वार्षिक प्रतिवेदन
ANNUAL REPORT
2023

भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो
पूसा परिसर, नई दिल्ली–110 012
ICAR-National Bureau of Plant Genetic Resources
Pusa Campus, New Delhi - 110012

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ICAR-NBPGR Annual Report 2023

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CONTENTS

अधिदेश

कृषि–बागवानी फसलों के पादप आनुवंशिक और जीनोमिक संसाधनों का प्रबंधन और स्थायी उपयोग को बढ़ावा देना तथा संबंधित अनुसंधान करना

पादप आनुवंशिक संसाधन प्रबंधन और उनके उपयोग की पहुंच और लाभ साझाकरण को नियंत्रित करने वाले नीतिगत विषयों में समन्वयन और क्षमता निर्माण

कृषि–बागवानी फसलों की किस्मों की आणविक रूपरेखा तैयार करना और जीएम– पहचान प्रौद्योगिकी अनुसंधान करना

MANDATE

Management and promote sustainable use of plant genetic and genomic resources of agri-horticultural crops and carry out related research

Coordination and capacity building in PGR management and policy issues governing access and benefit sharing of their use

Molecular profiling of varieties of agri-horticultural crops and GM-detection technology research

प्रस्तावना

मुझे भा.कृ.अनु.प.–रा.पा.आनु.सं.ब्यू. की वार्षिक रिपोर्ट–2023 प्रस्तुत करते हुए खुशी हो रही है, जिसमें पीजीआर प्रबंधन के क्षेत्र में उपलब्धियां बताई गई हैं। हम अपने निर्धारित कार्यकलापों को पूरा करने में देश भर के संरक्षक किसानों और संरक्षकों के साथ–साथ सभी सहयोगी संगठनों के अपार योगदान की सराहना करते हैं।

2023 में, देश भर में कुल 21 अन्वेषण किए गए, जिसमें भारत के 13 राज्यों/केंद्र शासित प्रदेशों के 43 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों के जंगली रिश्तेदारों और अन्य आर्थिक प्रजातियों के 1,203 परिग्रहण एकत्र किए गए। एनबीपीजीआर ने 55,145 जननद्रव्य परिग्रहणों के आयात की सुविधा प्रदान की। फसल सुधार कार्यक्रमों में उपयोग के लिए देश के भीतर विभिन्न फसलों के कुल 12,129 नमूने आपूर्ति किए गए। विभिन्न कृषि और बागवानी फसलों के 5,538 जननद्रव्य परिग्रहणों के बीजों को दीर्घकालिक संरक्षण के लिए संसाधित किया गया (कुल 4,68,660 परिग्रहण)। इन विट्रो सक्रिय जीनबैंक और बेस जीनबैंक को क्रमशः 53 नए परिग्रहण (कुल 2,015 परिग्रहण) और 14 परिवर्धन (कुल 333 परिग्रहण) के द्वारा समृद्ध किया गया। क्रायोबैंक में बीज, भ्रूण अक्ष और पराग के रूप में 308 नए परिग्रहण संरक्षित किए गए (कुल संग्रह 12,944 परिग्रहण)। संगरोध मंजूरी के लिए 1,68,800 से अधिक आयातित जर्मप्लाज्म नमूने संसाधित किए गए। 57,074 निर्यात नमूनों को संसाधित किया गया और 55 फाइटोसैनिटरी प्रमाण पत्र जारी किए गए। कीट–मुक्त संरक्षण के लिए 10,000 से अधिक स्वदेशी रूप से एकत्रित या गुणित बीज सामग्री को संसाधित किया गया। विभिन्न कृषि–बागवानी फसलों के कुल 31,251 परिग्रहणों को कृषि–आकृति विज्ञान लक्षणों (14,325 परिग्रहण), जैविक दबाव (4,919), अजैविक दबाव (2,722) और गुणवत्ता मापदंडों (9,285) के लिए चिह्नित किया गया, जिसमें सीआरपी–एग्रोबायोडाइवर्सिटी परियोजना के तहत किए गए मूल्यांकन प्रयोग शामिल हैं। जीनोम–वाइड एसोसिएशन स्टडी (GWAS) का उपयोग करके विशेषता मानचित्रण अध्ययनों ने चावल में विभिन्न गुणवत्ता लक्षणों के लिए पुष्पन लक्षण के लिए मोथ बीन में चार जीनोमिक क्षेत्रय और अनाज के लक्षणों के लिए 11 क्यूटीएल और गेहूं में अंकुर और वयस्क पौधे के तने के प्रतिरोध के लिए 20 क्यूटीएल 20 क्यूटीएल की पहचान की। एसएसआर मार्करों के माध्यम से एक कुसुम कोर सेट (351 अभिगम) नामित किया गया और जीबीएस का उपयोग करके एक तिल कोर सेट (1193 अभिगम) का गठन किया गया। वैज्ञानिकों ने *सेसमम इंडिकम* (सीवी. स्वेता) जीनोम (290.64 एमबीपी), *ओरिजा मेयरियाना* अंत. *इंडेंडमैनिका क्लोरोप्लास्ट* जीनोम और ब्राउनटॉप बाजरा जीनोम का अनुक्रम किया।

वर्ष 2023 को अंतर्राष्ट्रीय श्री अन्न वर्ष के रूप में मनाया गया। IYoM2023 का जश्न मनाने के लिए, आईसीएआर–एनबीपीजीआर ने राष्ट्रीय जीन बैंक में संरक्षित श्री अन्न जननद्रव्य की विशेषता बताने के लिए एक विशेष अभियान शुरू किया। महाराष्ट्र के वाशिम स्थित कृषि अनुसंधान केंद्र में देशी (28 राज्यों/केंद्र शासित प्रदेशों से एकत्रित) और विदेशी संग्रह (51 देशों से) सहित ज्वार के जर्मप्लाज्म की कुल 24,950 किस्में लगाई गईं। 26 कृषि–आकृति विज्ञान लक्षणों के लिए ज्वार के जननद्रव्य का व्यापक लक्षण– निर्धारण आईसीएआर–एनबीपीजीआर–नई दिल्ली, आईसीएआर–आईआईएमआर–हैदराबाद, डॉ. पीडीकेवी–अकोला, आईसीएआर–एनबीपीजीआर–आरएस–अकोला और एआरएस–वाशिम द्वारा संयुक्त रूप से किया गया। 13 मार्च 2023 को ज्वार के जननद्रव्य पर फील्ड डे का आयोजन किया गया। राष्ट्रीय जीन बैंक से बार्नयार्ड बाजरा जननद्रव्य का पूरा सेट पहली बार आईसीएआर–एनबीपीजीआर में उगाया और प्रदर्शित किया गया। आईसीएआर–एनबीपीजीआर, फार्म ईसापुर में 16 अक्टूबर 2023 को बार्नयार्ड मिलेट फील्ड डे का आयोजन किया गया। 23 डिस्क्रिप्टर का उपयोग करके कृषि–आकृति विज्ञान संबंधी लक्षणों के लिए बार्नयार्ड मिलेट की कुल 1,888 प्रजातियों की पहचान की गई। विभिन्न संस्थानों के वैज्ञानिक और बाजरा शोधकर्ता, किसान और केवीके के कर्मचारी तत्काल उपयोग के लिए आनुवंशिक परिवर्तनशीलता का प्रत्यक्ष दृश्य प्राप्त करने के लिए इस कार्यक्रम में शामिल हुए। ब्राउन टॉप मिलेट, लिटिल मिलेट और कोदो मिलेट और प्रोसो मिलेट में विविधता दिखाने के लिए 13 अक्टूबर 2023 को भा.कृ.अनु.प.–रा.पा.आनु.सं.ब्यू., पूसा फार्म, नई दिल्ली में माइनर मिलेट डायवर्सिटी डे का आयोजन किया गया। 29 डिस्क्रिप्टर लक्षणों का उपयोग करके कृषि–आकृति विज्ञान संबंधी लक्षण वर्णन के लिए रबी 2023 के दौरान टीएनएयू, कोयंबटूर में राष्ट्रीय जीन बैंक से फिंगर मिलेट के लगभग 12,000 जननद्रव्य को रोपा गया।

ज्ञानेन्द्र प्रताप सिंह
निदेशक

FOREWORD

I am pleased to present the Annual Report -2023 of ICAR-NBPGR providing the achievements in the area of PGR management. We acknowledge the immense contribution of the custodian farmers and conservers across the country as well as all the collaborating organizations in accomplishing our mandated activities.

In 2023, a total of 21 explorations were undertaken across the country wherein 1,203 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 43 districts of 13 states/UT of India. NBPGR facilitated import of 55,145 germplasm accessions. A total of 12,129 samples of different crops were supplied within the country for utilization in crop improvement programmes. Seeds of 5,538 germplasm accessions of various agricultural and horticultural crops were processed for long-term conservation (total holding 4,68,660 accessions). *In Vitro* active genebank and base genebank were enriched by addition of 53 new accessions (total holding 2,015 accessions) and 14 additions (total 333 accessions) respectively. In the cryobank, 308 new accessions in the form of seeds, embryonic axes and pollen were conserved (total collection 12,944 accessions). More than 1,68,800 imported germplasm samples were processed for quarantine clearance. As many as 57,074 export samples were processed and 55 phytosanitary certificates were issued. More than 10,000 indigenously collected or multiplied seed material were processed for pest-free conservation. A total of 31,251 accessions of various agri-horticultural crops were characterized for agro-morphological traits (14,325 accessions), biotic stress (4,919), abiotic stress (2,722) and quality parameters (9,285) including evaluation experiments carried out under CRP-Agrobiodiversity project. NBPGR provided DNA fingerprinting service for 39 samples of 19 crops and GMO testing service for 53 samples of 21 consignments of various crops. Trait mapping studies using the genome-wide association study (GWAS) identified 20 QTN for various quality traits in rice; four genomic regions in moth bean for flowering trait; and 11 QTNs for grain characters and 20 QTLs for seedling and adult plant stem resistance in wheat. A safflower core set (351 accessions) was designated through SSR markers and a sesame core set (1193 accessions) was constituted using GBS. Scientists sequenced *Sesamum indicum* (cv. Sweta) genome (290.64 Mbp); *Oryza meyeriana* var. *indandamanica* chloroplast genome and Browntop millet genome.

Year 2023 was observed as the International Year of Millets. To celebrate IYoM2023, ICAR-NBPGR launched a special drive to characterize millet germplasm conserved in the National Genebank. A total of 24,950 accessions of sorghum germplasm, including indigenous (collected from 28 states/UT) and exotic collections (from 51 countries) were planted in Agricultural Research Station, Washim, Maharashtra. The comprehensive characterization of sorghum germplasm for 26 agro-morphological traits was jointly executed by ICAR-NBPGR-New Delhi, ICAR-IIMR-Hyderabad, Dr. PDKV-Akola, ICAR-NBPGR-RS-Akola, and ARS-Washim. Sorghum Germplasm Field Day was organized on March 13, 2023. The entire set of Barnyard millet germplasm from the National Genebank was grown and showcased for the first time at ICAR-NBPGR. Barnyard Millet Field Day was organized at ICAR-NBPGR, Farm Issapur, on October 16, 2023. A total of 1,888 accessions of Barnyard millet were characterized for agro-morphological traits using 23 descriptors. Scientists and millet researchers from various institutions, farmers, and KVK personnel attended this event to gain a firsthand view of the genetic variability for immediate utilization. Minor Millets Diversity Day was organized at ICAR-NBPGR, Pusa Farm, New Delhi on October 13, 2023 to showcase diversity in brown top millet, little millet and kodo millet and proso millet. Around 12,000 germplasm accessions of finger millet from the National Genebank were planted at TNAU, Coimbatore during rabi 2023 for agro-morphological characterization using 29 descriptor traits.

Gyanendra Pratap Singh
Director

Millets stakeholders: Director of NBPGR, ICRISAT researcher and millet curator at National Genebank with sorghum farmer

Sorghum Field Day, Washim: Director ICAR-NBPGR communicating to the farmers about the efforts of National Genebank in millet research

Barnyard Millet Field Day, Issapur: Director ICAR-NBPGR with millet researchers and farmers

Characterization of millet germplasm during International Year of Millets 2023

Director, ICAR-NBPGR interacting with farmers during barnyard millet field day, Issapur

Characterization of finger millet germplasm at Coimbatore

Characterization of millet germplasm during International Year of Millets 2023

कार्यकारी सारांश

जननद्रव्य अन्वेषण और संग्रहण

वर्ष 2023 में, देश भर में कुल 21 पादप अन्वेषण किए गए, जिसमें भारत के 12 राज्यों और एक केंद्र शासित प्रदेश (अरुणाचल प्रदेश, असम, बिहार, गुजरात, जम्मू और कश्मीर, मध्य प्रदेश, महाराष्ट्र, मेघालय, मिजोरम, नागालैंड, राजस्थान, सिक्किम, उत्तर प्रदेश और तमिलनाडु) के 43 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों के वन्य संबंधियों और अन्य आर्थिक प्रजातियों के 1,203 जननद्रव्य एकत्रित किए गए। इनमें से 555 परिग्रहणों को 11 पादप अन्वेषणों के माध्यम से, आईसीएआर–एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा एकत्रित किया गया। इसके अतिरिक्त, एक पादप अन्वेषण (अकोला) द्वारा 38 भूप्रजातियों और 21 फसल वन्य संबंधियों (सीडब्ल्यूआर) सहित 61 परिग्रहण एकत्र किए गए। तमिलनाडु के तिरुचिरापल्ली, पेरम्बलुर, अरियालुर और कुड्डालोर (हैदराबाद) से मोरिंगा के 50 जननद्रव्य नमूने, झारखंड (रांची) के गोड्डा से धान की 50 भूप्रजातियों, मेघालय और त्रिपुरा के चार जिलों से 12 जेनेरा और 13 प्रजातियों से संबंधित 58 परिग्रहण एकत्र किए गए। विभिन्न फसलों के 35 जननद्रव्य और दो महत्वपूर्ण बैंगन वन्य संबंधी– सोलनम इंडिकम और सोलनम एथियोपिकम को त्रिपुरा के खोवाई, धलाई और गोमती जिलों से एकत्रित किया गया। (शिमला), जम्मू के किश्तवाड़ एवं रामबन और रियासी जिलों के सुदूर मारवाह–वारवान क्षेत्र और एक कश्मीर (श्रीनगर) के बांदीपुर जिले की गुरेज घाटी से दो अन्वेषणों के माध्यम से 156 कृषि और 73 वन्य संबंधी सहित 229 जननद्रव्य परिग्रहण एकत्रित किए गए। पूर्वी घाट और तमिलनाडु (त्रिशूर) के कलक्कड़ मुंडनथुराई टाइगर रिजर्व से दो अन्वेषणों के माध्यम से मोटे आनाज, दालें, तिल और वन्य संबंधियों को एकत्रित किया गया। नेशनल हर्बेरियम ऑफ कल्टीवेटेड प्लांट्स (एनएचसीपी) नई दिल्ली में कुल 597 वानस्पतिक नमूने, 32 बीज नमूने/आर्थिक उत्पादों को सम्मिलित किया गया। बेस सेंटर, कटक में कुल 1,480 पौधों के वानस्पतिक नमूने संरक्षित किए जा रहे हैं, दो प्रकार के आइसोटाइप सेंट्रल नेशनल हर्बेरियम (सीएएल), बी. एस.आई., हावड़ा में जमा किए गए हैं और एक होलोटाइप सहित चार नमूने एनएचसीपी, नई दिल्ली में जमा किए गए हैं। आम (मैंगीफेरा इंडिका) की 2,917 परिग्रहणों का भू–संदर्भ और मानचित्रण पूरा किया गया।

पादप जनन द्रव्य विनिमय

आईसीएआर–एनबीपीजीआर अनुसंधान उद्देश्यों के लिए पादप जननद्रव्य के आयात, निर्यात और घरेलू आपूर्ति की सुविधा प्रदान करता है। 2023 में, 55,145 परिग्रहण (2,10,173 नमूने) आयातित किए गए, जिनमें जननद्रव्य के 43,319 परिग्रहण (49,148 नमूने) और परीक्षण के लिए सीजीआईएआर नर्सरी के 11,826 परिग्रहण (1,61,025 नमूने) शामिल थे और कुल 2,052 नमूने निर्यात किए गए। विभिन्न फसल सुधार कार्यक्रमों में उपयोग के लिए देश के भीतर उपयोगकर्ताओं को सामग्री हस्तांतरण समझौते (एमटीए) के तहत विभिन्न फसलों के कुल 12,129 नमूने आपूर्ति किए गए। इसके अलावा, 97,446 नमूने रूपात्मक लक्षण वर्णन और प्रारंभिक मूल्यांकन के लिए आपूर्ति किए गए।

जननद्रव्य संरक्षण

विभिन्न कृषि और बागवानी फसलों के 5,538 जननद्रव्य परिग्रहणों के बीजों को दीर्घकालिक संरक्षण (-18^0C) के लिए जीनबैंक मानकों का पालन करते हुए संशोधित किया गया, जिससे राष्ट्रीय जीनबैंक में संरक्षित कुल जर्मप्लाज्म की संख्या 4,68,660 हो गई। 7477 संरक्षित परिग्रहणों के बीजों के अंकुरण की जांच और बीज की मात्रा को अद्यतन किया गया। भौतिक सत्यापन के बाद 24,773 परिग्रहणों को बारकोड किया गया। अद्वितीय नवीन विशेषताओं वाले 126 जननद्रव्य परिग्रहणों को पंजीकरण प्रमाणपत्र प्रदान किए गए। राष्ट्रीय कृषि अनुसंधान प्रणाली में पहचानी गई 473 किस्मों/संकरों और उनकी मूल वंशावली के संरक्षण एवं विमोचन अधिसूचना के लिए प्राप्त बीजों के लिए विशिष्ट राष्ट्रीय आईडी के साथ प्रमाण पत्र जारी किए गए। इन विट्रो एक्टिव जीनबैंक (आईवीएजी) में 53 नए परिग्रहणों को जोड़ने के बाद, कुल आईवीएजी संग्रह की संख्या बढ़कर 2,015 हो गयी है जिन्हें 8–25 डिग्री सेल्सियस के भंडारण तापमान पर बनाए रखा जाता है और 1–24 महीने की अवधि में सब कल्चर किया जाता है। इसके अलावा, 2023 के दौरान इन विट्रो बेस जीनबैंक (आईवीबीजी) में 14 नए परिग्रहण जोड़े गए, जो कुल मिलाकर 333 परिग्रहणों तक पहुंच गई। इसी प्रकार, फलों, औद्योगिक फसलों, फलियां, मिल्लेट्स, चारा, सब्जियों और और जंगली प्रजातियों के बीज, भ्रूणीय अक्षों एवं परागकणों

