sector. One of the possibilities to address fodder scarcity is through development of common lands. Common lands include pasture and grazing land, forest land, culturable wasteland, fallow land and river beds. They form a major chunk as one third of India's total land belongs to common land category. Common lands are source of food, fodder, firewood and also livelihoods to rural communities. For a various reasons like overgrazing, soil erosion, weed encroachment etc common lands are in bad condition. If these common lands are converted into productive grass lands, they make a significant contribution to fodder security through additional supplement of feed to livestock. Besides, they can play a key role in greenhouse gas mitigation, particularly in terms of global carbon storage and further carbon sequestration. Ruminants are efficient converters of grass into humanly edible energy and protein and grassland-based food production can produce food with a comparable carbon footprint as mixed systems. India has 312 million ha of common land which has the potential to produce estimated 12.05 million metric tons dry matter. Karnataka has around 6.11 m ha of common land which has potential to produce 2.78 m t of dry fodder which can feed 398.1 million livestock on daily basis.

Considering the importance of grasslands and their ecosystem services, Indian Grassland and Fodder Research Institute has developed agro-climatic zone specific grassland development technologies. Implementation of these technologies was however confined to smaller area. One of the reasons is vastness of grassland area, poor access to these areas (especially the middle part) and small window of soil moisture availability for sowing grasses in vast area. Apart from these, timely availability of seeds and sowing of tiny grass seeds in the presence of optimum soil moisture was also challenging.

Since the area under such common lands are very large and to cover these lands with productive fodder crops, use of artificial intelligence technology like Aerial Seeding technology using drone is the only way out. Aerial seeding is a technique wherein seed are sprayed using aerial devices such as drones. Drone consists of a global positioning system (GPS) and an auto-pilot device, the flight path can be controllable from the ground control station long-range remote controller. Drones can fly under variable altitude at speed range of 10-20 km/hour. The maximum seeds sowing rate can be achieved in minimum time with very less manual labour.

One such attempt for the first time in India was undertaken in partnership mode-IGFRI SRRS Dharwad provided technical backstopping for whole process, Livestock Breeding Farm, Hessarghatta of AHVS, Bangalore allocated 50 acre commonland and extended financial support and M/s Aerosight a private Drone company took up aerial sowing with needed modification of conveyor mechanism after continued discussion with IGFRI scientists. In a meeting of all the three partners, held before Kharif 2021, site of 50 acres was identified and suitable range grasses and legumes were suggested. C.ciliaris, Grazing guinea and Stylosanthes hamata were selected keeping in view the climatic conditions, soil type, hardiness, persistence and survivability.

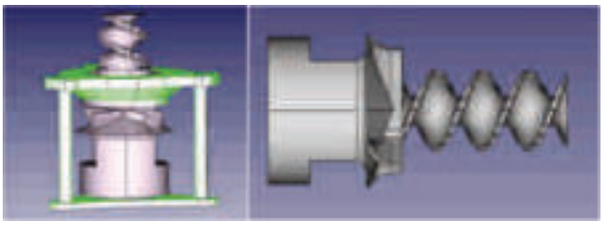
Sample of seed of these crops were given to M/s Aerosight to work on seed disbursal mechanism. Proper seed disbursal was felt very challenging due to tiny seeds as well as awns like structure on seed. It was required to ensure uniform flow of the seed from shaft of drone to achieve uniform sowing as well as attaining recommended seed rate. In subsequent meetings pros and cons of various methods like seed pelleting, seed soaking to increase seed weight etc were discussed .

However, considering the economics it was decided to design a conveyor with suitable material coating inside for smooth flow of seed. M/s Aerosight designed and tested two types suitable for identified grass species. These two conveyor mechanism designs with details are given in pictures. These conveyors helped to disperse tiny grass seed in a targeted pre-determined location rather than getting deterred by the wind. These fixtures are designed for extremely small seeds with the size ranging from 5 mm to 15 mm. Speed can be adjusted per second based on the speed set in the drone control system. The selected motor is used in conjunction with gearbox to achieve 900 RPM for Linear spraying system. The second type of fixture is used to spread seeds using BLDC motor upto 3000 RPM speed.

Dr. Amaresh Chandra, Director, IGFRI discussing with partners

Conveyor design for narrow line seeding used for Guinea Grass

Screw Details	:	Pitch: 30 mm
Total length	:	97.5mm
Total number of pitch	:	3.25
Motor selected	:	900 rpm
Seeds considered	:	Guinea grass
Output per rotation	:	0.5 grams/rotation
Output per minute	:	0.5*900= 450 grams/ minute



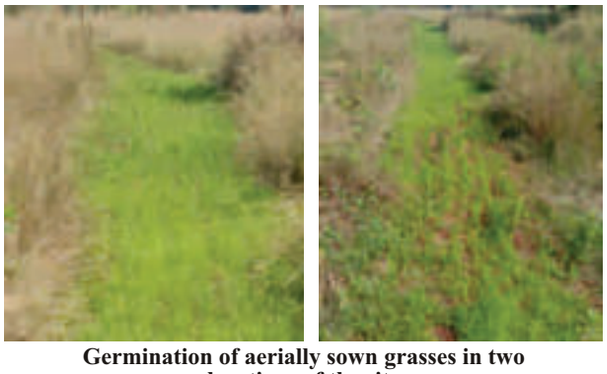
Conveyor design for wider seeding and lighter seeds - *Cenchrus ciliaris* and *S. hamata*

Screw Details	:	Pitch: 30 mm
Total length	:	150 mm
Motor selected	:	3000 rpm
Seeds considered	:	*S. hamata* and *Cenchrus* spp.
Output per rotation	:	0.3 grams/rotation
Output per minute	:	0.3*3000 = 900 grams/minute

Required quantities of grass seed were procured from IGFRI. Actual aerial sowing of these grass seed using drone was done in the month of September. Fifty acres land was marked with strips of natural grasses and emptied land to take up sowing by Drone with the intention to compare growth of sown grass in subsequent years. Sowing was covered in 2 days. The germination of grass seed is adjudged as very good. So, this leveraging of aerial seed sowing technology made developing vast grasslands a possibility. It saved the time besides reduced labour dependency. However, pelleting of seed has its own advantages. The process of the seed's germination and growth in pelleted seed requires no attention after it is dispersed and thus seed pellets are known as the "fire and forget" way of grassland development. They eliminate the need of soil tilth and have advantage as they are already surrounded by soil, nutrients and microorganisms. Pellets protect seed from damages due to birds, ants and rats.