के रूप में 308 नए परिग्रहण क्रायोजीनबैंक में जोड़े गए, जिससे इसकी कुल संख्या 12,944 परिग्रहणों तक पहुंच गई। इसके अलावा क्रायोजीनबैंक में 2,194 जीनोमिक संसाधनों को भी अनुरक्षित किया जा रहा है। वर्तमान में, आईसीएआर–एनबीपीजीआर के फील्ड जीनबैंक में 1,017 परिग्रहण (भोवाली), 598 (कटक), 2,204 (त्रिशूर), 1,126 (शिमला), रांची (684), 101 (ईसापुर) और 160 (श्रीनगर) परिग्रहण संरक्षित हैं। जीनबैंक से विभिन्न फसल प्रजातियों के 48 हजार, 5–5 हजार नई दिल्ली और अकोला से, 326 (भोवाली), 83 (कटक), 677 (हैदराबाद), 96 (शिलांग) और 533 (शिमला) परिग्रहण अनुसंधान के लिए वितरित किए गए। सहायक अनुसंधान के रूप में इन विट्रो में उगाए गए पौधों की आनुवंशिक अखंडता की पुष्टि, इन विट्रो गुणन और क्रायो–संरक्षण प्रोटोकॉल का विकास, धीमी वृद्धि मीडिया की स्थापना, बीज दीर्घायु लक्षणों का आणविक आनुवंशिक विश्लेषण, बीज छवियों से रंग के अर्ध–स्वचालित निर्धारण के लिए एक आर पैकेज ''सीडकलर'' का विकास किया गया।

पौध संगरोध और बीज स्वास्थ्य परीक्षण

कुल 1,68,800 आयातित जननद्रव्य नमूने (नई दिल्ली में 149K और हैदराबाद में 19K) और निर्यात नमूने (हैदराबाद में 54,242, नई दिल्ली में 2832) को संगरोध मंजूरी के लिए संसाधित किया गया और 55 फाइटोसैनिटरी प्रमाणपत्र जारी किए गए। उल्लेखनीय रूप से, 7,991 संक्रमित आयातित फसल जननद्रव्य नमूने बचाए गए और 53 संक्रमित नमूने खारिज कर दिए गए। इन अस्वीकृत नमूनों में ब्राजील (14) और चीन (4) से *टिलेटिया बार्कलेयाना* के कारण चावल के 18 नमूने, पेपर माइल्ड मोटल वायरस (पीएमएमओवी) और टोबैको माइल्ड ग्रीन मोजेक वायरस (टीएमजीएमवी) के कारण संयुक्त राज्य अमेरिका से 30 मिर्च, टोमैटो मोजेक वायरस (ToMV), टोमैटो मोटल मोजेक वायरस (ToMMV) और टोमैटो ब्राउन रूगोज फ्रूट वायरस (ToBFRV) के कारण टमाटर की 5 परिग्रहण, *पी. मैनशूरिका* से संक्रमित सोयाबीन के 10 परिग्रहण शामिल थे। विभिन्न देशों/स्रोतों से आयातित विभिन्न फलियों के विदेशी जननद्रव्य के 587 (नई दिल्ली) और 8,590 (हैदराबाद) नमूने प्रवेश के बाद के संगरोध ग्रीनहाउस में उगाए गए और वायरस से मुक्त पौधों की फसल मांगकर्ताओं को जारी की गई। बीज स्वास्थ्य परीक्षण के लिए, राष्ट्रीय जीनबैंक में कीट–मुक्त संरक्षण से पहले बीज स्वास्थ्य परीक्षण (एसएचटी) के लिए जननद्रव्य संरक्षण प्रभाग के माध्यम से कुल 10,252 स्वदेशी रूप से एकत्रित या प्रवर्धित बीज सामग्री प्राप्त हुई। एसएचटी के परिणामस्वरूप, 2447 नमूने कवक (270), कीट (1,522), नेमाटोड (574) और खरपतवार (81) से संक्रमित/दूषित पाए गए। इसके अलावा, 101 क्रायो नमूनों पर कार्रवाई की गई, जिनमें से दो फंगल रोगजनकों से संक्रमित थे और उन्हें बचा लिया गया। बीज स्वास्थ्य परीक्षण के लिए स्वदेशी रूप से विकसित जीई सरसों के बीज (4) और बीटी कपास के (60) नमूने प्राप्त हुए। तीन नमूनों में चेटोमियम एसपी., दो नमूनों मेंफ्यूसेरियम ऑक्सीस्पोरम और चार नमूनों में मेंक्लैडोस्पोरियम एसपीच पाया गया। स्वस्थ नमूनों को राष्ट्रीय जीनबैंक में संरक्षित किया गया हैं।

जननद्रव्य लक्षण वर्णन और मूल्यांकन

सीआरपी–एग्रोबायोडायवर्सिटी परियोजना के अन्तर्गत विभिन्न कृषि–बागवानी फसलों के कुल 31,251 परिग्रहणों को कृषि–रूपात्मक लक्षणों (14,325 परिग्रहण), जैविक तनाव (4,919), अजैविक तनाव (2,722) और गुणवत्ता मापदंडों (9,285) के लिए मूल्यांकन किया गया था। गेहूं (3,393), खेसारी (3,792), सांवा (1,888), ट्रिटिकेल (1,180), मिर्च (1,000), तिल (763), जंगली विग्ना (300), मूंग (400), रेपसीड और सरसों (400), आईसीएआर–एनबीपीजीआर, नई दिल्ली में अलसी (268), मक्का (200), सब्जीवाली लोबिया (197), सोयाबीन (89), बाकला (70) और कुट्टू (85) की पहचान की गई। विभिन्न जैविक दबावों के विरुद्ध कुल 4,919 परिग्रहणों का मूल्यांकन किया गया। इनमें स्पॉट ब्लॉच के लिए जौ कोर संग्रह के 678 परिग्रहण शामिल थे। एस्चोकाइटा ब्लाइट के लिए 100 जंगली चना परिग्रहण, और YMD प्रतिरोध के लिए 14 सोयाबीन परिग्रहण, डस्ट प्रतिरोध के लिए 111 मक्का परिग्रहण, chiLCD के लिए 180 मिर्च परिग्रहण, पौडेरी मिल्डेव के लिए 208 मटर परिग्रहण, अल्बुगो कैंडिडा के विभिन्न आइसोलेट्स के विरुद्ध 311 ब्रैसिका परिग्रहण। सफेद रतुआ रोग, चॉकलेट स्पॉट प्रतिरोध के लिए बाकला की 23 प्रविष्टियाँ। इसके अलावा, अलसी में बड फ्लाई टॉलरेंस (195) और अल्टरनेरिया ब्लाइट (244) के लिए संदर्भ सेट विकसित किए गए और हॉटस्पॉट स्थानों पर उनका मूल्यांकन किया गया। अजैविक दबाव सहनशीलता के लिए, गर्मी सहनशीलता के लिए ब्रैसिका (402), संयुक्त गर्मी और सूखा सहनशीलता के लिए जौ कोर संग्रह (678) और गेहूं (647), टर्मिनल ताप दबाव के लिए अलसी कोर संग्रह (259) सहित कुल 2,722 परिग्रहणों का मूल्यांकन किया गया। सूखा सहनशीलता के लिए अलसी संदर्भ सेट (200), लवणता सहनशीलता के लिए

मूंग कोर संग्रह (400) और जौ मिनी कोर संग्रह (110) और ठंड सहनशीलता के लिए मिर्च (26)। विभिन्न अनाजों (4,833), तिलहनों (2,425), फलियां (474), सब्जियों (578), फलों की कुल 8,556 प्रविष्टियाँ। (17) और संभावित फसलों (229) का मूल्यांकन महत्वपूर्ण जैव रासायनिक लक्षणों के लिए किया गया, जबकि फाइटोकेमिकल मूल्यांकन विभिन्न औषधीय और सुगंधित पौधों से संबंधित 318 परिग्रहणों के लिए किया गया। कृषि–जैव विविधता–पीजीआर घटक–II पर सीआरपी के तहत, रबी 2022–23 के दौरान कुल 455 गेहूं परिग्रहणों का मूल्यांकन जैविक तनाव के लिए किया गया और भारतीय सरसों के 1,000 परिग्रहणों का मूल्यांकन स्क्लेरोटिनिया और ओरोबंकी सहनशीलता के लिए किया गया। गुणवत्ता मानकों के लिए गेहूं के 411 परिग्रहणों का मूल्यांकन किया गया। इसके अतिरिक्त, विभिन्न फसलों से संबंधित कुल 10,413 जननद्रव्य परिग्रहण का लक्षण वर्णन अकोला (4,174), भोवाली (1,197), कटक (414), हैदराबाद (625), जोधपुर (1,892), रांची (90), शिलांग (917), शिमला (770), श्रीनगर (127) और त्रिशूर (207) द्वारा किया गया। एनबीपीजीआर वैज्ञानिकों ने 2023 के दौरान विभिन्न लक्षणों के लिए सात अद्वितीय जननद्रव्य पंजीकृत किए। संभावित फसलों को मुख्यधारा में लाने उद्देश्य से पीजीआर प्रबंधन (98), फसल सुधार (115), फसल उत्पादन (23), फसल सुरक्षा (14) और गुणवत्ता (45) के लिए कुल 276 प्रयोग आयोजित किए गए।

जीनोमिक संसाधन

जीनोम–वाइड एसोसिएशन स्टडी (जीडब्ल्यूएएस) दृष्टिकोण का उपयोग करके लक्षण मानचित्रण किया गया। चावल में गुणवत्ता गुणों के लिए जीडब्ल्यूएएस से सुगंध, हेड राइस रिकवरी (एचआरआर) और चॉकनेस (पीजीसी%) जैसे विभिन्न गुणवत्ता लक्षणों के लिए 20 क्यूटीएन की पहचान की गई। मोथ बीन में जीडब्ल्यूएएस से मल्टी–लोकस दृष्टिकोण का उपयोग करके 50% फूल विशेषता वाले दिनों पर महत्वपूर्ण फिनोटाइपिंग प्रभाव वाले चार जीनोमिक क्षेत्रों की पहचान की गई। गेहूं के मिनी कोर संग्रह में अनाज के आकार के लक्षणों के लिए जीडब्ल्यूएएस से, अनाज की लंबाई के लिए 4 चार अनाज की चौड़ाई और अनाज की चौड़ाई–लंबाई अनुपात के लिए क्रमशः एक–एक महत्वपूर्ण क्यूटीएन की पहचान की गई। गेहूं में एक अन्य एसोसिएशन मैपिंग अध्ययन में, 20 विश्वसनीय क्यूटीएल अंकुर और वयस्क पौधे के तने के प्रतिरोध से जुड़े पाए गए। कुसुम के 3115 एनजीबी परिग्रहण संग्रह से एसएसआर मार्कर्स का उपयोग करके एक कोर जर्मप्लाज्म सेट (351 परिग्रहण) की पहचान की गई। इसी प्रकार, सीसेमम में भी 3360 परिग्रहणों से एक कोर सेट (1,193 परिग्रहण) का गठन किया गया। सीसेमम इंडिकम (सीवी स्वेता) का ड्राफ्ट जीनोम 79 मचानों में 290.64 एमबीपी के आकार में इकट्ठा किया गया। क्रोमोसोम–स्तरीय क्लोरोप्लास्ट जीनोम को ओराइजा मेयेरियाना वार इंडंडमानिका के लिए इकट्ठा किया गया। एसएसआर मार्कर उत्पन्न करने के लिए ब्राउनटॉप बाजरा का संपूर्ण जीनोम अनुक्रमण किया गया। लुफा स्पीसीज में लिंकेज विश्लेषण तथा सीएल लोकस से 4.6 सीएम की दूरी पर फलने की विशेषता से जुड़े एक एसआरएपी मार्कर की पहचान की गई। अलसी में ट्रांस्क्रिप्टोम अध्ययन से फूल आने के समय के नियमन से जुड़े जीन की पहचान की गई। 19 फसलों के 39 नमूनों के लिए डीएनए फिंगरप्रिंटिंग सेवा प्रदान की गई। विभिन्न फसलों की 21 खेपों के 53 नमूनों के लिए जीएमओ परीक्षण सेवाएँ प्रदान की गईं।

EXECUTIVE SUMMARY

Germplasm Exploration and Collecting

In 2023, a total of 21 explorations were undertaken across the country wherein 1,203 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 43 districts of 12 states and one union territories of India (Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Rajasthan, Sikkim, Uttar Pradesh, and Tamil Nadu). Of these, 555 accessions were collected through 11 explorations undertaken by the ICAR-NBPGR Headquarter, New Delhi. Additionally, 61 accessions comprising 38 landraces and 21 crop wild relatives (CWR) collected in a single exploration (Akola); 50 *Moringa* germplasm samples in one exploration of Tamil Nadu from Tiruchirapalli, Perambalur, Ariyalurand Cuddalore (Hyderabad); 50 rice landraces in one exploration from Godda in Jharkhand (Ranchi); 58 accessions belonging to 12 genera and 13 species collected from four districts Meghalaya and Tripura across two explorations (Shillong); 35 germplasm of different crops and two important brinjal CWR—*Solanum indicum* and *Solanum aethiopicum* collected from Khowai, Dhalai and Gomati districts of Tripura (Shimla); 229 germplasm accessions comprising 156 cultivated and 73 CWR collected across two explorations in Jammu from remote Marwah-Warwan region of Kishtwar district and Ramban and Reasi districts, and one from Gurez valley of Bandipur districtin Kashmir (Srinagar); millets, pulses, sesame and CWR accessions from two exploration and collection trips covering the Eastern Ghats and Kalakkad Mundanthurai Tiger Reserve in Tamil Nadu (Thrissur). A total of 597 herbarium specimens, 32 seed samples/economic products were added to the National Herbarium of Cultivated Plants (NHCP)New Delhi. A total of 1,480 herbarium specimens are being preserved at Base Centre, Cuttack, two type specimens (isotypes) deposited at Central National Herbarium (CAL), B.S.I., Howrah and four specimens including one holotype are deposited at NHCP, New Delhi. Geo-referencing and mapping of 2,917 accessions of mango (*Mangifera indica*) was completed.

Germplasm Exchange

ICAR-NBPGR facilitates import, export and domestic supply of plant germplasm for research purposes. In 2023, 55,145 accessions (2,10,173 samples) were imported including 43,319 accessions (49,148 samples) of germplasm and 11,826 entries (1,61,025 samples) of CGIAR nurseries for trials. A total of 2,052 samples were exported. A total of 12,129 samplesof different crops were supplied under Material Transfer Agreement (MTA) to the users within the country for utilization in various crop improvement programmes. In addition, 97,446 samples were supplied for morphological characterization and preliminary evaluation.

Germplasm Conservation

Seeds of 5,538 germplasm accessions of various agricultural and horticultural crops were processed following genebank standards for long-term conservation (-18°C) thereby raising the total seed germplasm holding to 4,68,660. Monitoring of seed germination and updating of seed quantity was carried out in 7,477 conserved accessions. 24,773 accessions were barcoded after physical verification. 126 germplasm accessions with unique novel features were provided registration certificates whereas 473 varieties/ hybrids identified in the NARS were conserved and certified to facilitate their release and notification. 53 new accessions were added to the In Vitro Active Genebank thereby bringing the collection size to 2,015 accessions maintained at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months. 333 accessions are maintained in the In Vitro Base Genebank of which 14 accessions were added during 2023. Similarly, 308 new accessions in the form of seeds, embryonic axes and pollen were conserved in the cryobank bringing the total collection to 12,944 accessions. 2,194 genomic resources are also being maintained in the cryobank. At present, field genebanks of ICAR-NBPGR conserve 1,017 accessions (Bhowali), 598 (Cuttack), 2,204 (Thrissur), 1,126 (Shimla), Ranchi (684), 101 (Issapur) and 160 (Srinagar). As many as 48K accessions of different crop species from genebank, 5K each from New Delhi and Akola, 326 (Bhowali), 83 (Cuttack), 677 (Hyderabad), 96 (Shillong) and 533 (Shimla) were distributed for research. Supportive research included confirmation of genetic integrity of *in vitro* raised plants, developing *in vitro* multiplication and cryo-preservation protocols, establishing slow growth media, molecular genetic analysis of seed longevity traits, developing an R package "*seed colour*" for semi-automated determination of color from seed images, etc.

Plant Quarantine and Seed Health Testing

A total of 1,68,800 imported germplasm samples (149K at New Delhi and 19K at Hyderabad) and export samples (54,242 at Hyderabad; 2832 at New Delhi) were processed for quarantine clearance and 55 Phytosanitary Certificates were issued. Notably, 7,991 infected/ infested import crop germplasm samples were salvaged and 53 infected samples were rejected. These rejected samples included 18 samples of rice due to *Tilletia barclayana* from Brazil (14) and China (4); 30 chilli accessions from the USA due to Pepper Mild

Mottle Virus (PMMoV) and Tobacco Mild Green Mosaic Virus (TMGMV); 5 accessions of tomato due to Tomato Mosaic Virus (ToMV), Tomato Mottle Mosaic Virus (ToMMV) and Tomato Brown Rugose Fruit Virus (ToBFRV); 10 accessions of soybean infected with *P. manshurica*. As many as 587 (New Delhi) and 8,590 (Hyderabad) samples of exotic germplasm of different legumes imported from different countries/ sources were grown in post-entry quarantine greenhouses and the harvest of the plants free from viruses was released to the indenters. For seed health testing, a total of 10,252 indigenously collected or multiplied seed material were received through the Division of Germplasm Conservation for seed health testing (SHT) before pest-free conservation in the National Genebank. As a result of SHT, 2,447 samples were found infected/ infested/ contaminated with fungi (270), insect pests (1,522), nematodes (574) and weeds (81). In addition, 101 cryo samples were processed of which two were infected with fungal pathogens and were salvaged. Samples of indigenously developed GE mustard seed (4 samples) and Bt cotton samples (60 samples) were received for seed health testing. *Chaetomium sp*. was detected in three, *Fusarium oxysporum* was detected in two and *Cladosporium sp*. was detected in four accessions. The samples were released for conservation in National Genebank.

Germplasm Characterization and Evaluation

A total of 31,251 accessions of various agri-horticultural crops were characterized for agro-morphological traits (14,325 accessions), biotic stress (4,919), abiotic stress (2,722) and quality parameters (9,285) including evaluation carried out under CRP-Agrobiodiversity project. Wheat (3,393), grass pea (3,792), barnyard millet (1,888), triticale (1,180), chilli (1,000), sesame (763),wild *Vigna* (300), mungbean (400), rapeseed and mustard (400), linseed (268), maize (200) vegetable cowpea (197), soybean (89), fababean (70) and buckwheat (85) were characterized at ICAR-NBPGR, New Delhi. A total of 4,919 accessions were evaluated against various biotic stresses. These comprised 678 accessions of barley core collection for spot blotch, 100 wild *Cicer* sp. accessions for *Aschochyta blight*, 400 accessions of mungbean core collection and 14 soybean accessions for YMD resistance, 111 maize lines for MLB resistance, 180 chilli accessions for chiLCD, 208 garden pea accessions for powdery mildew, 311 brassica accessions against diverse isolates of *Albugo candida* causing white rust disease, 23 entries of fababean for chocolate spot resistance. In addition, reference sets for bud fly tolerance (195) and *Alternaria blight* (244) in linseed were developed and evaluated at hot spot locations. For abiotic stresses tolerance, a total of 2,722 accessions were evaluated including *Brassica* (402) for heat tolerance, barley core collection (678) and wheat (647) for combined heat and drought tolerance, linseed core collection (259) for terminal heat stress, linseed reference set for drought tolerance (200), mungbean core collection (400) for salinity tolerance, barley min core collection (110) for salinity stress and chilli (26) for cold tolerance. A total of 8,556 accessions of different cereals (4,833), oilseeds (2,425), legumes (474), vegetables (578), fruit sp. (17) and potential crops (229) were evaluated for important biochemical traits, while phytochemical evaluation was done for 318 accessions belonging to different medicinal and aromatic plants. Under CRP on Agro-biodiversity-PGR Component- II, a total of 455 wheat accessions were evaluated during *rabi* 2022-23 for biotic stresses (yellow, black, brown rusts and powdery mildew) and 1,000 accessions of Indian mustard germplasm were evaluated for *Sclerotinia* rot resistance and *Orobanche* tolerance and 411 accessions of wheat were evaluated for quality parameters. Pre-breeding for genetic base enhancement was done in flax. Additionally, characterization of a total of 10,413 germplasm accessions belonging to various crops was done by Akola (4,174), Bhowali (1,197), Cuttack (414), Hyderabad (625), Jodhpur (1,892), Ranchi (90),Shillong (917), Shimla (770), Srinagar (127) and Thrissur (207). NBPGR scientists registered as many as sevenunique germplasm during 2023 for various traits. As part of mainstreaming potential crops, a total of 276 experiments comprising of 10 potential crops were organized for PGR management (98), crop improvement (115), crop production (23), crop protection (14) and quality (45).

Genomic Resources

Trait mapping using the genome-wide association study (GWAS) approach was carried out. GWAS in rice identified 20 QTN for various quality traits such as aroma, head rice recovery (HRR), and chalkiness (PGC %). In moth bean, GWAS identified four genomic regions with significant phenotypic effects on days to 50% flowering trait. GWAS for grain shape traits in the mini core collection of wheat identified six QTNs, four for grain length and one each for grain width and grain width-length ratio. In another association mapping study in wheat, 20 QTLs were found to be associated with seedling and adult plant stem resistance. A core germplasm set of safflower (351 accessions) was designated through SSR markers. Sesamum core set (1193 accessions) was constituted using GBS. A draft genome of *Sesamum indicum* (cv. Sweta) was assembled in 79 scaffolds to a size of 290.64 Mbp. Chromosome-level chloroplast genome was assembled for *Oryza meyeriana* var. *ind andamanica*. Browntop millet was sequenced to generate SSR markers. Linkage analysis in *Luffa sp*. identified SRAP markers linked to the fruiting trait at a distance of 4.6 cM from the *Cl* locus. Transcriptome study in linseed identified genes associated with flowering time regulation. DNA fingerprinting service was provided for 39 samples of 19 crops. GMO testing services were provided for 53 samples of 21 consignments of different crops.

परिचय

भारतीय कृषि अनुसंधान परिषद (आईसीएआर) ने 1976 में आईसीएआर–नेशनल ब्यूरो ऑफ प्लांट जेनेटिक रिसोर्सेज (आईसीएआर–एनबीपीजीआर) की स्थापना की, जिसका मुख्यालय नई दिल्ली में है। ब्यूरो भारत में एक नोडल संगठन है, जिसके पास पौधों की खोज और संग्रह, लक्षण वर्णन से संबंधित सभी गतिविधियों की योजना बनाने, संचालित करने, बढ़ावा देने और समन्वय करने तथा फसल पौधों और उनकी वन्य प्रजातियों में स्वदेशी और शामिल आनुवंशिक परिवर्तनशीलता दोनों के सुरक्षित संरक्षण और वितरण के लिए राष्ट्रीय अधिदेश है। इसे आयात परमिट और फाइटोसैनिटरी प्रमाणपत्र जारी करने और विदेशों से लाए गए या अनुसंधान उद्देश्य (ट्रांसजेनिक सामग्री सहित) के लिए निर्यात किए गए सभी बीज सामग्री और पौधे के प्रसार पर संगरोध जांच करने का अधिकार भी निहित है।

संगठनात्मक व्यवस्था

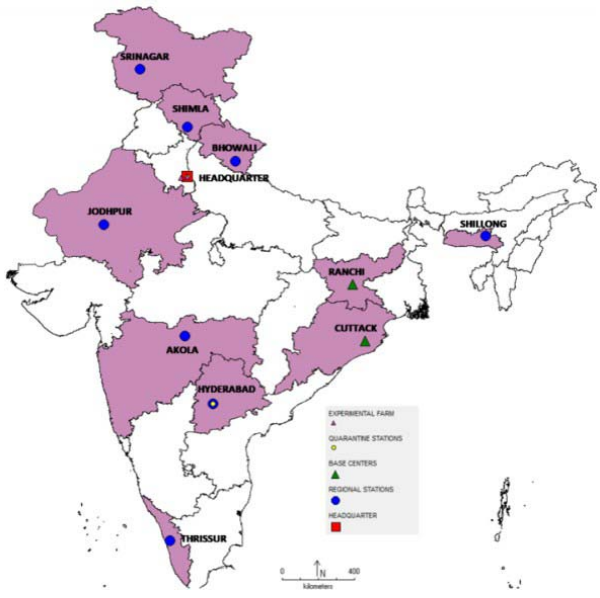
निदेशक, आईसीएआर–एनबीपीजीआर प्रशासन, अनुसंधान प्रबंधन और समन्वयन के लिए सक्षम प्राधिकारी हैं। संस्थान प्रबंधन समिति, अनुसंधान सलाहकार समिति, फसल सलाहकार समितियां और संस्थान अनुसंधान परिषद पीजीआर प्रबंधन में महत्वपूर्ण सलाहकारी भूमिका निभाते हैं। ब्यूरो अपने पांच मुख्य प्रभागों के माध्यम से कार्य करता है. अर्थात i) पादप अन्वेषण और जननद्रव्य संग्रह, ii) पादप संगरोध, iii) जननद्रव्य मूल्यांकन, iv) जननद्रव्य संरक्षण और v) जीनोमिक संसाधन और इकाइयों में, जननद्रव्य विनिमय एवं पॉलिसी (GEPU), टिशू कल्चर और क्रायोप्रिजर्वेशन (टी. सी.सी.यू.), पीजीआर नीति (पी.पी.यू.), कृषि ज्ञान प्रबंधन (एकेएमयू) और संस्थान प्रौद्योगिकी प्रबंधन (आईटीएमयू)। देश की विभिन्न कृषि पारिस्थितिकी स्थितियों में पीजीआर प्रबंधन के अधिदेश को पूरा करने के लिए ब्यूरो के पास 10 क्षेत्रीय केन्द्र का नेटवर्क है। इसके अतिरिक्त, 40 हेक्टे, इस्सापुर गांव (दिल्ली से लगभग 45 किमी पश्चिम) में प्रायोगिक फार्म मुख्यालय में अनुसंधान आवश्यकताओं को पूरा करता है। ब्यूरो का प्रमुख फसल– आधारित संस्थानों, राष्ट्रीय अनुसंधान केंद्रों, अखिल भारतीय समन्वित फसल सुधार परियोजनाओं, राज्य कृषि विश्वविद्यालय और अन्य हितधारकों के साथ मजबूत संबंध है।

आईसीएआर–एनबीपीजीआर द्विपक्षीय/बहुपक्षीय समझौतों के तहत विकसित समझौता ज्ञापनों और कार्य योजनाओं के माध्यम से कई अंतरराष्ट्रीय संस्थानों/संगठनों के साथ निकट सहयोग में भी काम करता है। ब्यूरो न केवल कृषि उत्पादकता और इसकी गुणवत्ता बढ़ाने के लिए चल रहे फसल सुधार कार्यक्रमों को आनुवंशिक संसाधन प्रदान करता है, बल्कि भविष्य की पीढ़ियों की जरूरतों को पूरा करने के लिए उन्हें सुरक्षित रूप से संरक्षित भी करता है। सहायक सेवाओं में प्रशासन, खरीद, भंडारण, रखरखाव, लेखा परीक्षा और लेखा तथा पुस्तकालय की इकाइयां शामिल हैं।

संस्थान के क्षेत्रीय केंद्र अकोला, भोवाली, कटक, हैदराबाद, जोधपुर, रांची, शिलांग, शिमला, श्रीनगर और त्रिशूर में स्थित हैं। इसमें संभावित फसलों पर एक अखिल भारतीय समन्वित अनुसंधान नेटवर्क परियोजना भी है।

राष्ट्रीय जीनबैंक

नेशनल जीनबैंक, आईसीएआर–एनबीपीजीआर, नई दिल्ली की स्थापना बीज, वनस्पति प्रोपग्यूल्स, ऊतक कोशिका संवर्धन, भ्रूण, युग्मक आदि के रूप में जननद्रव्य संग्रह की राष्ट्रीय विरासत को संरक्षित करने के लिए की गई थी। कोल्ड स्टोरेज



क्षेत्रीय स्टेशनों का एनबीपीजीआर नेटवर्क

सुविधा यूके के सहयोग से शुरू की गई थी। वर्ष 1983 में और उसके बाद, रूढ़िवादी प्रजातियों के बीजों को संरक्षित करने के लिए चार दीर्घकालिक भंडारण मॉड्यूल (100 मी^{3} की दो इकाइयों और 176 मी^{3} क्षमता की दो इकाइया) के साथ संवर्धित किया गया था। वानस्पतिक रूप से प्रचारित क्लोनल सामग्री और अड़ियल बीज जननद्रव्य को टिशू कल्चर और क्रायो रिपॉजिटरी के माध्यम से बनाए रखा जा रहा है और क्षेत्र की स्थितियों के तहत इसके रखरखाव की व्यवस्था की जा रही है।

वर्ष 1997 में शुरू की गई राष्ट्रीय जीनबैंक सुविधा में 13 मॉड्यूल हैं, जिनमें से प्रत्येक में बीज के आकार के आधार पर 50,000 से 76,000 नमूनों की भंडारण क्षमता है। इनमें से एक मॉड्यूल का उपयोग सक्रिय जर्मप्लाज्म संग्रहों के मध्यम अवधि ा भंडारण माध्यम के लिए किया जाता है और शेष दीर्घकालिक भंडारण के लिए। इसकी क्रायोप्रिजर्वेशन सुविधा में छह तरल नाइट्रोजन टैंक (क्रायो–टैंक) हैं, जिनमें से प्रत्येक में 1,000 लीटर तरल नाइट्रोजन है। इन छह क्रायो–टैंकों में 0.25 मिलियन नमूने संग्रहीत करने की क्षमता है। इस प्रकार, नेशनल जीनबैंक की कुल क्षमता 0.85 से 1.25 मिलियन नमूने संग्रहीत करने की है। एनजीबी के उन्नयन के लिए नए मॉड्यूल शामिल किए गए हैं।

भारतीय राष्ट्रीय पादप आनुवंशिक संसाधन प्रणाली (INPGRS)

आईसीएआर–एनबीपीजीआर राष्ट्रीय बेस संग्रहण (आईसीएआर– एनबीपीजीआर में दीर्घकालिक भंडारण के तहत रखा गया) को विभिन्न फसलों के लिए जिम्मेदार 59 राष्ट्रीय सक्रिय जननद्रव्य साइटों जहां जननद्रव्य संग्रह का मूल्यांकन एवं संवर्धन किया जाता है, के साथ जोड़ते हुए देश की पादप जननद्रव्य प्रणाली का सदृढ़ करना है। विभिन्न फसलों के लिए अनुसंधान सलाहकार समिति और जननद्रव्य सलाहकार समितियां ब्यूरो को अपनी सेवाओं की क्षमता, दक्षता और प्रभावशीलता में सुधार के संबंध में सलाह देती हैं।

संभावित फसलों पर अखिल भारतीय समन्वित अनुसंधान नेटवर्क

कम उपयोग वाली फसलों के महत्व को देखते हुए, उनके संग्रह, परिचय, मूल्यांकन और उपयोग पर काम 70 के दशक के अंत में आईसीएआर–आईएआरआई, नई दिल्ली में शुरू किया गया था और बाद में इस गतिविधि को देश के अन्य अनुसंधान केंद्रों तक बढ़ा दिया गया था। इन फसलों के सुधार और उपयोग पर वैज्ञानिक प्रयासों को मजबूत और सुसंगत बनाने के लिए, 1982 में छठी पंचवर्षीय योजना के दौरान आईसीएआर–एनबीपीजीआर, नई दिल्ली में मुख्यालय के साथ कम उपयोग और कम दोहन वाले पौधों पर एक अखिल भारतीय समन्वित अनुसंधान परियोजना स्थापित की गई थी। दसवीं पंचवर्षीय योजना के दौरान, इस परियोजना को नेटवर्क मोड में लाया गया और इसका नाम बदलकर अल्प उपयोगी फसलों पर अखिल भारतीय समन्वित अनुसंधान नेटवर्क (एआईसीआरएनयूसी) कर दिया गया। इसके अलावा, बारहवीं योजना के दौरान इसका नाम बदलकर संभावित फसलों पर अखिल भारतीय समन्वित अनुसंधान नेटवर्क (एआईसीआरएनपीसी) कर दिया गया। AICRNPC के उद्देश्य हैं:

i. भोजन, चारा, ईंधन, फाइबर, ऊर्जा और औद्योगिक उपयोग के नए पौधों के स्रोतों का पता लगाना और उन्हें डोमेस्टिकेट करना
ii. उपल का जननद्रव्य और उनकी वन्य प्रजातियों को एकत्रित / शामिल करना और उनका लक्षण–वर्णन करना
iii. इन नए पौधों के बेहतर जीनोटाइप की पहचान करना और विभिन्न कृषि जलवायु क्षेत्रों के लिए उन्नत किस्मों का विकास करना।

ग्यारहवीं योजना तक, नेटवर्क 14 एसएयू केंद्रों, आईसीएआर–एनबीपीजीआर के क्षेत्रीय केन्द्रों के छह सहयोगी केंद्रों और 17 पौधों की प्रजातियों पर अनुसंधान गतिविधियों को कवर करने वाले तीन स्वैच्छिक केंद्रों पर काम कर रहा था। बारहवीं योजना में, उत्तर बंगाल में राइसबीन और बकव्हीट जैसी महत्वपूर्ण फसलों के लिए आवश्यक तकनीकी सहायता प्रदान करने के लिए एक नया केंद्र यूबीकेवी, कूच बिहार (पश्चिम बंगाल) जोडा गया था। इसके अलावा, सात नए स्वैच्छिक केंद्र जोड़े गए हैं जैसे एनईएच क्षेत्र के लिए आईसीएआर अनुसंधान परिसर, शिलांग के साथ–साथ छह राज्यों (सिक्किम, अरुणाचल प्रदेश, नागालैंड, मणिपुर, त्रिपुरा और मिजोरम) में स्थित इसके छह केंद्र।

अंतरराष्ट्रीय सहयोग

एनबीपीजीआर आईसीएआर और बायोवर्सिटी इंटरनेशनल के बीच समझौता ज्ञापन के तहत विकसित कार्य योजनाओं को लागू करता है। एफएओ और बायोवर्सिटी इंटरनेशनल द्वारा प्रायोजित दक्षिण एशिया और आसपास के क्षेत्रों में कृषि महत्व की स्थानीय फसलों के आनुवंशिक संसाधनों के संरक्षण और

उपयोग पर क्षेत्रीय प्रशिक्षण पाठ्यक्रम आईसीएआर–एनबीपीजीआर द्वारा आयोजित किए जाते हैं।

बायोवर्सिटी इंटरनेशनल के साथ मिलकर काम करने के अलावा आईसीएआर–एनबीपीजीआर ICRISAT, IRRI, ICARDA और CIMMYT जैसे अंतर्राष्ट्रीय कृषि अनुसंधान केंद्रों के साथ भी सक्रिय रूप से सहयोग करता है। इसने 80 से अधिक देशों के साथ पादप जननद्रव्य का आदान–प्रदान किया है और द्विपक्षीय, क्षेत्रीय और अंतर्राष्ट्रीय समझौतों के तहत विकसित कार्य योजनाओं को लागू किया है।

प्रशिक्षण कार्यक्रम और सूचना सेवाएँ

ब्यूरो पीजीआर के संग्रह, विनिमय, संगरोध/जैव सुरक्षा, बायोसेफटी, जैव सूचना विज्ञान, डीएनए फिंगरप्रिंटिंग, मूल्यांकन, दस्तावेजीकरण और संरक्षण के लिए वैज्ञानिक प्रक्रियाओं पर ध्यान केंद्रित करते हुए प्रशिक्षण कार्यक्रम आयोजित करता है। आईसीएआर–एनबीपीजीआर समय–समय पर वार्षिक रिपोर्ट और न्यूजलेटर (त्रैमासिक) निकालता है। इसके अलावा, फसल सूची और जर्मप्लाज्म रिपोर्टर भी प्रकाशित किए जाते हैं। प्रौद्योगिकी प्रगति के साथ, पीजीआर के कुशल उपयोग के लिए ब्यूरो द्वारा पीजीआर प्रबंधन और पहुंच से संबंधित विभिन्न डेटाबेस और ऐप विकसित किए गए हैं।

मुख्यालय में ब्यूरो का पुस्तकालय पादप आनुवंशिक संसाधनों से संबंधित जानकारी में विशेषज्ञता रखता है और विशेष रूप से पीजीआर से संबंधित विभिन्न विदेशी और राष्ट्रीय पत्रिकाओं की सदस्यता लेता है।