This initiative of ICAR-IGFRI is first such attempt in India and the work lead to design of conveyor mechanism with precise seed dispersal and good germination. This brings closer to the reality of converting unreached common lands to productive grasslands in the country.

Aerial sowing of grass seed in progress



Germination of aerially sown grasses in two locations of the site

Chapter 11

Events and Meetings

11.1 ICAR- IGFRI, Jhansi – Foundation day

ICAR- Indian Grassland and Fodder Research Institute, Jhansi celebrated 61st Foundation day on 1st November, 2022. On this occasion, the chief guest Dr. A. K. Singh, Hon'ble Vice Chancellor, RLBCAU, Jhansi inaugurated a farmers' fair cum technology demonstration exhibition and delivered foundation day lecture. He highlighted the need for proper extension of forage and livestock technologies. The technologies must reach the farmers and all related stakeholders and should be refined based on feedback. He talked on various aspects of forage and grassland development and thanked scientists for their supportive roles in various University programmes. Dr. Amaresh Chandra, Director, ICAR-IGFRI presented the highlights of the research activities, outreach programmes, HRD activities and infrastructure created and new initiatives taken by institute during the year. Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi and guest of honour congratulated institute staff for the significant achievements and stressed upon the need for more effective collaboration between the two institutes to develop technologies for better livelihood options of farmers. Dr. N. P. Singh, Hon'ble Vice Chancellor, BUAT, Banda and guest of honour explained the role of agriculture in Bundelkhand and highlighted the need of forage and livestock technologies. Dr. S. K. Rao, Hon'ble Vice Chancellor, RVSKVV, Gwalior and guest of honour highlighted the need of forage seed production supply network and stressed upon the active role and guidance of IGFRI for enhancing forage seed resources. Dr. Mukesh Pandey, Hon'ble Vice Chancellor, Bundelkhand University, Jhansi and guest of honour congratulated IGFRI staff for completing 60 years of service and entering in the 61st year. He appreciated the significant achievements of the institute especially in terms of publication and varieties. Guest of eminence Padma Shri Dr. B. S. Dhillon, Former Vice Chancellor, PAU, Ludhiana appreciated institute for new varieties and high ranking publications. He stressed upon the need for better coordination among institutes of maize, bajra, sorghum crops with IGFRI with an aim to develop better dual purpose, multicut varieties. Several institute publications including technical bulletins, leaflets in different languages and e-publications were released by the dignitaries. Awards were conferred upon the selected staff of all categories and teams. A technology demonstration exhibition followed by scientists-farmers interaction meet was organized for the benefit of multiple stakeholders. Several public and private sector institutions, FPOs, seed companies demonstrated their activities and products.

Fig. 11.1. Glimpses of 61st foundation day celebration

11.2 National Symposium on "Innovations in forage and livestock sector for improving entrepreneurship and farm profitability"

Institute in association with Range Management Society of India, Jhansi organized a national symposium on "Innovations in forage and livestock sector for improving entrepreneurship and farm profitability" during 01-03 November 2022. Padma Shri Dr BS Dhillon, former VC, PAU, Ludhiana was the Chief Guest of the Inaugural function while Dr PS Pathak, former Assistant Director General (Agroforestry) graced the occasion as eminent guest. Dr Dhillon highlighted the importance of the symposium and emphasized the need for entrepreneurship development in the forage and

livestock sector. Dr Pathak spoke about the need for rejuvenation of our grasslands and community pastures. Dr Amaresh Chandra, President, Range Management Society of India and Director, ICAR-IGFRI Jhansi highlighted the achievements of the society and the importance of the forage and livestock sector in the enhancement of livelihood of farmers. During the inaugural session, RMSI awards in different categories were distributed. On this occasion, the souvenir cum abstract book and the latest issue of Range Management and Agroforestry Journal were released by the guests. A three day exhibition was also held to demonstrate new innovations and popular technologies in the forage and livestock sector. Nine scientific sessions including various aspects of forage production, conservation, utilization and entrepreneurship potential were held during the symposium. A special farmer-scientist-stakeholder interface session was also organized in collaboration with ICRISAT in which farmers from Odisha, Uttar Pradesh and Madhya Pradesh participated. More than 280 participants including about 100 farmers attended this symposium.

Fig. 11.2. Glimpses of national symposium

11.3 Parthenium Awareness Week

The institute organized 17th *Parthenium* Awareness at several locations i.e., institute premises and at Central Research Farm (FSR site, FMPHT yard, Animal Research complex, CP farm etc) from 16- 22 August, 2022. Posters, banners, awareness program were organized at important places in the institute for promoting awareness among the staffs of ICAR-IGFRI, Jhansi. Dr Amaresh Chandra, Director, IGFRI Jhansi in closing session stressed about harmful effect of this Parthenium on human and animal health and losses caused to crop yields and he directed all staff members to keep their premises free of Parthenium. All scientists, technical staff, research associates, senior researchers and other IGFRI workers were actively involved and demonstrated interest in the eradicating *Parthenium*. Dr Sunl Kumar, Head CP Division detailed information about management of this weed and urged all staff member to keep their premises Parthenium free and regular monitoring of their fields.

Fig. 11.3. Creating awareness on Parthenium

11.4 World Soil Day

The 'World Soil Day' was organized on 5th December, 2022 on the theme 'Soil: Where Food Begins'. The aim of this program is to create awareness about the importance of soil health in food ecosystem. In this program, 45 farmers from 3 villages of Jhansi district were participated. The chief guest of this function was Dr. Adarsh Singh, Divisional Commissioner, Jhansi. In total 56 Soil Health Cards were distributed to the farmers. Dr. Amaresh Chandra, Director, ICAR-IGFRI on his address highlighted the importance of soil health for benefits of coming generations and advised farmers about crop residue management and rain water harvesting. Dr. Sunil Kumar Tiwari, Head, Crop Production Division emphasized the need of soil testing and also explained the use of information in the soil health card for sustainable agriculture.