पुस्तकालय और दस्तावेजीकरण सेवाएँ

एनबीपीजीआर के पास पादप आनुवंशिक संसाधन प्रबंधन पर एक समर्पित पुस्तकालय है और इसका उपयोग सभी कर्मचारियों और छात्रों द्वारा नियमित रूप से किया जाता है। पुस्तकालय ने पुस्तकों और पत्रिकाओं के अधिग्रहण, साहित्य के आदान–प्रदान, पुस्तकालय संग्रह डेटाबेस के विकास, संचलन, संदर्भ सेवाओं और दस्तावेजीकरण की अपनी निर्दिष्ट सेवाओं और गतिविधियों को बनाए रखा। एनबीपीजीआर लाइब्रेरी आईसीएआर–सीईआरए कंसोर्टियम के सदस्यों में से एक है जो क्षेत्रीय स्टेशनों से पत्रिकाओं और डेटाबेस तक ऑनलाइन पहुंच की सुविधा भी प्रदान करती है। पीजीआर और उससे संबंधित विषयों पर समाचार पत्र कतरन सेवाएँ पाठकों को नियमित रूप से प्रदान की गई। रिपोर्ट के तहत वर्ष के दौरान, पीजीआर प्रबंधन और कृषि के विभिन्न पहलुओं से संबंधित 115 पुस्तकें खरीद और विनिमय के आधार पर पुस्तकालय संग्रह में जोड़ी गईं। मुख्यालय और क्षेत्रीय स्टेशनों पर पाठकों को नए आगमन की एक मासिक सूची भी प्रसारित की गई। लाइब्रेरी को विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय संगठनों से 110 प्रकाशन निःशुल्क प्राप्त हुए हैं।

स्नातकोत्तर शिक्षण कार्यक्रम

शैक्षणिक सत्र 1997 से, ब्यूरो पादप आनुवंशिक संसाधनों में स्नातकोत्तर शिक्षण का कार्य कर रहा है, जिससे एम.एससी. पोस्ट ग्रेजुएट स्कूल, आईएआरआई, नई दिल्ली से संबद्ध डिग्री प्रदान की जाती है। शैक्षणिक सत्र 2004–2005 से, पीएच.डी. डिग्री प्रोग्राम पोस्ट ग्रेजुएट स्कूल, आईएआरआई, नई दिल्ली द्वारा शुरू किया गया था। पीजी स्कूल आईएआरआई के 62वें दीक्षांत समारोह में सात एम.एससी. और ग्यारह पीएच.डी. के विद्यार्थियों को डिग्री प्रदान की गई। वर्तमान में, 8 एम.एस.सी. एवं 24 पीएच.डी. सहित कुल 32 छात्र नामांकित हैं।

पीजीआर जागरूकता के लिए विस्तार सेवाएँ

ब्यूरो रबी और खरीफ फसलों के लिए किसान दिवस/क्षेत्र दिवस आयोजित करता है और फसल उगाने और पीजीआर के प्रबंधन के लिए तकनीकी जानकारी पर प्रासंगिक साहित्य के साथ बीजरोपण सामग्री वितरित करता है। गांवों में जैव विविधता मेलों का आयोजन करके जमीनी स्तर के श्रमिकों, आदिवासी लोगों और किसानों (विशेषकर महिलाओं) के बीच पीजीआर जागरूकता पैदा करने पर विशेष जोर दिया जाता है। शैक्षणिक दौरों पर छात्र पीजीआर पर जानकारी हासिल करने के लिए नई दिल्ली के मुख्य परिसर में स्थित राष्ट्रीय जीनबैंक, डीएनए फिंगरप्रिंटिंग, टिशू कल्चर और संगरोध प्रयोगशालाओं, प्लांट संगरोध ग्लासहाउस/कंटेनमेंट सुविधाओं आदि का दौरा करते हैं।

INTRODUCTION

Indian Council of Agricultural Research (ICAR) established the ICAR-National Bureau of Plant Genetic Resources, (ICAR-NBPGR) in 1976 with its headquarter at New Delhi. The Bureau is the nodal organization in India with the national mandate to plan, conduct, promote and coordinate all activities concerning plant exploration and collection, characterization and also for safe conservation and distribution of both indigenous and introduced genetic variability in crop plants and their wild relatives. It is also vested with the authority to issue Import Permit and Phytosanitary Certificate and conduct quarantine checks on all seed materials and plant propagules introduced from abroad or exported for research purpose (including transgenic material).

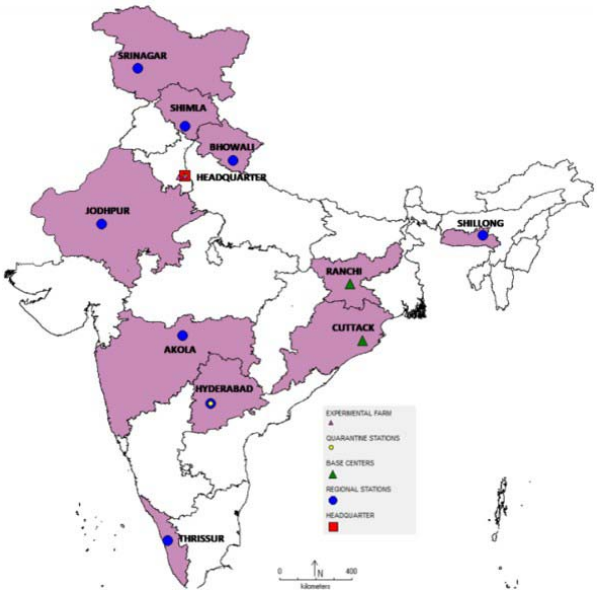
Organizational Set-up

The Director, ICAR-NBPGR is the competent authority for administration, research management and coordination. The Institute management committee, Research advisory committee, Crop advisory committees and the Institute research council play important advisory roles in PGR management. The Bureau functions through its five main divisions, namely i) Plant Exploration and Germplasm Collection, ii) Plant Quarantine, iii) Germplasm Evaluation, iv) Germplasm Conservation and v) Genomic Resources and Units viz., Germplasm Exchange and Policy Unit (GEPU), Agricultural Knowledge Management (AKMU) and Institute Technology Management Unit (ITMU).

The Bureau has a network of 10 RS / BCs to fulfill the mandate of PGR management across different agro-ecological conditions of the nation. Besides, 40 hectares experimental farm at Issapur village (about 45 km west of Delhi) caters to the research requirements at HQ. It has strong linkages with leading crop-based Institutes, National Research Centres, All India Coordinated Crop Improvement Projects, State Agricultural Universities and other stakeholders. ICAR-NBPGR also works in close collaboration with several international institutes/ organizations through memoranda of understanding/and work plans developed under bilateral/ multilateral agreements. The Bureau not only provides genetic resources to on-going crop improvement programmes to enhance agricultural productivity and its quality, but also conserves them safely to meet the needs of future generations. Supportive services include units of administration, purchase, stores, maintenance, audit and accounts and library. Regional Stations/ Base Centres of the institute are located at Akola, Bhowali, Cuttack, Hyderabad, Jodhpur, Ranchi, Shillong, Shimla, Srinagar and Thrissur. It also houses an All India Coordinated Research Network Project on Potential Crops.

National Genebank

The National Genebank, ICAR-NBPGR, New Delhi was established to conserve national heritage of germplasm collections in the form of seeds, vegetative propagules, tissue/ cell cultures, embryos, gametes, etc. The cold storage facility was initiated with the support of UK wayback in 1983 and later, was augmented with four long-term storage modules (two units of 100 m^3 and two of 176 m^3 capacity) to conserve seeds of orthodox species. Vegetatively propagated clonal materials and recalcitrant seeds germplasm are being maintained through tissue culture and cryo repositories and backed up with its maintenance under field conditions. The National Genebank facility commissioned in 1997 has 13 modules, each with a storage capacity of 50,000 to 76,000 samples depending upon the size of seeds. One of these modules is used for medium term storage of active germplasm collections and the rest for long- term storage. Its cryopreservation facility contains six liquid nitrogen tanks (cryo-tanks), each containing 1,000 litres of liquid nitrogen.



NBPGR network of regional stations

These six cryo-tanks have a capacity to store 0.25 million samples. Thus, the National Genebank has a total capacity to store 0.85 to 1.25 million samples. New modules have been commissioned for upgradation of the NGB.

Indian national plant genetic resources system (INPGRS)

ICAR-NBPGR strengthens the national PGR system by linking the National Base Collection (kept under long-term storage at ICAR-NBPGR) with 59 National Active Germplasm Sites responsible for different crops where germplasm collections are evaluated and multiplied under field conditions, backed by medium-term storage facilities. The Research Advisory Committee and Germplasm Advisory Committees for different crops advise the Bureau regarding improving the capability, efficiency and effectiveness of its services.

All India coordinated research network on potential crops

In view of the importance of underutilized crops, the work on their collection, introduction, evaluation and utilization was initiated at ICAR-IARI, New Delhi during late 70's and the activity was later extended to other research centres in the country. In order to strengthen and harmonize the scientific efforts on improvement and utilization of these crops, an All India Coordinated Research Project on Underutilized and Underexploited Plants was established in 1982 during VI Five Year Plan with its Headquarters at the ICAR-NBPGR, New Delhi. During the X Five Year Plan, this project was brought into a network mode and was renamed as All India Coordinated Research Network on Underutilized Crops (AICRNUC). Further, during the XII Plan it was re-named as All India Coordinated Research Network on Potential Crops (AICRNPC). The objectives of the AICRNPC are:

i. To explore and domesticate new plant sources of food, fodder, fuel, fibre, energy and industrial uses
ii. To collect/ introduce and characterize available germplasm and its wild relatives
iii. To identify superior genotypes of these new plants and to develop improved varieties for different agro-climatic regions.

Until XI Plan, the network was working at 14 SAU centres, six cooperating centers of ICAR-NBPGR Regional Stations and three voluntary centers covering research activities on 17 plant species. In the XII Plan, a new centre UBKV, Cooch Behar (West Bengal) was added for providing necessary technical back stopping for important crops in North Bengal such as ricebean and buckwheat. Further, seven new voluntary centres have been added such as ICAR Research Complex for NEH Region, Shillong along with its six centres located in six states (Sikkim, Arunachal Pradesh, Nagaland, Manipur, Tripura and Mizoram).

International collaboration

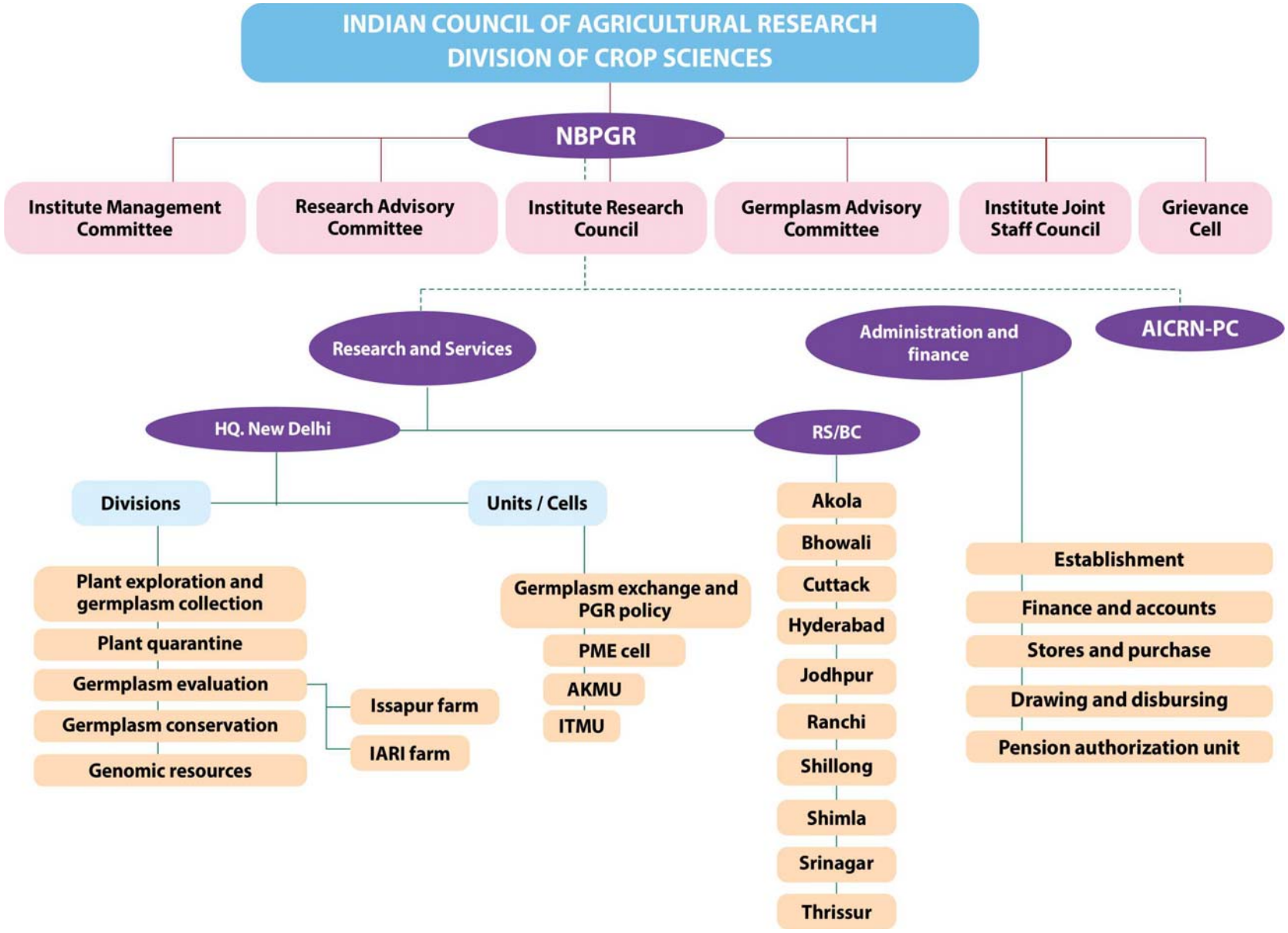
NBPGR implements work plans developed under MoU between ICAR and Bioversity International. Regional training courses on conservation and utilization of genetic resources of local crops of agricultural importance in South Asia and adjoining regions sponsored by FAO and Bioversity International are organized by ICAR- NBPGR. Besides working closely with Bioversity International, ICAR-NBPGR also collaborates actively with the International Agricultural Research Centers like ICRISAT, IRRI, ICARDA and CIMMYT. It has exchanged plant germplasm with more than 80 countries and implements work plans developed under bilateral, regional and international agreements.

Training programmes and information services

The Bureau organizes training programmes focusing on scientific procedures for collection, exchange, quarantine/ biosecurity, biosafety, bioinformatics, DNA fingerprinting, evaluation, documentation and conservation of PGR. ICAR-NBPGR brings out annual report and Newsletter (quarterly) periodically. Besides, Crop catalogues and germplasm reporter are also published. With the technology advancement, various databases and apps related to PGR management and access are developed by the Bureau for efficient utilization of PGR. Bureau's library at headquarters is specialized in information dealing with plant genetic resources and subscribes to various foreign and national journals particularly related to PGR.

Library and documentation services

NBPGR has a dedicated library on plant genetic resource management and is being used by all staff and students regularly. The library maintained its designated services and activities of acquisition of books and journals, exchange of literature, development of library collection database, circulation, reference services and documentation. NBPGR library is one of the members of ICAR- CeRA Consortium that facilitates online access to the journals and databases from NBPGR HQ and Regional Stations as well. Newspaper clipping services on PGR and its related subjects were provided to readers regularly. During the year under report, 155 books related to various aspects of PGR management, agriculture and Hindi literature were added to the library collections



Organogram of ICAR-NBPGR

through purchase and exchange basis. A monthly list of new arrivals was also circulated to readers at the headquarters and regional stations. Library has received 110 publications as gratis from various national and international organizations.

Post-graduate teaching programme

Since academic session 1997, Bureau has been undertaking post-graduate teaching in plant genetic resources leading to M.Sc. degree affiliated to Post Graduate School, IARI, New Delhi. From the academic session 2004-2005, Ph.D. degree programme was started by the Post Graduate School, IARI, New Delhi. Seven M.Sc. and elevan Ph.D. students were awarded degree in 62nd Convocation of P G School IARI. Currently, a total of 32 students including 8 M.Sc. and 24 Ph.D. are on rolls.

Extension services for PGR awareness

The Bureau organizes Kisan Diwas/field days for Rabi and Kharif crops and distributes seeds/ planting material along with relevant literature on technical know-how for raising crops and management of PGR. Special emphasis is given to create PGR awareness among grass-root level workers, tribal people, and farmers (particularly women) by organizing biodiversity fairs in villages. Students on educational tours visit the National Genebank, DNA fingerprinting, tissue culture and quarantine labs, plant quarantine glass houses/ containment facilities etc. located in the main campus at New Delhi to gain insights on PGR.

1 DIVISION OF PLANT EXPLORATION AND GERMPLASM COLLECTION

सारांशः वर्ष 2023 में, देश भर में कुल 21 पादप अन्वेषण किए गए, जिसमें भारत के 13 राज्यों और एक केंद्र शासित प्रदेश (अरुणाचल प्रदेश, असम, बिहार, गुजरात, जम्मू और कश्मीर, मध्य प्रदेश, महाराष्ट्र, मेघालय, मिजोरम, नागालैंड, राजस्थान, सिक्किम, उत्तर प्रदेश और तमिलनाडु) के 43 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों के वन्य सम्बन्धियो और अन्य आर्थिक प्रजातियों के 1,203 जननद्रव्य एकत्रित किए गए। इनमें से 555 परिग्रहणों को 11 पादप अन्वेषणों के माध्यम से, आईसीएआर–एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा एकत्रित किया गया। नेशनल हर्बेरियम ऑफ कल्टीवेटेड प्लांट्स (एनएचसीपी) नई दिल्ली मे कुल 597 वानस्पतिक नमूने, 32 बीज नमूने/आर्थिक उत्पादों को सम्मिलित किया गया। आम (*मैंगीफेरा इंडिका*) की 2,917 परिग्रहणों का भू–संदर्भ और मानचित्रण पूरा किया गया। टीएसपी उप–योजना के तहत आदिवासी कृषक समुदायों के पोषण और आजीविका सुरक्षा के लिए पीजीआर संरक्षण जागरूकता कार्यक्रम (2) और जैव विविधता मेले भी आयोजित किए गए थे।

Summary: In 2023, a total of 21 explorations were undertaken across the country wherein 1203 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 43 districts of 13 states and one union territories of India (Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Uttar Pradesh, and Tamil Nadu). Of these, 555 accessions were collected through 11 explorations undertaken by the ICAR-NBPGR Headquarters, New Delhi. A total of 597 herbarium specimens, 32 seed samples/economic products were added to the National Herbarium of Cultivated Plants (NHCP). Geo-referencing and mapping of 2,917 accessions of mango (*Mangifera indica*) was completed. PGR conservation awareness programmes (2) and biodiversity fairs for nutritional and livelihood security of tribal farming communities were also organized under Tribal Sub-plan (TSP).

1.1. Plant Exploration and Germplasm Collection

During the report period, a total of 21 explorations were carried out involving 12 collaborators from the NARS system and collected 1203 accessions of different agri-horticultural crops and their wild relatives from 43 districts covering 13 states and one union territories of India (Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tamil Nadu and Uttar Pradesh). These collections consist diversity in 263 species (cultivated 895 acc.; 74% and wild species 308 acc.; 26%) belonging to 11 crop-groups (Table. 1.1 & Fig. 1.1). Emphasis was mainly given in collecting of germplasm of crop wild relatives, minor fruits/wild edibles, unattended species and named landraces from various diversity-rich, remote/ tribal inhabited, disturbed and under-explored areas covering Assam, Arunachal Pradesh, Jammu & Kashmir, Manipur, Mizoram, Nagaland, Rajasthan, Tripura, Sikkim and Uttar Pradesh. Of these, 781 accessions were sent to Germplasm Handling Unit (GHU) for conservation, while the remaining were sent for multiplication and maintence in National Active Germplasm Sites (NAGS). Details of germplasm of different crops, species and CWR collected and explorations conducted by ICAR-NBPGR and its regional stations/base centers are given in (Tables 1.1 & 1.2).

Table 1.1: Explorations undertaken and germplasm collected

Headquarters/Station/Centre	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	1	38	23	61
Bhowali	1	7	43	50
Hyderabad	1	47	03	50
New Delhi (HQ)	11	432	123	555
Shillong	2	76	05	81
Srinagar	3	158	71	229
Thrissur	2	137	40	177
Total	**21**	**895**	**308**	**1203**

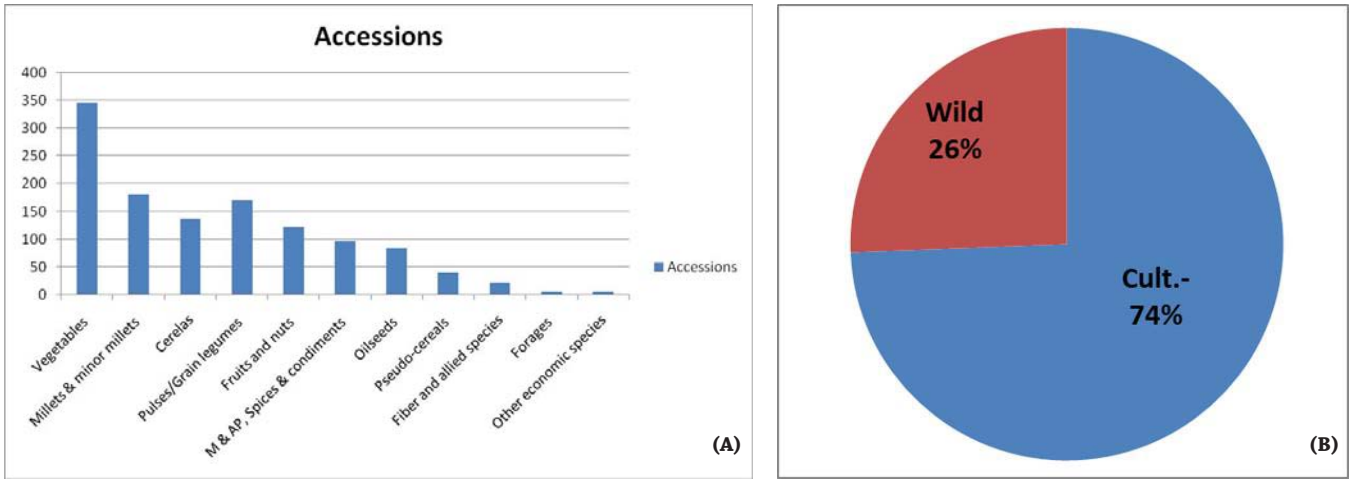


Fig.1.1. Germplasm collected across different crop groups (A); Percent share of cultivated and wild accessions in total germplasm collection (B)

Table 1.2: Crops, species germplasm collected in different crop-groups

Crop-groups (accs.)	Species (accessions)
Cereals (137)	*Avena sativa* (1), *Coix lacryma-jobi* (11), *Elymus caninus* (1), *E. nutans* (2), *E. semicostatus* (2), *Hordeum vulgare* (8), *Oryza nivara* (6), *O. rufipogon* (21), *O. sativa* (48), *O. sativa* var. *spontanea* (11), *Triticum aestivum* (7), and *Zea mays* (19)
Pseudo-cereals (40)	*Amaranthus caudatus* (10), *A. cruentus* (5), *A. dubius* (2), *A. hybridus* (1), *A. tricolor* (1), *A. tristis* (1), *A. tuberculatus* (1), *Chenopodium album* (9), *C. foliosum* (1), and *Fagopyrum tataricum* (9)
Millets & minor millets (182)	*Brachiaria ramosa* (2), *Echinochloa crus-galli* (1), *E. frumentacea* (17), *Eleusine coracana* (22), *E. indica* (1), *Panicum miliaceum* (16), *P. sumatrense* (30), *Paspalum scrobiculatum* (10), *Pennisetum glaucum* (12), *Setaria italica* (55), *S. pumila* (1), *Sorghum bicolor* (12), and *S. propinquum* (1)
Pulses (170)	*Cajanus albicans* (1), *C. cajan* (11), *C. platycarpus* (1), *C. scarabaeoides* (4), *Cicer arietinum* (2), *Dolichos lablab* (1), *Dunbaria ferruginea* (1), *Lathyrus sativus* (12), *Lens culinaris* (9), *Macrotyloma uniflorum* (15), fodder *Phaseolus lunatus* (8), *Vigna mungo* (2), *P. vulgaris* (37), *Vigna aconitifolia* (1), *V. angularis* var. *nipponensis* (3), *V. dalzelliana* (1), *Vigna mungo* (9), *V. radiata* (5), *V. sahyadriana* (8), *V. sublobata* (7), *V. trilobata* (1), *V. umbellata* (13), and *V. unguiculata* (19)
Oilseeds (84)	*Brassica juncea* (2), *B. nigra* (3), *B. rapa* var. *yellow sarson* (4), *B. rapa* var. *brown sarson* (4), *Glycine max* (16), *Guizotia abyssinica* (7), *Helianthus annuus* (1), *Linum perenne* (1), *L. usitatissimum* (8), *Perilla frutescens* (12), *Sesamum indicum* (23), *S. laciniatum* (1), and *S. indicum* rusep *Malabarium* (2).
Fiber and allied species (22)	*Corchorus aestuans* (1), *C. capsularis* (3), *C. fascicularis* (1), *C. olitorius* (3), *C. trilocularis* (1), *Crotalaria assamica* (2), *C. juncea* (1), *C. pallida* (3), *Hibiscus cannabinus* (1), *H. lunarifolius* (1), *H. sabdariffa* (2), *Sesbania cannabina* (1), and *S. sesban* (2)
Fruits and nuts (122)	*Actinidia callosa* (1), *Annona squamosa* (9), *Berberis lycium* (1), *Carissa carandas* (1), *Choerospondias axillaris* (3), *Citrus aurantifolia* (14), *C. macrophylla* (1), *C. reticulata* (6), *C. sinensis* (25), *Corylus jacquemontii* (1), *Cotoneaster integerrimus* var. *nummularius* (2), *Crataegus songarica* (3), *Diospyros kaki* (1), *Docynia indica* (2), *Dimocarpus longan* (1), *Elaeagnus indica* (1), *Eriobotrya angustissima* (2), *E. japonica* (1), *Feronia limonia* (1), *Fragaria vesca* (1), *Garcinia gummi-gutta* (1), *Hippophae rhamnoides* subsp. *turkestanica* (1), *H. salicifolia* (1), *Lilium polyphyllum* (1), *Litsea citrata* (1), *Mimusops elengi* (1), *Phoebe cooperiana* (1), *Physalis alkekengi* (1), *P. minima* (1), *Prunus cornuta* (3), *Ribes acuminatum* (1), *R. glaciale* (2), *R. griffithii* (2), *R. luridum* (1), *R. nigrum* (1), *Rubus acuminatus* (1), *R. calycinoides* (1), *R. calycinus* (1), *R. ellipticus* (1), *R. fruticosus* (1), *R. kumaonensis* (1), *R. macilentus* (1), *R. paniculatus* (2), *R. rugosus* (1), *R. sikkimensis* (2), *R. saxatilis* (1), *R. treutleri* (1), *R. ulmifolius* (3), *Spondias pinnata* (1), *Schisandra grandiflora* (1), *Syzygium gardneri* (1), *S. caryophyllatum* (1), and *S. zeylanicum* (1).

Crop-groups (accs.)	Species (accessions)
Vegetables (346)	*Abelmoschus esculentus* (5), *A. ficulneus* (2), *A. manihot* var. *pungens* (2), *A. manihot* var. *tetraphyllus* (1), *A. tuberculatus* (1), *Allium auriculatum* (2), *A. cepa* (1), *A. chinense* (3), *A. consanguineum* (9), *A. fasciculatum* (3), *A. hookeri* (2), *A. prattii* (2), *A. sikkimense* (4), *A. spicatum* (1), *A. tuberosum* (1), *A. victorialis* (3), *A. wallichii* (4), *Benincasa hispida* (3), *Brassica juncea* var. *rugosa* (2), *B. oleracea* (1), *Capsicum annuum* (10), *C. chinense* (1), *C. frutescens* (11), *Coccinia grandis* (1), *Cucumis maderaspatanus* (1), *C. melo* var. *agrestis* (3), *C. melo* (2), *C. melo* var. *momordica* (6), *C. sativus* (17), *C. sativus* var. *hardwickii* (4), *C. sikkimensis* (1), *C. triogonus* (3), *Cucurbita maxima* (3), *C. moschata* (5), *Cyclanthera pedata* (3), *Dioscorea oppositifolia* (2), *D. pentaphylla* (1), *Gymnopetalum cochinchinense* (33), *Herpetospermum operculatum* (1), *Lablab purpureus* (1), *Lagenaria siceraria* (5), *Luffa acutangula* (8), *L. aegyptiaca* (4), *L. cylindrica* (4), *L. hermaphrodita* (4), *Lycopersicon esculentum* (2), *Momordica balsamina* (3), *M. charantia* (1), *M. charantia* var. *muricata* (3), *M. dioica* (5), *M. subangulata* (1), *Moringa oleifera* (49), *M. concanensis* (3), *Pachyrhizus erosus* (1), *Praecitrullus fistulosus* (2), *Pisum arvense* (2), *P. sativum* (7), *Psophocarpus tetragonolobus* (1), *Solanum aethiopicum* (6), *S. betaceum* (4), *S. chrysotrichum* (1), *S. coagulens* (1), *S. giganteum* (1), *S. incanum* (2), *S. indicum* (2), *S. insanum* (1), *S. lycopersicum* var. *cerasiforme* (2), *S. macrocarpon* (1), *S. melongena* (9), *S. nigrum* (2), *S. pseudocapsicum* (1), *S. torvum* (2), *S. trilobatum* (1), *S. tuberosum* (1), *S. viarum* (1), *S. violaceum* (6), *S. vagum* (1), *S. viarum* (6), *S. violaceum* (2), *S. virginianum* (1), *Spinacia oleracea* (2), *Trichosanthes anamalaiensis* (1), *T. bracteata* (2), *T. cucumerina* (5), *T. khasiana* (2), *T. wallichiana* (1), *Vicia faba* (6), and *Zehneria maysorensis* (1)
Medicinal and aromatic plants, spices and condiments (97)	*Alstonia venenata* (1), *Abrus precatorius* (2), *Aconitum heterophyllum* (1), *Acorus calamus* (1), *Allium sativum* (4), *Alpinia officinarum* (1), *A. malaccensis* (1), *Anethum graveolens* (1), *Angelica glauca* (1), *Antedesma bunius* (1), *Arisotolochia indica* (1), *Atropa belladonna* (2), *Arivella viscosa* (3), *Bacopa monnieri* (1), *Bistorta amplexicaulis* (1), *Cinnamomum malabathrum* (1), *C. filipedicellatum* (1), *Clitoria ternatea* (1), *Coriandrum sativum* (2), *Curcuma longa* (1), *C. aromatica* (1), *Digitalis lanata* (1), *Dioscorea deltoidea* (6), *D. oppositifolia* (1), *Diplocyclos palmatus* (1), *Elaeocarpus ganitrus* (1), *Heracleum candicans* (1), *Hyoscyamus niger* (3), *Kedrostis rostrata* (1), others dye *Lilium polyphyllum* (1), *Malva verticillata* (1), *Meistera acuminata* (1), *M. cannicarpa* (2), *Murraya koenigii* (4), *Nicandra physalodes* (1), *Ocimum americanum* (2), *O. basilicum* (1), *O. tenuiflorum* (5), *Piper argyrophyllum* (3), *P. attenuatum* (1), *P. peepuloides* (1), *P. galeatum* (1), *P. schmidtii* (1), *Podophyllum hexandrum* (4), *Polygonatum verticillatum* (1), *Rauvolfia tetraphylla* (1), *Rosa beggeriana* (2), *R. canina* (3), *R. macrophylla* (1), *Saussurea costus* (3), *Taxus wallichiana* (1), *Trigonella foenum-graecum* (2), others dye *Withania somnifera* (1), *Zanthoxylum armatum* (2), and *Z. rhetsa* (1)
Forages (5)	*Lathyrus aphaca* (1), *Lupinus angustifolius* (1), *Vicia sativa* (2), and *Tripsacum laxum* (1)
Other economic species (6)	Others dye *Bentinckia condapanna* (1), *Jasminum calophyllum* (1), *J. cordatum (1), J. coarctum* (1), and *Michelia champaca* (1)

1.2. Explorations undertaken and germplasm collected by the Headquarters

Eleven explorations were undertaken in parts of Arunachal Pradesh, Assam, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Nagaland, Rajasthan, and Uttar Pradesh and 555 accessions (cultivated: 432 and wild species: 123) were collected in different agri-horticultural crops (Table 1.3).

1.2.1. Grasspea and linseed germplasm from parts of Bihar

In this exploration, a total of 50 germplasm samples which included grasspea (12), lentil (9), faba bean (7), field pea (5), linseed (5), paddy (4), mungbean (2), pigeonpea (4) and others (3) were collected from the Madhubani, Sitamarhi and Darbhanga districts of Bihar. Good variability was observed in grasspea for biomass, plant type, earliness, and seeds per pod. In surveyed areas, tremendous potential of *Lathyrus* as leafy vegetable was observed, as it is grown at largescale for consumption and sold in local markets, as source of income. Farmers cultivating grass pea, lentil and linseed by broadcasting seeds since long-back. The leaves of *Coccinea indica*, a wild species is used in preparation of local snacks named "*Tilkor kachri*" in these three districts of Bihar (Fig. 1.2).

1.2.2. Minor fruits and CWR germplasm from Rajasthan

In an exploration to parts of Sirohi, Pali, Udaipur, Rajsamand, Chittorgarh districts of Rajasthan, a total of 39 accessions comprising of *Annona squamosa* (9), *Cucumis melo* var. *momordica* (4), *Momordica dioica* (4), *Cucumis trigonus* (3), *Momordica balsamina* (3), *Cucumis callosus* (2), *Cucumis sativus* (2), *Momordica charantia* var. *muricata* (2) and others (10) were collected. Variability was observed for fruit size, shape and colour of *Annona squamosa* (Fig. 1.3).

Table 1.3: Explorations undertaken and germplasm collected by the ICAR-NBPGR, Headquarters

Sl. No.	Crops collected	Districts, state and period	No. of Accessions			Collaborating Institute/ SAU
			Cult.	Wild	Total	
1	Multi-crops	Sitamarhi, Madhubani, Darbhanga (Bihar), 20-26 March, 2023	49	01	50	
2	Fruits, M&AP and Vegetables	Sirohi, Pali, Udaipur, Rajsamand, Chittorgarh (Rajasthan), 28 Aug.- 4 Sept., 2023	13	26	39	MPUAT, Udaipur
3	Citrus spp.	Ahmednagar, Jalna, Akola (Maharashtra) 18-26 Sept., 2023	45	-	45	MPKV Rahuri, SORS, Badnapur, PDKV, Akola
4	Millets and minor millets	Alirajpur, Badwani (Madhya Pradesh) 23- 30 Sept., 2023	53		53	KVK, Alirajpur, KVK, Badwani
5	Multi-crops	Tuensang, Noklak (Nagaland) 4-13 Oct., 2023	70	3	73	
6	Multi-crops	Chandauli (Uttar Pradesh) 17-22 Oct., 2023	22	9	31	KVK, Chandauli
7	Coix and vegetables	Kohima, Phek, Kiphire, Zunheboto (Nagaland) 11-20 Oct., 2023	66	15	81	KVK Phek, Kiphire, Kiphire and Zunheboto
8	Multi-crops and vegetables	Seoni, Balaghat (Madhya Pradesh) Gondia (Maharashtra) 31 Oct.-9 Nov., 2023	53	11	64	ICAR-IIVR Varanasi
9	Multi-crops amd minor millets	Ballia, Mirzapur, Sonbhadra (Uttar Pradesh) 2-10 Nov., 2023	42	14	56	KVK Mirzapur
10	Multi-crops	Lakhimpur, Dhemaji (Assam) Papumpare, Kamle (Arunachal Pradesh) 16-24 Nov., 2023	19	14	33	
11	Wild rice	Sonitpur, Biswanath Chariali (Assam) 24 Nov. -2 Dec., 2023	-	30	30	
		Total	**432**	**123**	**555**	

Fig.1.2. Variability in seed shape, size and colour of grasspea (a); and habitat of grasspea (b)

Fig. 1.3. Fruits, seeds and leaves of *Momordica balsamina* (a); and habitat of *Momordica dioica* (b)

1.2.3. Citrus germplasm from parts of Maharashtra

A total of 45 diverse germplasm of citrus comprising of *Citrus sinensis* (25), *C. aurantifolia* (13), *C. reticulata* (6) and *C. macrophylla* (1) were collected from parts of Ahmednagar, Jalna and Akola districts of Maharashtra. Variability was observed for fruit size, shape and colour of *Citrus aurantifolia*. Also, rich variability was observed in *Citrus sinensis* for fruit size and shape (oblong, oval) and colour at maturity (light yellow, yellow, light brown and orange) (Fig. 1.4).