Fig. 11.4. Distribution of soil health cards to farmers

11.5 World Water Day

World Water Day was celebrated on March 22, 2022. The pragramme was attended by 40 farmers of Shivpuri district of Bundelkhand region and scientists of the institute. Dr. Amaresh Chandra, Director, ICAR-IGFRI, Jhansi stressed on the need for 'More Crop Per Drop' and the adoption of advanced techniques for soil water conservation. The key speaker Dr. Ramesh Singh, Principal Scientist, ICRISAT deliver a talk on the theme 'Groundwater: Making invisible visible' and highlighted the water conservation and watershed management strategies especially in Bundelkhand region. Dr. Sunil Kumar, Head, Division of Crop Production, ICAR-IGFRI, Jhansi emphasized on increasing water productivity and decreasing water footprints by adopting suitable cropping systems and micro irrigation.

Fig. 11.5. Celebration of World Water Day

11.6 Quinquennial review team visit

The Quinquennial review team constituted by the ICAR critically reviewed the research and development activities of IGFRI and AICRP-FCU for the period of 2016-20. The team was chaired by Dr. Panjab Singh and the members of the committee were Dr. M.M. Roy, Dr. P.N. Jagdev, Dr. R.C. Jakhmola, Dr. M.L. Sharma and Dr. V.K. Yadav. During the period of review both ICAR-IGFRI and AICRP (FC&U) have made significant progress in the generation and dissemination of several technologies for enhancing fodder production, value addition and efficient utilization. National Initiatives for Fodder Technology Demonstration (NIFTD) extended its reach directly to 100 KVKs of different agro-climatic zones. Developed state-wise fodder resource development plan would be ready reckoner to the development departments and other progammes such as technological empowerment of *Gaushalas*, MGMG, DFI, FFP, SCSP, TSP, NEH plan have given a pace to extending technological advantages to the aspirant areas. However, to meet the emerging challenges with respect to forage production, ecological balance, climatic adaptations, low input-agriculture etc., the institute and the project have to play a very significant role in future technology development. Therefore, the institute needs to be given a special treatment for its strengthening in terms of manpower and infrastructure so as to assume a higher and effective role at the national level.

Glimpses of IGFRI activities

Glimpses of QRT visits at different locations

Glimpses of QRT visits at different locations

Glimpses of other events and meetings

Republic Day Celebration 26th January 2022

World Water Day-2022 celebrated on 22nd March, 2022

National Awareness Campaign on Balance Use of Fertilizers and Area Specific Agroforestry on 21st June, 2022 at ICAR-IGFRI, Jhansi

Awareness camp on fodder production and animal health at village Drini , District Kangra HP

International Yoga Day Celebrated on 21st June 2022 at ICAR-IGFRI, Jhansi


International Womens Day organized on 8th March 2022

Celebration of International Women Day at IGFRI RRS Avikanagar


PMC Visit (Rabi 2022) on 8th March 2022


Two awareness programmes were organised under SCSP at Samba and R S Pora regions of Jammu region.

Trainings/Kisan Gosthi

Progressive farmers training from 7-11th, March 2022

Progressive farmers training from 21-25th, March 2022

Kisan Gosthi organized on 23rd April 2022

Kisan Gosthi 24-25th April 2022

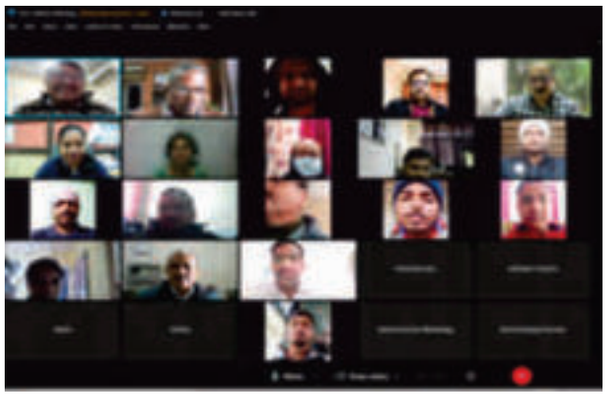

Scheduled Caste Farmers beneficiary conference. 28th May 2022

Training program on 'Quality seed production in forage crops,' started from 24-26th March, 2022.


Training programme organized by ICAR-IGFRI, RRS Srinagar at Mankot, Rajouri on 19th February, 2022


Training programme organized ICAR-IGFRI, RRS Srinagar at Dhanwankot, Rajouri on 20th February, 2022

Training programme organized ICAR-IGFRI, RRS Srinagar at Tandwal village, Rajouri on 20th February, 2022



Collaborative Online Training Programme of ICAR-IGFRI, Jhansi & MANAGE, Hyderabad on "Agripreneurship development on value added fodder products

Training of Tribal Farmers at IGFRI RRS Avikanadar on 8th March 2022

Meetings/Workshop

Dr. Mangla Rai, Ex-DG, ICAR & Secretary, Govt. Of India Interacting with the Scientist on 4th March 2022

Hindi Workshop on 07th March 2022

Technology and Machinery Mela, 16th March,2022

Hindi workshop organized on 21st May, 2022

National Acdemy of Agricultural Sciences Lucknow Chapter. 25th March 2022

QRT team under the Chairmanship of Dr. Panjab Singh visited IGFRI, SRRS, Dharwad on June 1-2nd, 2022

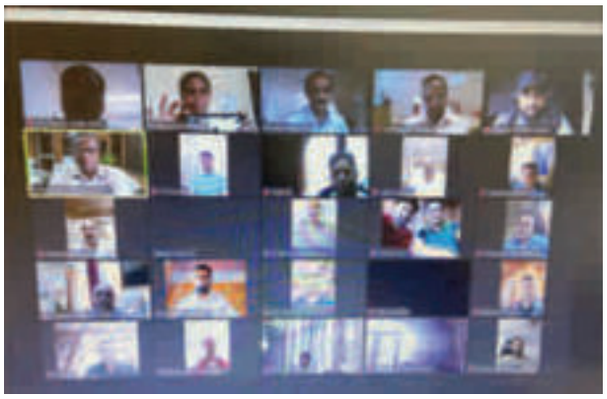
MOS Agriculture, GOI Hon'ble Shri Kailash Choudhary visiting IGFRI Exhibition in CSWRI Golgen Jubilee Foundation Day Mela on 4 Jan 2022 at Avikanagar