1.2.4. Small millets germplasm from parts of Madhya Pradesh

Exploration was conducted for collection of small millets, a total of 53 germplasm samples of minor millets comprising *Setaria italica* (14), *Panicum miliaceum* (6), *P. sumatrense* (11), *Paspalum scrobiculatum* (6), *Echinochloa frumentacea* (5), *Eleusine coracana*, (3) and others (8) were collected from parts of Alirajpur and Badwani districts of Madhya Pradesh. Significant variability was observed in foxtail millet, barnyard millet, and snap melon. In foxtail millet, variability was observed for grain colours (yellowish/straw colour, pinkish/reddish), panicle size and length and in grain size (medium and bold); in snap melon for fruit colour (whitish yellow, cream, light yellow, yellowish with strips), flash thickness, color and fruit weight (ranged from 2-5kg) (Fig. 1.5).

1.2.5. Multi-crop germplasm from remote districts of Nagaland

Exploration was conducted for collection of multi-crops (except rice and maize) in parts of Tuensang and Noklak districts of Nagaland. During exploration, a total of 73 germplasm samples comprising of *Setaria italica* (13), *Phaseolus vulgaris* (9), *Perilla frutescens* (6), *Glycine max* (6), *Chenopodium album* (5), *Coix lacryma-jobi* (4), *Capsicum* spp. (4), *Brassica* spp. (3), *Cucurbita maxima* (3), *Panicum miliaceum* (3), *Vigna umbellata* (2) and others (16) were collected. Significant diversity was observed in coix, French bean, soybean, chilli and pumpkins. Variability was observed in

Fig. 1.4. *Citrus sinensis* in orchards

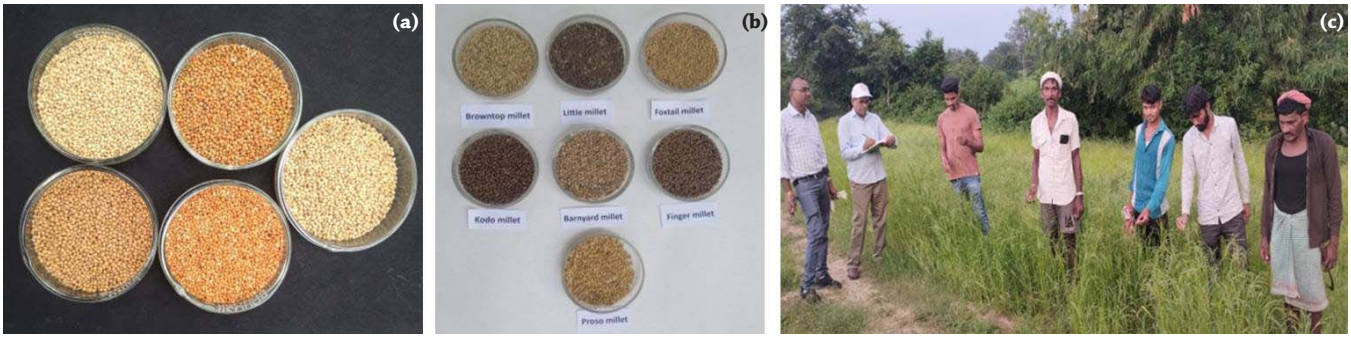
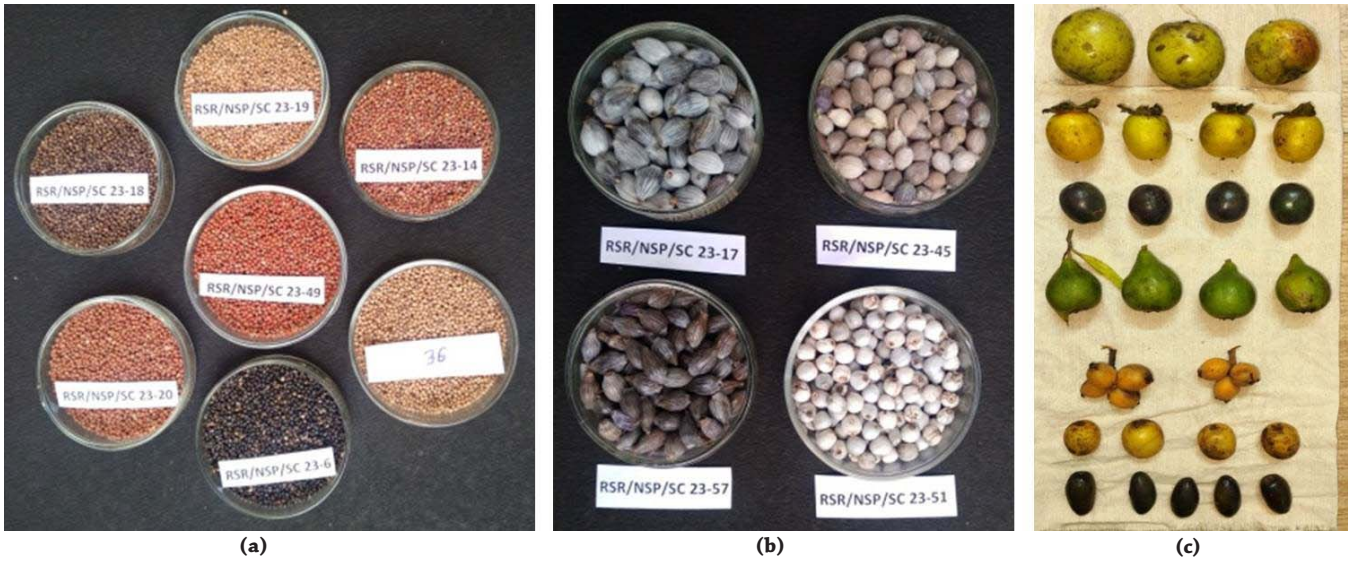


Fig. 1.5. Variability in grain colour, shape and size of foxtail millet (a); different small millets (b); and data recording on little millet field in Chandpur, Kathiwara in Alirajpur (c)

foxtail millet for grain size and colour (straw, yellow, red, and black) and panicle size. In French bean, variability was observed for seed colour (red, grey, brown, white and mottled), size (small, medium, bold) and shape (kidney and round shaped). In pumpkin, variability was observed for fruit shape (spherical, round, flask shape, cylindrical, and curved type), weight (1.0- 6.0kg) and colour (light yellow, yellow, light brownish, greenish yellow) at maturity. In chilli, variability was observed for fruit size, shape and colour. Germplasm of minor fruits (*Choerospondias axillaris, Diospyros kaki, Docynia indica, Eriobotrya japonica* etc.) was also collected during survey (Fig. 1.6).

1.2.6. Multi-crop and CWR germplasm from remote districts of Nagaland

In another exploration to parts of Phek, Kiphire and Zunheboto districts of Nagaland, a total of 81 accessions comprising of *Setaria italica* (9), *Coix-lacryma jobi* (6), *Perilla frutescens* (5), *Solanum violaceum* (5), *Sesamum indicum* (3), *Allium chinense* (3), *Abelmoschus manihot* var. *tetraphyllus* (2), *Capsicum annuum* (2), *Glycine max* (2), *Brassica juncea* var. *rugosa* (2), *Phaseolus vulgaris* (2), *Vigna umbellata* (2), *Solanum aethiopicum* (2) and others (36) were collected. Variability was observed in *Perilla*, *Glycine max,* French bean, and job's tear for maturity duration (early and late), plant height, seed shape, size and colour. Interesting variability was observed in seed colour (brown, black and golden yellow) of foxtail millet (*Setaria italica*), and seed size (small and bold types), shape (round/lens shape) and colour (white and creamy white) of soyabean. Generally in Nagaland the grains of job's tear are roasted and kernels consumed as snacks, while Chakhesang and Pochurys tribes use their grain for brewing purposes (Fig. 1.7).



(a) (b) (c)

Fig. 1.6. Seed variability in foxtail (a) millet and coix (b); minor & wild fruits from top to below lines are *Docynia indica, Diospyros kaki, Phoebe cooperiana, Caryodaphnopsis tonkensis, Eriobotryia japonica, Choerospondias axillaris* and *Phoebe cooperiana* (c)

Fig.1.7. *Vigna angularis* var. *nipponensis* plant at flowering (a); and green pods (b); fruits of *Momordica subangulata* subsp. *subangulata* (c)

1.2.7. Multi-crop germplasm from Chandauli district, Uttar Pradesh

Thirty-one accessions comprising of *Pisum sativum* (3), *Sesamum indicum* (3), *Corchorus olitorius* (2) *Hordeum vulgare* (2), *Linum usitatissimum* (2), *Luffa cylindrica* (2), *L. hermaphrodita* (2), *Oryza nivara* (2), *Pisum arvense* (2), *Zea mays* (2) and others (9) were collected from Chandauli district of Uttar Pradesh. Variability was observed for fruit size and shape of *Luffa* and *Momordica* spp., seed size and colour of field-pea. Unique collections include, red wheat, muthiya maize, bhuteyia field pea, white and black seeded sesame, yellow and black mustard landraces, wild bitter gourd, sponge gourd and chilli. The occurrence of *Luffa hermaphrodita* was abundant and used as vegetable, their transitions of fruits from wild to semi-domesticated stage with variability in its fruit size was collected. Variability was recorded for crop maturity (early and late), plant height, seed shape, size and colour of *Sesamum indicum* and *Zea mays*. Population of wild rice (*Oryza nivara*) was found in low lying, swampy areas, uncultivated lands and forests, mostly in Chakiaya, Sahabganj, Naugarh and Dhanapur blocks (Fig. 1.8).

1.2.8. Multi-crop germplasm from parts of Madhya Pradesh and Maharashtra

Sixty-four accessions comprising of *Macrotyloma uniflorum* (6), *Solanum melongena* (6), *Vigna unguiculata* (5), *Sesamum indicum* (4), *Ocimum tenuiflorum* (3), *Phaseolus lunatus* (3), *Vigna umbellata* (3), *Abelmoschus esculentus* (2), *Brassica rapa* subsp. *toria* (2), *Cicer arietinum* (2), *Corchorus capsularis* (2), *Lagenaria siceraria* (2), *Luffa aegyptiaca* (2), *Trichosanthes cucumerina* (2) and others (20) were collected from parts of Seoni, Balaghat (Madhya Pradesh) and Gondia districts (Maharashtra) during November, 2023. During the survey and farmers interaction, it was recorded that flour of chickpea landrace "Chanuali" is used as cancer medication by Gond tribe in Balaghat and Gondia and neem leaves are used to store the seeds and protect from borer infestation. The leaves of Karra plant (*Cleistanthus collinus* Roxb) were used by Gond tribe to protect the paddy from rice caseworm in standing field condition. Seeds of *Corchorus capsularis* are used to treat throat pain (Fig. 1.9).

Fig.1.8. Variability in seed shape, size and colour of maize, garden pea and field pea, satputiya and sesame (a); variability in fruit shape and size of *Luffa hermaphrodita* (b)

Fig 1.9. Seed variability in Horse gram (a); sem bean (*Lablab purpureus*) (b); and seed shape, size and colour in Okra (c)

1.2.9. Multi-crop germplasm from remote districts of Uttar Pradesh

Fifty-six accessions comprising of *Echinochloa frumentacea* (9), *Oryza sativa* (8), *Zea mays* (5), *Oryza rufipogon* (4), *Sesamum indicum* (4), *Trichosanthes bracteata* (2), *Trichosanthes cucumerina* var. *cucumerina* (2), *Benincasa hispida (2), Brassica rapa* var. *brown sarson (2), Luffa cylindrica* (2), *Paspalum scrobiculatum* (2), *Pennisetum glaucum (2), Arivella viscosa* (2) and others (10) were collected from parts of Mirzapur and Sonbhadra districts of Uttar Pradesh. Variability was observed for crop maturity (early and late), plant height, seed shape, size and colour in *Echinochloa frumentacea, Sesamum indicum* and *Zea mays*. Variability was also observed in named rice landraces *viz. Basant bahar, Bhatewara* (light yellow), *Kala Namak* and *Dev dhan* (Scented, suitable for chevda and kheer making) for grain size (small and bold types), shape and colour (light yellow, white and golden) (Fig. 1.10).

1.2.10. Multi-crop and CWR germplasm from parts of Assam and Arunachal Pradesh

In an exploration to the parts of Lakhimpur, Dhemaji (Assam) and Papumpare (Arunachal Pradesh) districts, a total of 33 accessions comprising of *Brassica juncea* var. *rugosa* (2), *Cucurbita maxima* (2), *Luffa acutangula (2), Sesamum indicum* (2), *Solanum violaceum* (2) *and* others (23) were collected. Diversity in wild relatives of *Corchorus, Crotalaria, Luffa, Momordica* and *Solanum* was frequently observed. Populations in wild state in first three genera was quite frequent in wastelands, roadside and forests. Variability in fruit shape of pumpkin; different colours and size of pods of lablab bean, long-elliptical and round shape of sponge-gourd were observed and collected. Germplasm of Rice-bean, Yardlong bean, white and black seeded sesame, were collected. Fruits of *Solanum violaceum* are commonly used as chutaney (vegetable). Among M&AP, accessions of *Ocimum, Rauwolfia,*

Fig. 1.10. Variability in seed-shape, size and colour in barnyard millet (a); and rice germplasm (b)

Fig. 1.11. Fruiting plants of *Solanum violaceum* (a); *Capsicum frutescens* (b); and a very large field of wild rice (*Oryza rufipogon* habitat) in Ghatapather, Dhemaji district of Assam (c)

Cleome were collected. The area is dominated by rice, grown in three seasons. After rice, mustard crop is occasionally grown and was found in limited pockets. Blackgram cultivation was found in Dhekuakhana block of Lakhimpur and Majuli district (Fig. 1.11).

1.2.11. Wild rice germplasm from districts of north Assam

Survey, exploration, and germplasm collection of wild rice was conducted in Sonitpur and Biswanath Chariali districts of Assam. A total of 30 germplasm accessions of wild and weedy rice (*Oryza rufipogon*, *O. nivara* and *O. sativa* f. *rufipogon*, *O. spontanea* f. *nivara*) were collected. Good diversity was observed as wild/weedy rice for grain size, shape, grain and kernel colour, plant height, leaf size and shape and in number of tillers, awnless and awned (6-10 cm long) type in weedy rice. The *Oryza sativa f. spontanea/O. spontanea, O. nivara f. spontanea* were grown naturally with *Bao rice* (deep water rice), local farmers use the wild rice for consumption occassionally. Seed, soil, and water samples were collected from the wild rice in-situ conservation site Borjuli along with other data (Fig. 1.12).

1.3. National Herbarium of Cultivated Plants (NHCP)

A total of 597 herbarium specimens, 32 seed samples/ economic products were added to the National Herbarium of Cultivated Plants (NHCP), making total collection of 629 herbarium specimens (representative of 4,415 species belonging to 1,552 genera and 267 families), 3,202 seed samples and 787 economic products. During the report period, 21 new taxa, not represented earlier, were added in the form of herbarium specimens to the NHCP. A total of 951 including unrepresented belonging to crop genepool were authenticated and digitized making a total of 2351 digitised images. Herbarium digital resource for consultation of users is made available through webpage (http://www.nbpgr.ernet.in:8080/nhcp/cSimplesearch.aspx.) Identification services provided and authentication certificates (104) were issued to students and researchers for their experimental study (Table 1.4).

1.4. Diversity mapping in mango germplasm

Geo-referencing and mapping of 2,917 accessions of mango belonging to various parts of the country was done. Mapping of assembled diversity revealed that Karnataka

Fig. 1.12. Panicle variability in wild rice (*O. rufipogon*, *O. nivara* and *O. spontanea* (a); variability in grain size, shape, colour (b); and in grain & kernel size, shape & colour (c)

Table 1.4: New taxa added in NHCP during 2023

Family	New Species	Source/State	Wild/ Cultivated
Amaryllidaceae	*Allium wallichii* Kunth, *Allium prattii* C.H.Wright	Sikkim	Wild
Araceae	*Typhonium trilobatum* (L.) Schott	Arunachal Pradesh	Wild
Asparagaceae	*Chlorophytum nepalense* (Lindl.) Baker	Sikkim	Wild
Fabaceae	*Lathyrus cassius* Boiss., *Lathyrus latifolius* L., *Lathyrus japonicus* Willd., *Lathyrus cilicicus* Hayek & Siehe, *Lathyrus basalticus* Rech.f.	New Delhi	Wild Relative
Grossulariaceae	*Ribes luridum* Hook.f. & Thomson, *Ribes griffithii* Hook.f. & Thomson, *Ribes acuminatum* Wall. & G.Don	Sikkim	Wild
Malvaceae	*Abelmoschus odishae* R. C. Misra sp.nov.	Odisha	Cultivated (Type specimen)
Poaceae	*Aegilops juvenalis* (Thell.) Eig, *Aegilops bicornis* (Forssk.) Jaub. & Spach, *Triticum turanicum* Jakubz., *Triticum urartu* Thumanjan ex Gandilyan	New Delhi	Wild Relative
Poaceae	*Saccharum benghalense* Retz.	Bihar	Wild
Rosaceae	*Rubus calycinoids* Kuntze, *Rubus inopertus* (Focke ex Diels) Focke, *Rubus kumaonensis* N.P.Balakr.	Sikkim	Wild

(532), followed by Andhra Pradesh (391), Uttar Pradesh (379), Kerala (298), Telangana (239), Odisha (147), Tamil Nadu (96), Maharashtra (93), Andaman & Nicobar (62), Gujarat (59), Goa (44), Uttarakhand (42), West Bengal (39), Jharkhand (28), Assam (27), Madhya Pradesh (27), Rajasthan (25), Meghalaya (24), Tripura (20) and Manipur (19) were extensively explored states. Most of the diversity-rich areas of mango (*Mangifera indica*) in the country have been surveyed and germplasm collected; in the future, only trait-specific and variability need to be collected from Central India, Gujarat, Eastern Uttar Pradesh and Malda (West Bengal) areas of the country (Fig. 1.13).

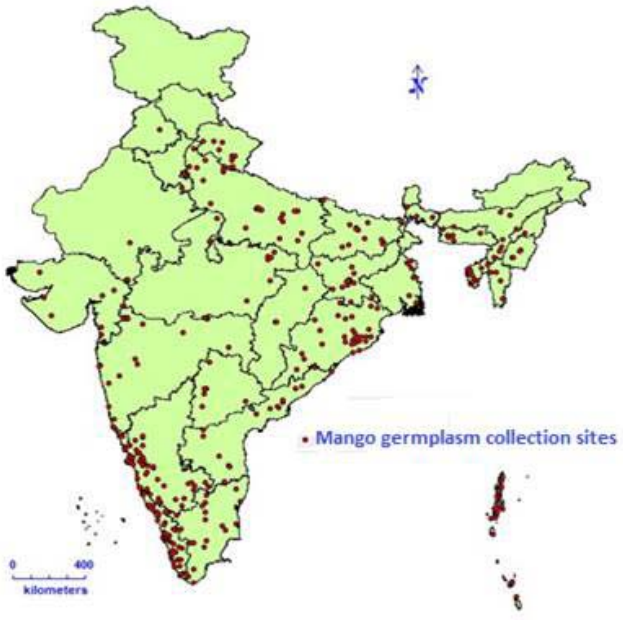


Fig.1.13. Mango germplasm collected from different states of the country

1.5. PGR conservation awareness programmes conducted during 2023

Two PGR Conservation Awareness Programmes and Biodiversity Fairs for nutritional and livelihood security of tribal farming communities were organized in Udaipur and Alwar districts of Rajasthan involving KVKs, under TSP Sub-Plan. Farm implements as inputs, vegetable seed kits were distributed to 200 tribal farmers (Fig. 1.14).