Visit of Dr. Kehar singh Thakur Scientist, KVK UHF Chamba HP for demonstration and timing of sowing of Temperate grasses

Visit of Dr.T.R. Sharma DDG Crop Science at IGFRI RRS Palampur

ADG FFC, Dr. R.K. Singh and Director, IGFRI, Dr. Amaresh Chandra visited RRS Srinagar on 14th June, 2022

TSP activities conducted at Dhule and Nadurbar districts of Maharashtra



The ICAR-Indian Grassland and Fodder Research Institute, RRS, Srinagar in collaboration with the Social Forestry Department, Govt. of J & K, organized the *Virtual Workshop* on 19th May, 2022

Hindi Week at IGFRI RRS Srinagar

Kisan Diwas at IGFRI RRS Srinagar on 23rd Dec. 2022

Chapter 12

Awards and Recognitions

Dr. A. K. Roy received **Rafi Ahmed Kidwai Award** for Outstanding Research in Agricultural Sciences 2021 (Crop and Horticultural Sciences) on 16-07-2022 (ICAR foundation day).

ICAR-Indian Grassland and Fodder Research Institute–Network Project on Bhadawari Buffaloes received **Breed Conservation Award 1st Prize** for conservation of Bhadawari buffaloes on 23-12-2022 from ICAR-National Bureau of Animal Genetic Resources, Karnal.

Professional Societies Award

- Drs. A. K. Roy, D. R. Malaviya, P. Kaushal and A. Chandra were conferred with **Dr. S. K. Vasal Award-2021** by Indian Society of Plant Genetic Resources for efficient use of PGR on 20-08-2022

Indian Society of Agroforestry Awards 2022

- Dr. AK Roy received **Gold Medal Award-2021**
- Dr. Amaresh Chandra received **Honorary Fellow**

- Dr. DR Palsaniya was awarded with **Fellow 2021**
- Dr. Sunil Kumar was awarded with **Fellow 2021**
- Drs. Purushottam Sharma and Ramesh Singh received **Team award 2020-21**
- Dr. Mukesh Choudhary was conferred with **Best Paper Award 2020**

Range Management Society of India Awards (01-11-2022)

- Dr. Sultan Singh received **Gold Medal Award-2020**
- Dr. Sunil Kumar received **Gold Medal Award-2020**
- Dr. Nagaratna Biradar received **Gold Medal Award-2020**
- Dr. DR Palsaniya was awarded with **Fellow 2021**
- **Best paper Award 2021 -** Drs. Sultan Singh, B. K. Bhadoria, P. Koli and Suman Lata. Seasonal

variation in chemical and biochemical constituents of tropical top feed species: components in silvipasture system, Range Management and Agroforestry 42(2): 312-319.

- Dr. Sanjay Kumar Singh was awarded with ISAE **Distinguished Service Award 2022**

- Dr. BB Choudhary received **Associate Fellow** of National Academy of Dairy Science
- Dr. Sunil Kumar received **Outstanding Achievements Award-2021** from Hi-Tech Horticultural Society, Meerut.
- Dr. BK Mehta received **Young Researcher Award 2022** from InSc International Publishers, Bangalore.
- Er. AK Patil received **Young Scientist Award-2022** from Vigyan Varta Society

Conferences/Seminar/Symposium Awards

- Shashikumara P, Harikrishna, Neelu Jain, PK Singh, GP Singh and KV Prabhu - **Best oral paper presentation award -** 1st International symposium, cereals for food security and climate resilience, 18 to 20-01-2022, ICAR-IIWBR, Karnal.

International Conference on Advance in smart agriculture and biodiversity conservation for sustainable development, Jaipur National University and Agricultural Technology Development Society, Ghaziabad, 04 to 06-03-2022.

- Dr. Rajesh Kumar Singhal - **Young Scientist Award (2021)**
- Drs. Indu, RK Singhal, Mahesha HS, M Rana, Bhargavi HA, Keerthi MC, N Dikshit, Manjunath N, S Singh, DC Joshi, S Ahmed - **Best oral paper presentation award**
- Drs. R Patel, D Borban, BL Aanjna, R K Singhal, N Kumar, M Rana, Indu, and S Ahmed - **Best oral paper presentation award**
- Dr Indu - **Young women scientist award** - International Conference (GIRISDA-2022), Just Agriculture, Guru Kashi University & AEEFWS-Society, 06 to 08-06-2022
- Dr. BK Mehta - **Best oral paper presentation award** - Symposium on 'Tending Mendel's garden for perpetual and bountiful harvest', ICAR-IARI, New Delhi, 16 to 19-07-2022.
- Dr. Pooja Tamboli - **Best oral paper presentation award** - 5th Annual Convention and National Conference of National Academy of Veterinary Nutrition and Animal Welfare, NDVSU, Jabalpur, 21 to 22-09-2022

International Conference on 'Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environment Security', Baramulla, J&K, 28 to 30-09-2022

- Dr. Sultan Singh - **Distinguished Scientist Award**
- Dr. Nagaratna Biradar - **Outstanding Scientist Award-2022**
- Dr. Avijit Ghosh - **Young Scientist Award**
- Dr. Sultan Singh - **Best oral paper presentation award**
- Dr. Avijit Ghosh - **Best oral paper presentation award**
- Dr. BB Choudhary - **Best oral paper presentation award**

RMSI National Symposium on Innovations in forage and livestock sector for enhancing entrepreneurship and farm productivity, 01 to 03-11-2022 at ICAR-IGFRI, Jhansi.

- Drs. BG Shivakumar and RK Agrawal - **Best oral paper presentation award**
- Drs. Gupta, G., DR Palsaniya, SS Manjanagouda, D Upadhyay, K Chand, M Suman, RK Patel, BB Choudhary and SK Singh - **Best oral paper presentation award**
- Dr. Avijit Ghosh - **Best oral paper presentation award**
- Dr. Sunil Kumar - **Best poster award**
- Drs. RP Nagar, SS Meena ,V Kumar, RP Saini and HS Meena - **Best poster award**
- Dr. Pooja Tamboli - **Best poster award**

Institute Foundation Day Awards

- **Best Scientist Award** – Dr Mukesh Choudhary
- **Best Team Award 2022**- Kisan Mitra project team: P Sharma, S Kumar, SR Kantwa, D Updhyay, VK Wasnik, M Prasad, G Gupta, BB Choudhary, RK Sharma, RK Gupta, NK Singh and Vijay Kant.

Other Awards / Recognitions

- Dr. Avijit Ghosh - **Editorial board member** - Frontiers in Agronomy, Frontiers in Soil Science
- IGFRI exhibition stall received **Third prize in Soya Kumbh 2022** at ICAR-IISR Indore

Chapter 13

Administration and Accounts

Progressive Expenditure up to 31.12.2022

13.1 Expenditure of ICAR-IGFRI, Jhansi

(Rs. In Lakhs)

Sl. No.	Sub-head	Budget 2022-23		Progressive Expenditure				
		BE	Released	Other than TSP, NEH & SCSP	NEH	TSP	SCSP	Total (5+6+7+8)
1	2	3	4	5	6	7	8	9
1	GIA- Capital	200.00	117.01	42.73	0.00	0.00	1.46	44.19
2	GIA- Salary	3200.00	2811.83	2511.09	0.00	0.00	0.00	2511.09
3	GIA- General							
	(a) Pension	600.00	280.00	193.15	0.00	0.00	0.00	193.15
	(b) Other	830.00	678.63	519.92	6.50	9.74	18.28	554.44
4	**Total**	**4830.00**	**3887.47**	**3266.89**	**6.50**	**9.74**	**19.74**	**3302.87**
5	Loans & Advance	0.00	0.00	% of Exp.	Over BE	**68.38**	Over Released	**84.96**

13.2 Expenditure of AICRP (FCU) IGFRI, Jhansi

(Rs. In Lakhs)

Sl. No.	Sub-head	Budget 2022-23		Progressive Expenditure				
		BE	Released	Other than TSP, NEH & SCSP	NEH	TSP	SCSP	Total (5+6+7+8)
1	2	3	4	5	6	7	8	9
1	GIA- Capital	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	GIA- Salary	800.00	676.00	616.00	52.00	0.00	0.00	668.00
3	GIA- General							
	(a) Pension	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(b) Other	196.00	159.90	112.71	7.71	32.73	0.00	153.15
4	**Total**	996.00	835.90	728.71	59.71	32.73	0.00	**821.15**
5	Loans & Advance	0.00	0.00	% of Exp.	Over BE	**82.44**	Over Released	**98.24**

13.3 Staff Strength as on 31.12.2022

Cadre	Sanctioned	In position	Vacant
Cadre	**Sanctioned**	**In position**	**Vacant**
Research Management	01	01	-
Scientist	121	76	45
Technical	85	53	32
Administrative	76	38	38
Skilled Supporting Staff	55	42	13
Total	338	210	129

Departmental Promotion in respect of Scientific, Technical, Administrative and Skilled Supporting Staff during the period 01.01.2022 to 31.12.2022

13.4 New appointments

S. No.	Name of officer	Designation	Date of joining
1.	Sh. Uttam Singh Verma	T-3 (F&F)	20.06.2022
2.	Sh. Limbalkar Omkar Maharudra	T-6 (F&F)	22.06.2022
3.	Sh. Veeranna Rudrappa Kadakol	T-5 (Lab)	22.07.2022
4.	Dr. Anjaly, M. V.	T-6 (F&F)	27.07.2022

13.5 Probation period confirmation

Sl. No.	Name of scientist	Probation period confirmation date	Date of office order
1.	Dr. Prabha Singh (Plant Physiology)	04.01.2021	23.02.2022
2.	Mrs. Parichita Priyadarshini (Agril. Biotechnology)	04.01.2021	23.02.2022
3.	Dr. Shashikumara P. (Genetics & Plant Breeding)	04.01.2021	23.02.2022
4.	Dr. Brijesh Kumar Mehta (Genetics & Plant Breeding)	04.01.2021	23.02.2022
5.	Sh. Mahesha H.S. (Plant Physiology)	02.07.2020	09.03.2022
6.	Sh. Rajesh Kumar Singhal (Plant Physiology)	02.07.2020	09.03.2022
7.	Dr. Manjanagouda S. Sannagoudar (Agronomy)	02.07.2020	09.03.2022
8.	Dr. Gaurendra Gupta (Agronomy)	02.07.2020	09.03.2022
9.	Dr. Anup Kumar (Agril Chemicals)	04.01.2021	18.05.2022

13.6 Promotion to next level

Sl. No.	Name of officer	Nature of promotion	Date of office order
Scientist			
1.	Dr. Reetu, Scientist (Plant Biochemistry)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
2.	Dr. Kautkar Sheshrao Sakharam, Scientist (ASPE)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
3.	Dr. Amit Kumar Singh, Scientist (Agril. Meteorology)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
4.	Sh. Rahul Gajghate, Scientist (Genetics & Plant Breeding)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
5.	Dr. Nitish Rattan Bhardwaj, Scientist (Plant Pathology)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
6.	Dr. Kamini, Scientist (Agro-forestry)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
7.	Dr. Hanamant M. Halli, Scientist (Agronomy)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022

8.	Dr. Deepak Upadhyay, Scientist (LPM)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
9.	Sh. Nazim Hamid Mir, Scientist (Agronomy)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022
10.	Dr. Maneet Rana, Scientist (Agril. Biotechnology)	Research Level-11 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 7000/- pre revised)	08.06.2022