1.6. Agri-Drone technology demonstration in farmer's field

Three programme on agri-drone technology demonstration were conducted in farmer's fields of villages *viz.* Garhi Alawalpur (July 20, 2023 & December 27-29, 2023) and Malahera (August 11-12, 2023) Rewari, District, Haryana. Total 54 farmers attended the demonstration programme, and had given very good feedback about drone technology for spraying nano urea and pesticide. All Farmers realized that manual spray is taking too much time as compared to drone technology. Many farmers have shown their interest to purchase drone for nutrient and pesticide application, provided battery life should be longer or diesel operated drones in near future (Fig. 1.15).

Fig. 1.14. PGR conservation awareness programme at Udaipur Rajasthan under Tribal Sub-Plan (TSP)

Fig. 1.15. Agri-Drone technology demonstration at farmer's field in Rewari, Haryana

Research Programme (Programme Code: Title, Leader)
PGR/DPEGC-BUR-DEL-01.00: Exploration for collection of germplasm of agri-horticultural crops, maintenance of herbarium and biosystematics and ethno-botanical studies (**PK Singh**)
Research Projects (Project Code: Title, PI, Co-PIs and Associates)
PGR/DPEGC-BUR-DEL-01.01: Exploration for collection of genetic resources of agricultural crops and their wild relatives (**SP Ahlawat**, KC Bhatt, RS Rathi, DP Semwal, Puran Chandra, Soyimchiten, RK Pamarthi, PK Malav, Pankaj Kumar Kannaujia, NS Panwar and OP Dhariwal)
PGR/DPEGC-BUR-DEL-01.02: Exploration for collection of genetic resources of horticultural crops, species and their wild relatives (**RS Rathi** (w.e.f. 01.04.2022), KC Bhatt, DP Semwal, SK Malik, Puran Chandra, PK Malav, Pankaj Kumar Kannaujia, NS Panwar and OP Dhariwal)
PGR/DPEGC-BUR-DEL-01.03: National Herbarium of Cultivated Plants (NHCP), establishment, maintenance, build-up and taxonomic studies on crop plants (**KC Bhatt**, K Pradheep**,** RK Pamarthi, Pankaj Kumar Kannaujia, PK Malav (w.e.f. w.e.f. 01.04.2023) and Rita Gupta) (upto 31.10.2023)
PGR/DPEGC-BUR-DEL-01.04: Geo-informatics for assessment of diversity distribution in agri-horticultural crops (**DP Semwal**, KC Bhatt, N Sivaraj, Soyimchiten, RK Pamarthi, PK Malav and NS Panwar)

2 GERMPLASM EXCHANGE AND POLICY UNIT

सारांशः रिपोर्ट की तहत अवधि के दौरान 55,145 accessions (2,10,173 नमूने) आयात किए गए, जिनमें जर्मप्लाज्म के 43,319 accessions, (49,148 नमूने) और परीक्षण के लिए नर्सरी की 11,826 accessions (1,61,025 नमूने) शामिल हैं जोकि CGIAR संस्थान से आयात किये गए। सहयोगात्मक अनुसंधान के अन्तर्गत कुल 2052 नमूने निर्यात किए गए। सामग्री हस्तांतरण समझौते (एमटीए) के तहत अनुसंधान कार्यकर्ताओं से प्राप्त अनुरोधों के आधार पर विभिन्न फसल सुधार कार्यक्रमों में उपयोग के लिए देश के भीतर उपयोगकर्ताओं को विभिन्न फसलों के कुल 12,129 नमूने प्रदान किए गए थे। पीजीआर प्रबंधन से संबंधित मुद्दों पर विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय स्तरों पर बातचीत और नीतियों के निर्माण के लिए नीति निर्माताओं की आवश्यकताओं के अनुसार विश्लेषणात्मक इनपुट प्रदान किए गए थे।

Summary: The Unit functions to facilitate import, export and domestic supply of plant germplasm for research purposes. During the period under report 55,145 accessions (2,10,173 samples) were imported including 43,319 accessions (49,148 samples) of germplasm and 11,826 entries (1,61,025 samples) of CGIAR nurseries for trials. A total of 2052 samples were exported under CRP. A total of 12,129 samples of different crops were supplied to the users within the country for utilization in various crop improvement programmes based on requests received from research workers under Material Transfer Agreement (MTA). In addition, 97,446 samples were supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing. Analytical inputs were provided as per requirements of the policy makers for negotiations and formulations of policies at various national and international levels on issues related to PGR management.

2.1. Import

The Unit continued its efforts for germplasm introduction to meet the specific requirements of scientists working in ICAR research institutes, State Agricultural Universities (SAUs), other public and private sector organizations with DSIR recognized R&D, and non-governmental organizations (NGOs). Plant genetic resources import/ introduction comprised of material obtained on request from the scientists as well as collaborators for international trials to be conducted in India. Trait specific accessions and wild species imported during the period are listed in (Table 2.1, Fig. 2.1). A detail of import of seed/ planting material during the year 2023 is as follows:

Germplasm accessions procured and processed	:	43,319 accessions (49,148 samples)
CGIAR nurseries for trials	:	11,826 entries (1, 61,025 samples)
No. of countries involved	:	41 (Fig. 2.2)
No. of Import Permits issued	:	521
Resource generated	:	Rs. 1,62,41,914

(Rs. One crore sixty two lakhs forty one thousand and nine hundred fourteen)

Cereals: *Hordeum vulgare* (20) from Australia, (115) from Netherlands and (3246) from USA, *H. vulgare* subsp. *vulgare* (68) from USA; *Oryza alta* (1), *O. australiensis* (10), *O. brachyantha* (1) all from Philippines; *O. glaberrima* (1) from Ivory Coast; *O. grandiglumis* (5), *O. granulata* (8), *O. latifolia* (9), *O. meyeriana* (4), *O. minuta* (1), *O. officinalis* (1), *O. ridleyi* (1),*O. rufipogon* x *sativa* (24) all from Philippines, *O. sativa* (50) from Bangladesh, (58) from Brazil, (40) from Burundi, (10,173) from Philippines, (268) from USA and (10) from Vietnam, *O. sativa* var. *indica* (4) from Ivory Coast; *Triticum aethiopicum* (4), *T. carthlicum* (13), *T. dicoccoides* (44), *T. dicoccum* (99), *T. durum* (745) all from Lebanon and (1) from USA, *T. polonicum* (12), *T. turanicum* (13), *T. turgidum* (17) all from Lebanon and *T. aestivum* (79) from USA; *Zea diploperennis* (2,) *Z. luxurians* (2) both from USA, *Z. mays* (523) from Brazil, (4138) from Chile, (10) from Egypt, (417) from France, (5795) from Guatemala, (285) from Indonesia, (3258) from Mexico, (273) from Philippines, (1443) from South Africa, (1719) from Thailand, (560) from USA and (114) from Zimbabwe, *Z. mays* subsp. *huehuetenangensis* (1), *Z. mays* subsp. *parviglumis* (3), *Z. mexicana* (3), *Z. nicaraguensis* (1), *Z. perennis* (1) all from USA.

Millets: *Echinochloa esculenta* (4), *E. frumentacea* (14) both from Germany; *Eleusine coracana* (5) from Kenya; *Pennisetum glaucum* (5) from Kenya; *Sorghum bicolor* (10) from Austria; (172) from Italy, (65) from Kenya, (78) from USA.

Grain legumes: *Cajanus cajan* (143) from Australia (4) from Kenya; *Cicer arietinum* (2), *C. bijugum* (10), *C. chorassanicum* (2), *C. cuneatum* (6), *C. echinospermum* (30), *C. judaicum* (21), *C. pinnatifidum* (15), *C. reticulatum* (46), *C. yamashitae* (2) all from USA; *Lens culinaris* (20), *L. culinaris* subsp. *orientalis* (17), *L. ervoides* (28), *L. nigricans* (4), *L. odemensis* (4) all from USA; *Pisum abyssinicum* (2), *P. sativum* (247), *P. sativum* subsp. *asiaticum* (3), *P. sativum* subsp. *elatius* (7), *P. sativum* subsp. *transcaucasicum* (1) all from USA; *Tylosema esculentum* (18) from Namibia; *Vigna* sp. (44) from Philippines, (45) from

Table 2.1: Wild species and trait specific (promising) seed/planting material imported in 2023

Crop/EC No/ Country	Traits	Supplied to
Cereals		
Wheat		
EC1174992-1175723/ Lebanon	Global durum panel	ICAR-NBPGR, New Delhi
EC1166082-1166156/ USA	Ditelosomic, nullisomic/Tetrasomic lines	ICAR-NBPGR, New Delhi
Millets		
Sorghum		
EC1154677-78, EC1154713/Kenya	Striga tolerant	ICRISAT, Hyderabad
EC1154679-89, 93, EC1154723,728, Kenya	Restorer & Maintainer lines	ICRISAT, Hyderabad 740 /
EC1154694-727/Kenya	Drought tolerant/low temperature tolerant	ICRISAT, Hyderabad
Grain Legumes		
Lentil		
EC1178452- 1178524/USA	Bold seeded germplasm and wild species	ICAR-NBPGR, New Delhi
Pea		
EC1178132- 1178172/USA	Species - *Pisum fulvum, Pisum sativum* subsp. *elatius, Pisum sativum* subsp. *ranscaucasicum*	ICAR-NBPGR, New Delhi
Chickpea		
EC1184515-1184648/USA	Species - *Cicer bijugum, C. chorassanicum, C. cuneatum, C. pinnatifidum, C. judaicum, C. echinospermum, C. yamashitae, C. reticulatum*	ICAR-NBPGR, New Delhi
Oilseeds		
Soybean		
EC1154362-486/ USA	Landraces and promising varieties	ICAR-NBPGR, New Delhi
Sesame		
EC1176050-1176111/USA	Elite lines	ICAR-IIOR, Hyderabad
Castor		
EC1187582-1187666/USA	Diverse germplasm collection	ICAR-IIOR, Hyderabad
Fruits		
Almond		
EC1160666/USA	SG1 Titan is an advanced selection of Titan peach/almond hybrid with excellent vigor and root knot nematode resistance, well-anchored deep rooting, and drought tolerance. SG1 tolerates boron, high lime/high pH soil and salinity	Seven Star Fruits Pvt. Ltd.
EC1170564-566/Uzbekistan	Promising and elite varieties- Turkmenskiysvetliy, Ugamskiy Yaltinskiy	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Apricot		
EC1170567-576/Uzbekistan	Varieties-Arzami, Bobo radjabi, Vympel, Guliston, Komsomolets, Marokand Navruz, Ruhi juvanonmiyona, Sovetskiy, Joubert foulon	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Apple		
EC1170644-665/Uzbekistan	Elite varieties- Jonathan, Parmen zimniyzolotoi, Renetsimirenko, Kamola	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Cherry plum		
EC1170685-690/Uzbekistan	Cultivars highly fertile, early ripening, strong and prolific tree, cold hardy	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Citrus		
EC1170599-600, EC1170638 / Uzbekistan	Variety Meyer having sweet flavor.	ICAR-IARI, New Delhi

Crop/EC No/ Country	Traits	Supplied to
Golden currant		
EC1170643/Uzbekistan	Heat resistant variety Rukhshona	ICAR-NBPGR RS Shimla; ICAR- CITH, Srinagar
Grape		
EC1170601-637/Uzbekistan	Improved varieties of different colours red, black, crimson, very aromatic	ICAR-NBPGR RS Shimla, ICAR- IARI, New Delhi
Kiwi fruit		
EC1160667-1160689/USA	Wild and related species viz. *Actinidia chinensis var. deliciosa, Actinidia arguta, A. callosa, A. macrosperma, A. melanandra, A. latifolia, A. lanceolata, A. eriantha*	ICAR-NBPGR RS Shimla
Persimmon		
EC1165953-1166003 /USA	Promising varieties - Fuji, California Maru, Fujiwaragosho, Izu, Chienting, Maekawa Jiro, Fuyui, Jiro, Mishirasu, Shuruga, Vainiglia, Thiene, Mandarino, Rispoli, Moro, Lampadina, Lycopersicon, Castellani, Costata, Bruniquel, Nui Nai, Tishishtzu, Yedo, Hanagosho, Hazegosho, Gofu, Sangokuichi, Kyara, Muraya, Syouro, Yashima, Ichidagaki, Emon, Kakiyamagaki, Glomba, Tam kam, Korean, Great Wall	ICAR-NBPGR RS Shimla
EC1170639-642/Uzbekistan	Elite varieties-Zendzhi maru, Dig tamopon, Hiakume and Tadzhikskiy	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Plum		
EC1170535-539/Uzbekistan	Variety Washington with yellow flesh , firm, very sweet and luscious, separating freely from the stone and other promising varieties	ICAR-NBPGR RS Shimla; CITH, Srinagar
Peach		
EC1170540-563/Uzbekistan	Heirloom varieties	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Pear		
EC1170577-593/Uzbekistan	Oleaster leaved varieties Williams, Zimnyayanashvati 2, Kulyalya no. 2, Lesnayakrasavitsa, Clappsfavorite, Levavasser, Mramornayarossoshansk, Olivier de serres, Podarok, Rano, Spina carpi, Sary guzal, Salom 2, Starkrimson, Talgarskayakrasavitsa, Elsari, Yubileynaya	ICAR-NBPGR RS Shimla; ICAR-CITH, Srinagar
Pomegranate		
EC1170594-597/Uzbekistan	Promising varieties-Achikdona, Desertniy, Kazakeanor, Kzyluluchshenniy	ICAR-NBPGR RS Shimla, NBPGR, New Delhi
Sour Cherry		
EC1170667-672/Uzbekistan	Promising varieties- Griot Ostgeymskiy, Lyubskaya, Podbelskaya, Samarkandskaya, Turgenevka, Shpankachomaya	ICAR-NBPGR RS Shimla; CITH, Srinagar
Walnut		
EC1170598/Uzbekistan	Promising variety Yubileyniy nuts are large,the core is sweet, oily, the peel is easily separated	ICAR-NBPGR RS Shimla; CITH, Srinagar
Zizyphus		
EC1180565-66/Australia	Variety Chico & Li (crisp texture and flavourful, early fruiting)	Dr YSPUHF, Solan
EC1170666/Uzbekistan	Variety U sin khun	ICAR-NBPGR, New Delhi

Crop/EC No/ Country	Traits	Supplied to
Vegetables		
Musk melon		
EC1194984-85/USA	Fusarium wilt differentials, CPPSIH4 03 (CM 17187 differential), CPPSIH4 04 (Isabelle differential)	ICAR-NBPGR, New Delhi
Ec1194986-5006/USA	Powdery mildew differentials	ICAR-NBPGR, New Delhi
Lettuce		
EC1177321-360/USA	Diverse germplasm	ICAR-IARI, New Delhi
Spices & Condiments		
Black Cumin		
EC1174043, 46,49,53,54 / Germany	Species-*Nigella arvensis* & *N. damascena*	ICAR-NRCSS, Ajmer
Cumin		
EC 1190482-498/USA	Fragrant varieties	ICAR-NRCSS, Ajmer
Fibre crops		
Cotton		
EC1194596/Nepal	*Gossypium barbadense* variety Himalayan cotton with good fibre strength and length	ICAR- CICR, Nagpur

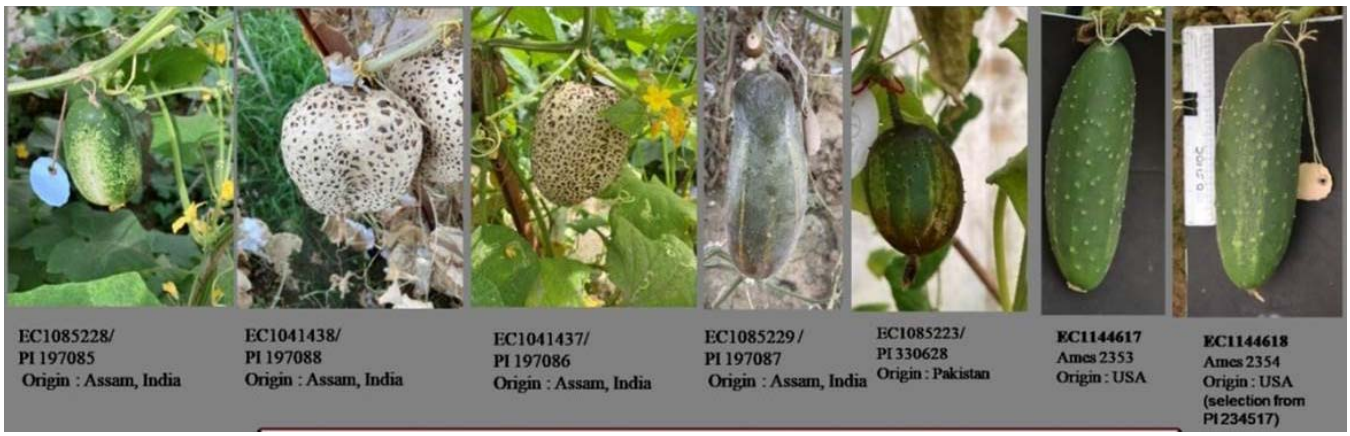


Fig. 2.1. Repatriation/Augmentation and multiplication of global source of resistance to Downy mildew in cucumber

USA, *Vigna radiata* (37) from Taiwan; *Vigna subterranea* (20) from Burkina Faso and *Vigna unguiculata* (12) from Nigeria.

Oilseeds: *Arachis hypogaea* (294) from Niger**;** *Brassica barrelieri* (1),*B. carinata* (144), *B. elongata* (5), *B. fruticulosa* (18), *B. incana* (6), *B. maurorum* (4), *B. oxyrrhina* (1) all from Germany; *Capsella bursa-pastoris* (7) from Germany; *Carthamus glaucus* (1), *C. lanatus* (4), *C. palaestinus* (1), *C. tenuis* (1), *C. tinctorius* (1), *C. turkestanicus* (3) all from USA; *Diplotaxis* sp. (1), *D. tenuifolia* (11), *D. tenuisiliqua* (1) all from USA; *Eruca sativa* (140) from USA; *Eruca strumgallicum* (1) from Germany; *Glycine max* (13) from Japan, (1) from Taiwan, (30) from USA and (30) from Zambia; *Helianthus annuus* (21) from France; *Ricinus communis* (53) from USA; *Sesamum indicum* (108), *S. radiatum* (3) both from USA; *Sinapis alba* (216), *S. pubescens* (5), *S. arvensis* (38) from Germany.