Scientist to be designated as Senior Scientist

1.	Dr. Sheeraz Salam Bhat, Scientist (Agro-forestry)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
2.	Dr. Manjunatha, N. Scientist (Plant Pathology)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
4	Dr. Prabhu Govindasamy, Scientist (Agronomy)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
5	Dr. Vinod Kumar Wasnik, Scientist (Agronomy)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
6	Dr. Suheel Ahmad Dand, Scientist (Agro-forestry)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
7	Dr. Tejveer Singh, Scientist (Genetics & Plant Breeding)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
8	Dr. Debyendu Deb, Scientist (Agricultural statistics)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
9	Dr. Mukesh Chaudhary, Scientist (Agronomy)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022
10	Sh. A. Radhakrishna, Scientist (Agricultural Biotechnology)	Research Level-12 (7th CPC) in the pay matrix (Pay Band Rs. 15600-39100 + RGP 8000/- pre revised)	08.06.2022

Technical

1.	Sh. Shyam Murari Singh	T-6 to T-7/8 01.01.2020	17.01.2022
2.	Sh. N.K. Tripathi	T-6 to T-7/8 01.01.2020	17.01.2022
3.	Sh. Rajesh Kumar Singh	T-6 to T-7/8 01.01.2020	17.01.2022
4.	Sh. U.P. Singh	T-6 to T-7/8 01.01.2020	17.01.2022
5.	Sh. Ami Chand	T-6 to T-7/8 01.01.2020	17.01.2022
6.	Sh. Raj Kapoor Singh	T-6 to T-7/8 01.01.2020	17.01.2022

7.	Sh. Kapil Kumar	T-6 to T-7/8 01.01.2020	17.01.2022
8.	Sh. Neeraj Kumar Dubey	T-6 to T-7/8 01.01.2020	17.01.2022
9.	Smt. Sandhya Bhargav (Retd)	T-7/8 to T-9 01.01.2019	17.01.2022
10.	Sh. L.N. Singh (Retd)	T-7/8 to T-9 01.07.2015	17.01.2022
11.	Dr. Harish Chand Pandey	T-6 to T-7/8 01.01.2020	17.01.2022
12.	Smt. Anita Srivastava	T-4 to T-5 29.06.2021	03.03.2022
13.	Sh. Dheeraj Kumar Dhingra	T-5 to T-6 07.11.2020	25.05.2022
14.	Sh. Gopal Lal Meena	T-4 to T-5 04.08.2021	28.06.2022
15.	Sh. Bhagwat Narayan Kushwah	SSS to T-1 04.08.2022	03.08.2022
16.	Smt. Sudha Shrivastava	SSS to T-1 03.08.2022	03.08.2022
17.	Sh. Ashiq Ali	SSS to T-1 03.08.2022	03.08.2022

Administrative

1.	Sh. Vijay Kumar Paliwarl	Assistant to AAO (provisionally) 23.02.2022 Provisionally waive off on 04.03.2022	23.02.2021
2.	Sh. Y.P.S. Tomer	Assistant to AAO (provisionally) 23.02.2022 Provisional waive off on 02.07.2022	04.03.2022
3.	Sh. Uma Shankar	LDC to UDC 09.06.2022	09.06.2022
4.	Sh. Sanjay Kumar	UDC to Assistant 27.07.2022	27.07.2022
5.	Smt. Girja	SSS to LDC 04.08.2022	03.08.2022
6.	Shri. Prem Chand	PS to PPS 03.08.2022	03.08.2022

Chapter 14

Distinguished Visitors

Dr. Anurag Sharma
Hon'ble MP, Jhansi

Sh. Jawahar lal Rajpoot
MLA, Garotha

Dr. R.K. Singh, Secretary
D/o Animal Husbandry & Fisheries, GOI New Delhi

Shri Ravindra Kumar
DM, Jhansi

Dr. B.S. Dhillon
Former VC, PAU & Former ADG (FFC), ICAR
New Delhi

Dr. Anil Kumar
Director
ICAR-CIWA, Bhubaneswar (Orissa)

Dr. A.B. Pande
Vice President
BAIF, Pune (Maharashtra)

Dr. N.P. Bajpai
Director Extension
BAUT, Banda (UP)

Mr. R.K. Thapliyal
Assistant Economic, DES (Govt. of India)
New Delhi

Mr. M.B. Khandare
Assistant Director, DES (Govt. of India)
New Delhi

Dr. M.M. Roy
Former Director
ICAR-CAZRI, Jodhpur (Rajasthan)

Dr. P.S. Pathak
Former Director
ICAR-IGFRI, Jhansi (UP)

Dr. J.C. Rana
Bioversity – CIAT
New Delhi

Sh. Ravi Sharma
MLA, Sadar Jhansi

Prof. Panjab Singh
Former Secretary, DARE &
Director General, ICAR, New Delhi

Dr. N.P. Singh
Vice Chancellor
BUAT, Banda (UP)

Padamshree Dr. Anil Joshi
Environmental Expert

Dr. Neejam Patel
Senior Advisor, NITI Aayog, GOI
New Delhi

Dr. Vinod Ji Talashi
Advisor, DES (Govt. of India)
New Delhi

Dr. KML Pathak
Former DDG (AS)
ICAR, New Delhi

Dr. Vinod Ji Talashi
Advisor, DES (Govt. of India)
New Delhi

Dr. A.C. Mishra
Director Research
BUAT, Banda (UP)

Dr. A.K. Patra
Former Director
ICAR-IISS, Bhopal (MP)

Dr. S.K. Dhyani
Former Director
ICAR-CAFRI, Jhansi (UP)

Dr. G. Singh
Director
ICAR-IIWBR, Karnal (Haryana)

Dr. K.K. Singh
Former ADG, ICAR
New Delhi

Chapter 15

List of Personnel

DIRECTOR

Dr. Amaresh Chandra	Director	

SCIENTIFIC

Division of Crop Improvement

Dr. Shahid Ahmad	Principal Scientist (Plant Breeding) & I/c Head	
Dr Nilamani Dixit	Principal Scientist (Economic Botany and PGR)	
Dr. (Mrs) G. Sahay	Principal Scientist (Genetics & Cytogenetics)	Up to 26.09.2022
Dr. K.K. Dwivedi	Principal Scientist (Biotechnology)	
Dr. Tejveer Singh	Senior Scientist (Genetics)	
Sri A. Radhakrishna	Scientist (Agricultural Biotechnology)	Up to 23.04.2022
Sri Rahul Gajghate	Scientist (Genetics & Plant Breeding)	Up to 31.03.2022
Dr. Maneet Rana	Scientist (Agricultural Biotechnology)	
Dr. Reetu	Scientist (Plant Biochemistry)	
Sri Neeraj Kumar	Scientist (Genetics & Plant Breeding)	Up to 31.03.2022
Sri Keerthi, M.C.	Scientist (Agricultural Entomology)	Up to 11.08.2022
Ms. Bhargavi, H.A.	Scientist (Genetics & Plant Breeding)	On study leave
Ms. Indu	Scientist (Genetics & Plant Breeding)	
Dr. Rajesh Kumar Singhal	Principal Scientist (Plant Physiology)	
Sri Brijesh Kumar Mehta	Scientist (Genetics & Plant Breeding)	
Sri Shashikumara P.	Scientist (Genetics & Plant Breeding)	
Dr. Parichita Priyadarshini	Scientist (Ag. Biotechnology)	On study leave

Division of Crop Production

Dr. Sunil Kumar	Principal Scientist (Agronomy) & I/c Head	
Dr. J.B. Singh	Principal Scientist (Ag. Meteorology)	
Dr. S.K. Rai	Principal Scientist (Ag. Meteorology)	
Dr. A.K. Dixit	Principal Scientist (Agronomy)	
Dr. Sita Ram Kantwa	Principal Scientist (Agronomy)	
Dr. Srinivasan R.	Principal Scientist (Microbiology)	
Dr. D.R. Palsaniya	Principal Scientist (Agronomy)	
Dr. Mukesh Choudhary	Scientist (Agronomy)	
Dr. Mahendra Prasad	Scientist (Soil Science)	
Sri Sonu Kumar Mahawer	Scientist (Agricultural Chemicals)	On study leave

Division of Grassland and Silvipasture Management

Dr. R.V. Kumar	Principal Scientist (Plant Breeding) & I/c Head	
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)	

Dr. Amit Kumar Singh	Scientist (Ag. Meteorology)	
Sri Vikas Chandra Tyagi	Scientist (Economic Botany & PGR)	on study leave
Dr. Kamini	Scientist (Agroforestry)	
Sri Avijit Ghosh	Scientist (Soil Science)	
Dr. Manjanagouda S. Sannagoudar	Scientist (Agronomy)	

Division of Plant Animal Relationship

Dr. K.K. Singh	Principal Scientist (Animal Nutrition) & I/c Head	
Dr. M.M. Das	Principal Scientist (Animal Nutrition)	
Dr. Sultan Singh	Principal Scientist (Animal Nutrition)	
Dr. Deepak Upadhyay	Scientist (LPM)	
Sri Pushpendra Koli	Scientist (Agricultural Chemicals)	on study leave
Dr. Anup Kumar	Scientist (Agricultural Chemicals)	
Dr. Pooja Tamboli	Scientist (LPM)	

Division of Seed Technology

Dr. V.K. Yadav	Principal Scientist (Plant Breeding) & Head	
Dr. A.K. Singh	Senior Scientist (Plant Breeding)	
Sri Anirudhha Maity	Scientist (Seed Technology)	on study leave
Sri V.K. Wasnik	Senior Scientist (Agronomy)	
Sri Swami Sunil Ramling	Scientist (Seed Science & Technology)	on study leave
Sri Maharishi Tomar	Scientist (Plant Biochemistry)	on study leave
Dr. Ravi Prakash Saini	Scientist (Agricultural Biotechnology)	
Ms. Prabha Singh	Scientist (Plant Physiology)	
Dr. H.S. Mahesha	Scientist (Genetics & Plant Breeding)	
Dr. Surendra Kumar Meena	Scientist (Plant Physiology)	

Division of Farm Machinery and Post Harvest Technology

Dr. P.K. Pathak	Principal Scientist (ASPE) & & I/c Head	
Dr. P.N. Dwivedi	Principal Scientist (Animal Nutrition)	
Dr. C.S. Sahay	Principal Scientist (Farm Machinery & Power)	Up to 26.09.2022
Dr. Sanjay Kumar	Principal Scientist (APE)	
Er. Bholuram Gurjar	Scientist (Farm Machinery & Power)	on study leave
Er. Amit Kumar Patil	Scientist (Farm Machinery & Power)	

Division of Social Science

Dr. P. Sharma	Principal Scientist (LPM) & I/C Head	
Dr. (Mrs) M. Suman	Principal Scientist (Ag. Extension)	
Dr. Gaurendra Gupta	Scientist (Agronomy)	
Dr. Bishwa Bhaskar Choudhary	Scientist (Ag. Economics)	

AICRP (Forage Crops & Utilization)

Dr. A.K. Roy	Principal Scientist (Genetics & Cytogenetics) & I/c Project Coordinator	
Dr. R.K. Agrawal	Principal Scientist (Agronomy)	
Dr. Nitish Rattan Bhardwaj	Scientist (Plant Pathology)	Up to 31.08.2022
Sh. Subhash Chand	Scientist (Genetics & Plant Breeding)	

Regional Research Station, Avikanagar (Rajasthan)

Dr. R.P. Nagar	Principal Scientist (Plant Breeding) & Officer-in-Charge	
Sri 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	Senior Scientist (Plant Physiology)	
Dr. (Mrs.) Ramyashree Devi G.S	Scientist (Plant Pathology)	

Regional Research Station, Srinagar (J & K)

Dr. Suheel Ahmad	Scientist (Forestry) & Officer-in-Charge	
Dr. S. Radotra	Principal Scientist (LPM)	
Dr. Surinder Paul	Scientist (Plant Biotechnology)	
Sri Nazim Hamid Mir	Scientist (Agronomy)	
Dr. Sheeraj Saleem Bhat	Scientist (Forestry)	

TECHNICAL

Dr. R.K. Sharma	Chief Technical Officer	
Sri P.K. Karpe	Chief Technical Officer	
Sri P.K. Tyagi	Chief Technical Officer	
Sri A.K. Saxena	Chief Technical Officer	
Sri Avinash Chandra	Chief Technical Officer	
Sri V.D. Chhabra	Chief Technical Officer	
Sri H.K. Agrawal	Chief Technical Officer	
Mrs. Seema Khatri	Chief Technical Officer	
Sri K.P. Rao	Chief Technical Officer	
Sri R.B. Bhondele	Assistant Chief Technical Officer	
Dr. D.K. Singh	Assistant Chief Technical Officer	Up to 31.01.2022
Sri Ram Asrey	Assistant Chief Technical Officer	
Sri P.C. Gehlot	Assistant Chief Technical Officer	
Sri Mohd. Irfan	Assistant Chief Technical Officer	
Sri C.B. Tripathi	Assistant Chief Technical Officer	
Sri S.M. Singh	Asstt. Chief Technical Officer	
Sri K.L. Meena	Senior Technical Officer	
Sri Rajesh K. Singh	Asstt. Chief Technical Officer	Up to 30.11.2022
Sri U.P. Singh	Asstt. Chief Technical Officer	
Sri Ami Chand	Asstt. Chief Technical Officer	
Sri N.K. Tripathi	Asstt. Chief Technical Officer	
Dr. H.C. Pandey	Asstt. Chief Technical Officer	
Sri O.P. Yadav	Senior Technical Officer	Up to 31.01.2022

Sri Neeraj K. Dubey	Asstt. Chief Technical Officer	
Sri Kapil Kumar	Asstt. Senior Technical Officer	
Sri Raj Kapoor Singh	Asstt. Senior Technical Officer	
Sri P.N. Ahirwar	Senior Technical Officer	Up to 01.08.2022
Sri Shailendra Sinha	Senior Technical Officer	
Sri Ashok K. Singh	Senior Technical Officer	
Dr. Limbalkar Omkar Maharudra	Senior Technical Officer	w.e.f. 22.06.2022
Dr. Anjaly M. V.	Senior Technical Officer	w.e.f. 27.07.2022
Sri Dheeraj K. Dhingra	Senior Technical Officer	
Sri Satya Naresh Singh	Technical Officer	
Sri Rajesh K. Sharma	Technical Officer	
Sri Harish Chandra	Technical Officer	
Sri Ganga Sagar Yadav	Technical Officer	
Sri Prem Swaroop	Technical Officer	
Sri D.K. Niranjan	Technical Officer	
Sri Haider Ali	Technical Officer	
Sri S.V. Shinde	Technical Officer	
Sri Pawan Kumar	Technical Officer	
Dr. R.S. Patel	Technical Officer	
Smt. Anita Srivastava	Technical Officer	
Sri Devendra Pratap	Technical Officer	
Sri Gopal Lal Meena	Technical Officer	
Sri V.K. Gupta	Technical Officer	
Sri Veeranna Rudrappa Kadakol	Technical Officer	
Sri Syed Zulfikar Ali	Senior Technical Assistant (Driver)	
Sri M.K. Tripathi	Senior Technical Assistant (Driver)	
Sri Sudhir Ramteke	Technical Assistant	
Sri Deepak Choudhary	Technical Assistant	
Sri Arun Prajapati	Technical Assistant	
Sri Uttam Singh Verma	Technical Assistant	w.e.f. 20.06.2022
Sri Mathura Prasad	Senior Technician	
Sri M.K. Vishwakarma	Technician	Up to 31.07.22
Sri V.N. Pathak	Technician	Up to 30.04.22

ADMINISTRATIVE

Sri Abhishek Yadav	Sr. Administrative Officer	Up to 30.03.2022
Sri Kumar Vivek	Sr. Administrative Officer	w.e.f. 16.08.2022
Sri Mithilesh Kumar	Sr. Finance & Accounts Officer	Up to 30.07.2022
Sri K.K. Sharma	Asstt. Administrative Officer	
Sri Rakesh Kumar	Asstt. Administrative Officer	Up to 28.10.2022
Sri Gautam Saxena	Asstt. Administrative Officer	
Sri H.S. Yadav	Asstt. Administrative Officer	

Sri M.C. Jetwani	Asstt. Administrative Officer	Up to 28.02.2022
Sri Vijay K. Tiwari	Asstt. Administrative Officer	
Sri Raj Kumar Nayak	Asstt. Administrative Officer	
Sri V.K. Paliwal	Asstt. Administrative Officer	
Sri Yashpal	Asstt. Administrative Officer	
Sri Prem Chand	Principal Private Secretary	
Smt. Kumud Bhatia	Personal Secretary	
Sri Jagdish Prasad	Personal Secretary	
Sri Kriparam	Personal Secretary	
Sri Ajay K. Gaur	Personal Assistant	
Sri Sanjay Rajak	Assistant	
Sri D.K. Namdev	Assistant	
Smt. Neelam Swarnkar	Assistant	
Sri Arvind Yadav	Assistant	
Sri Faiyaz Khan	Assistant	
Smt. Shobita Pillai	Assistant	
Sri Amit Kumar	Assistant	
Sri R.K. Chhipa	Assistant	
Sri R.S. Negi	Assistant	
Sri Sanjay Kumar	Assistant	
Ms. Neha	Senior Clerk	
Sri Rajkumar	Senior Clerk	
Sri Uma Shankar	Senior Clerk	
Sri H.P. Khaddar	Gestetner Operator	
Ms. Renu Shah	Lower Division Clerk	
Ms. Monu Ahirwar	Lower Division Clerk	
Sri Jitendra Kushwaha	Lower Division Clerk	
Sri Bharat Singh	Lower Division Clerk	
Ms. Priyanka Prajapati	Lower Division Clerk	
Sri Vijay Kumar	Lower Division Clerk	Up to 16.09.2022
Sri Prashant Saxena	Lower Division Clerk	
Sri Yash Kapoor	Lower Division Clerk	
Ms. Sanjana Yadav	Lower Division Clerk	
Sri Brij Bihari	Lower Division Clerk	

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

Swachh Bharat Abhiyan

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एक कदम स्वच्छता की ओर

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भाकृअनुप ICAR

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