Vegetables: *Abelmoschus caillei* (3), *A. crinitus* (1) both from USA, *A. esculentus* (80) from Nigeria, (293) from Thailand, (615) from USA, *A. ficulneus* (1), *A. manihot* (19), *A. manihot* var. *tetraphyllus* (1), *A. moschatus* (3), *A. tuberculatus* (2) all from USA; *Allium cepa* (75) from Israel (6) from Thailand; *Benincasa hispida* (13) from Taiwan; *Brassica oleracea* (99) from Philippines; *Brassica oleracea* var. *botrytis* (3) from Netherlands, (71) from USA; *Brassica oleracea* var. *capitata* (34) from Netherlands, (33) from USA; *Bunias erucago* (1) from Germany; *Capsicum annuum* (2) from Mexico, (342) from Netherlands, (1580) from Taiwan, (5) from Thailand and (2) from USA, *C. baccatum* (4) from Netherlands, *C. baccatum* var. *pendulum* (2) from Taiwan, *C. chacoense* (2) from USA, *C. chinense* (1) from Netherlands and (14) from Taiwan, *C. eximium* (1) from USA, *C. frutescens* (2) from Netherlands,

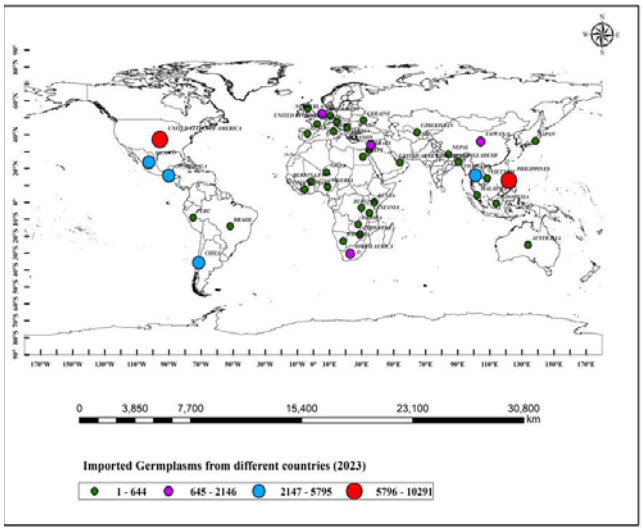


Fig. 2.2. Import from different countries during the reporting period

(3) from Taiwan, (10) from USA, *C. galapagoense* (1) and *Capsicum* sp. (6) both from USA; *Citrullus amarus* (16), *C. colocynthis* (2), *C. lanatus* (24),*C. mucosospermus* (1) all from USA; *Cucumis heptadactylus* (1) from USA , *C. melo* (9) from Netherlands, (23) from USA; *C. melo* subsp. *melo* (6) from USA, *C. myriocarpus* (1) and *C. myriocarpus* subsp. *leptodermis* (1) all from USA; *C. sativus* (112) from Netherlands, (2) from Taiwan, *C. sativus* var. *sativus* (353) from USA; *Cucurbita maxima* (1) from USA and *C. pepo* (5) from Netherlands; *Daucus carota* (5) from USA; *Lactuca sativa* (38), *L. serriola* (2) both from USA; *Momordica balsamina* (1) from Taiwan, *M. charantia* (29) from Philippines, (380) from Thailand, (19) from Vietnam, *M. cochinchinensis* (1) from Taiwan; *Raphanus sativus* (5) from Taiwan; *Solanum chilense* (1), *S. habrochaites* (1) both from USA, *S. lycopersicum* (1) from Israel, (269) from Netherlands, (34) from Philippines, (41) from Spain, (171) from Taiwan, (483) from Thailand, (274) from USA, *S. lycopersicum* var. *cerasiforme* (1), *S. peruvianum* (6) and *S. pimpinellifolium* (2) from USA.

Fibres: *Gossypium barbadense* (1) from Nepal and *G. hirsutum* (39) from USA.

Fruit crops: *Actinidia arguta* (6), *A. callosa* (3), *A. chinensis* (1), *A. chinensis* var. *deliciosa* (7), *A. eriantha* (1), *A. hemsleyana* (1), *A. lanceolata* (1), *A. latifolia* (1), *A. macrosperma* (1), *A. melanandra* (1) all from USA; *Citrus aurantifolia* (1), *C. aurantium* (2), *C. australasica* (1) all from USA, *C. limon* (4) from USA and (1) from Uzbekistan, *C. medica* (2) from USA, *C. reticulata* (17) from USA and (1) from Uzbekistan; *C. sinensis* (6) from USA and (1) from Uzbekistan; *Citrus* spp. (10) from USA; *Cydonia oblonga* (6) from Uzbekistan; *Diospyros kaki* (51) from USA, *D. lotus* (4) from Uzbekistan; *Fortunella* sp. (3) from USA; *Juglans regia* (1) from Uzbekistan; *Malus domestica* (8) from Australia, (3) from South Africa, (22) from Uzbekistan and *Musa* spp. (2) from Tanzania; *Poncirus trifoliata* (1) from USA; *Prunus amygdalus* (1) from USA and (3) from Uzbekistan, *Prunus armeniaca* (10), *Prunus avium* (6), *Prunus cerasia* (6), *Prunus cerasifera* (6), *Prunus domestica* (5) all from Uzbekistan; *Prunus dulcis* (1) from USA, *Prunus persica* (24), *Punica granatum* (4), *Pyrus communis* (17) all from Uzbekistan; *Ribes aureum* (1) from Uzbekistan; *Vasconcellea goudotiana* (2), *Vasconcellea parviflora* (1), *Vasconcellea pubescens* (1) all from USA; *Vitis vinifera* (37) from Uzbekistan; *Ziziphus jujuba* (5) from Australia and (1) from Uzbekistan.

Spices: *Cuminum cyminum* (17) from USA; *Nigella arvensis* (6), *N. damascena* (15) both from Germany.

Tubers: *Solanum tuberosum* (2) from France, (5) from Germany, (11) from Netherlands. (3) from Peru, (2) from UK and (26) from USA.

Narcotics: *Nicotiana tabacum* (2) from Brazil.

Potential crops: *Chenopodium quinoa* (12) from UAE.

Others: *Arabidopsis thaliana* (2) from USA; *Casuarina* spp. (15) from Malaysia.

2.2. Export

The seed and plant material of agricultural and horticultural crops were exported to other countries on the basis of requests received by NBPGR/ICAR headquarters or from scientists working in ICAR institutes/SAUs/other universities in India as per approved International Collaborative Research Projects. The plant material intended for export were forwarded to foreign collaborators along with phytosanitary certificates issued by NBPGR and import permit, if any, with the approval from ICAR/DARE and signing of MTA/SMTA as applicable. The details of export of seed/planting material during 2023 are indicated below.

a) **Collaborative Research Projects:** 71 cultivars (757 samples) of different temperate fruit crops to Uzbekistan; 494 accessions of Amaranth to Germany; 45 accessions of cowpea to Namibia; 378 accessions of wheat to Bangladesh and 378 accessions of wheat to Mexico.

b) **National Biodiversity Authority Approval:** A total of 19 accessions (2 accession of wheat to Portugal; 15 accessions of banana to Germany and 2 samples of Citrus to Canada) were exported with approval of NBA.

c) **CIMMYT Trials:** Facilitated supply of 54 CIMMYT HTMA trials.

d) **Issuance of Phytosanitary Certificate:** Facilitated proposals for issuance of phytosanitary certificate for

export of 16 accessions of rice from Bayer Bioscience, India to Bayer Bioscience, Philippines and 65 accessions of cucumber from RizkZwan, India to RizkZwam, Netherlands.

2.3. Domestic supply

The seed and planting material of diverse agri-horticultural crops were supplied to ICAR institutes/ coordinated projects, agricultural universities and other users in India. Based on specific requests 12,129 samples (Table 2.2 & Fig. 2.3) were supplied under the Material Transfer Agreement (MTA). The crop wise samples and the recipient institutes are listed in Table 2.2. In addition, a total of 97,446 samples (Fig. 2.4) were supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

Table 2.2: National supply of seed/planting material to recipients during 2023

Crop	No. of samples	Indenter
Cereals (1579)		
Barley	79	VPKAS, Almora; IIWBR, Karnal
Maize	352	Jammu University, Jammu; Eagle Seeds and Biotech Ltd, Indore; ICAR RC for Eastern Region, RS-Ranchi; Abhilashi University, Mandi; Amrita Vishwa Vidypeetham, Coimbatore; ICAR RS for NEH Region, Sikkim Centre, Gangtok, CAU Sikkim; Banda Univeristy of Agriculture and Technology, Banda
Rice	293	Guru Ghasi Das Vishwavidyalaya, Bilaspur; IIRR,Hyderabad;Cotton University, Guwahati; KAU, Thrissur ; MSSRF, Chennai; NIPB, New Delhi; NRRI, Haazaribagh; CAU, Imphal
Wheat	855	VPKAS, Almora; VNMKV, Parbhani; SHUATS, Prayagraj; VPKAS, Almora; BHU, Varanasi; Murli Manohar Town Post Graduate College, Balia; Nuziveedu Seeds, New Delhi ; CHKHPKV, Palampur; LPU, Phagwara; IARI, New Delhi
Millets (1882)		
Sorghum	109	Amrita Vishwa Vidyapeetham, Faridabad, Haryana; Central University of Haryana, Mahendergarh
Little millet	05	SKUAST-K, Srinagar
Kodo millet	05	SKUAST-K, Srinagar
Browntop millet	05	SKUAST-K, Srinagar
Finger Millet	1657	Dr PDKV, Akola
Pearl millet	101	University of Lucknow, Lucknow
Grain legumes (3483)		
Black gram	790	University of Ag Scinces, Vijaypur; CRIDA, Hyderabad; NAU, Navsari; Sri Manakula Vinayagar Engineering College, Pudcherry; JNKV, Jabalpur
Chick pea	227	Osmania University, Hyderabad; Amrita Vishwa Vidyapeeth, Coimbatore
Cowpea	425	RAU, Sabore; ICAR-IARI, Jharakhand; Graphic Era Hill University, Dehradun; SHUATS, Prayagraj; IARI New Delhi; SKUAST-K, Srinagar
Horsegram	300	ICAR-CRIDA, Hyderabad
Lentil	185	Amity University, Noida; IARI, Hazaribagh
Mothbean	250	JNU, New Delhi; Jiwaji University, Gwalior
Mungbean	868	OUAT, Bhubneshwar; Pawar College of Agriculture, Pune ; NAU, Navsari
Pigeonpea	308	ICGEB, New Delhi
Rice bean	79	CAU Sikkim
Vigna spp.	50	ICAR-NIASM, Pune
Oilseeds (1380)		
Rapeseed mustard	204	Rasi Seeds Private Limited, Coimbatore; IISER, Thiruvananthpuram; ICAR-DRMR, Bharatpur; CSIR-IHBT, Palampur; BCKV, Mohanpur; Amrita Vishwa Vidyapeetham, Coimbatore
Groundnut	825	ICAR-CRIDA, Hyderabad

Crop	No. of samples	Indenter
Sesame	270	Agriculture University, Jodhpur ; LPU, Phagwara ; Annamalai University, Cuddalore
Soybean	72	Eagle Seeds and Biotech Ltd., Indore
Linseed	9	ICAR-NBPGR, New Delhi
Vegetables (2362)		
Ash gourd	60	UHS, Bagalkot, Karnataka
Bitter gourd	153	KAU, Thrissur; SKUAST-K, Srinagar; KAU, RARS, Kumarakom; SVBPUAT, Meerut; Mali Agritech Pvt Ltd., Ranaghat; TNAU, Coimbatore; YSRHU, Godavari
Bottle gourd	4	ICAR-IARI, New Delhi
Brinjal	516	TNAU,Coimbatore; Dr YSPUAT, Solan; KAU, Thiruvananthapuram; ICAR-IIVR, Varanasi
Broad bean	27	HPKV, Palampur
Chilli	477	GKVK, Bengaluru ; IARI RS Pune; ICAR-IIHR, Bengaluru ;YSRHU, Guntur; Badrinarayhan Barwle Mahavidyalaya, Jalna; University of Hyderabad, Hyderabad ; University of Agriculture Sciences, Raichur ; Telangana State Ag University, Hyderabad ; TNAU, Coimbatore ; Monsoon Crop science LLP, Nashik; SKUAST-J, Jammu; SHUATS, Allahabad; M/s ACSEN Hy. Veg. Private Ltd., Gurugram
Cucumber	223	ICAR-IARI New Delhi; Keladi Shivappa Nyaka University of Agriculture Sciences, Shivmogga, UAS, Bengaluru ; SVBPUAT, Meerut ; Integral University, Lucknow ; LPU, Phagwara; SKUAST-K, Srinagar ;VPKAS, Almora ; Dr YSPUHF, Solan
French bean	77	UAS, Dharwad ; AbhilashiUniv, Mandi
Lablab bean	11	TNAU, Theni, Tamil Nadu
Moringa	20	KAU, Thrissur
Musk melon	81	PAU, Ludhiana; IIHR Benguluru; GKVK, Bengaluru; IARI New Delhi
Okra	334	ICAR-IARI, New Delhi; BCKV, Nadia; Coimenzo Agri Science Ltd, Raipur; M/s ACSEN Hy. Veg. Private Ltd., Gurugram; Institute of Agriculture Sciences, Jhansi; KAU, Thiruvananthapuram; Nunhems India Pvt Ltd, Bangalore; GKVK, Bengaluru; HPKV, Palampur
Onion	45	ICAR-DOGC, Pune
Pea	157	BAU, Sabour; NABI, Mohali ; SKUAST-K, Srinagar
Pumpkin	15	Annamalai University, Tamil Nadu
Ridge Gourd	55	SKUAST-K, Srinagar; HAU, Hisar
Tomato	63	M/s ACSEN Hy. Veg. Private Ltd., Gurugram; Annamalai University, Tamil Nadu
Water melon	7	SKNU, RARI, Jaipur
Yardlong bean	37	TNAU, Theni
Fibres (84)		
Cotton	80	Rasi Seeds (P) Ltd, Salem; Amrita Vishwa Vidyapeetham, Coimbatore; Moolji Jaitha College, Jalgaon
Sun hemp	4	PAU, Ludhiana
Potential crops (173)		
Amaranthus	141	TNAU, Coimbatore; HAU, Hissar; Srinivasan Medicinal College and Hospital, Tiruchirapalli; IIAB, Ranchi
Quinoa	30	Navsari Agriculture University, Navsari
Buckwheat	2	AMU, Aligarh
Fruit crops (214)		
Pomegrannate	156	ICAR-IARI, New Delhi
Musa spp	24	ICAR-NRC Banana, Thyanur
Citrus medica	3	CSIR-NBRI, Lucknow

Crop	No. of samples	Indenter
Vitis spp	24	ICAR-IARI, New Delhi
Parthenocissus quinquefolia	6	ICAR-IARI, New Delhi
Solanum muricatum	1	DRDO, Leh
Medicinal and aromatic plants (861)		
Costus speciosus	1	Kumaon University, Nainital
Dioscorea deltoidea	3	KAU, Thiruvananthapuram
Dioscorea bulbifera	4	Panjab University, Chandigarh
Eclipta alba	17	Annamalai Univ, Annamalainagar
Gloriosa superba	01	Kumaon University, Nainital
Medicinal Plants (various spp)	142	University of Delhi, Delhi
Mucuna pruriens	6	Central University of Kerala, Kasargod
Nigella sativa	70	SKUAST-K, Srinagar; NRC on seed Spices, Ajmer
Picrorhiza kurroa	12	Panjab University, Chandigarh
Piper spp.	31	Rajiv Ranjan Dayalbagh Education Institute, Agra; Panjab University, Chandigarh
Plantago ovata	72	CAZRI, Jodhpur
Solanum spp.	64	Scottish Church College, Kolkata
Withania somnifera	438	ICAR-CTRI, Rajahmundary
Spices (66)		
Coriander	41	CSKHPAU, Palampur
Cumin	25	Agriculture University, Jodhpur
Forage grasses (45)		
Bracharia	43	ICAR-IARI, New Delhi
Lotus corniculatus	2	CSIR-NBRI, Lucknow

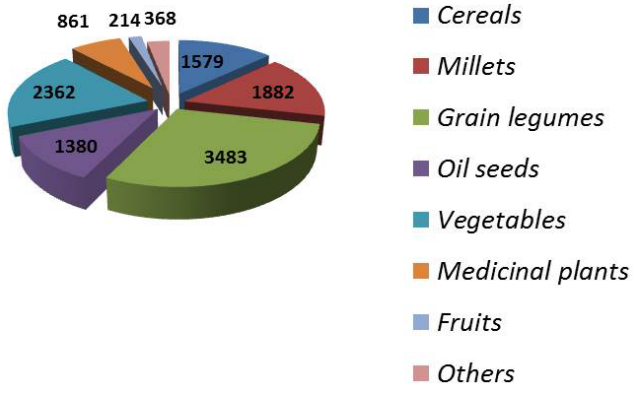


Fig. 2.3. Germplasm supplied to various organizaions for research

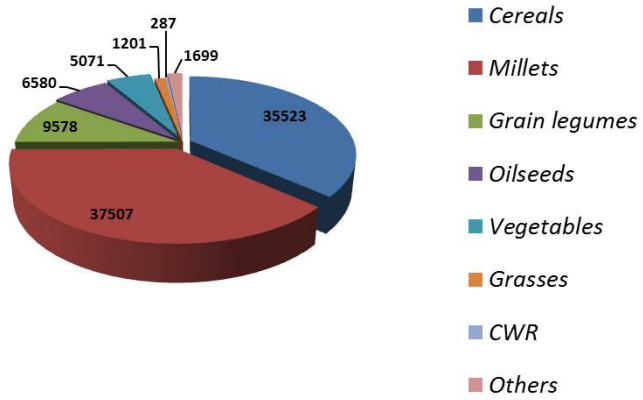


Fig. 2.4. Germplasm supplied for regeneration & characterization

2.4. Policy Issues on Agro-biodiversity Management

10th Session of the Governing Body of the International Treaty on the Plant Genetic Resources on Food and Agriculture (GB10) was held in FAO, Rome from 20-24 Nov 2023.

Dr Sunil Archak of ICAR-NBPGR was part of Indian delegation that participated in the GB10. Farmers' Rights, Enhancement of the MLS and Digital Sequence Information in relation to PGRFA were discussed among various other issues. As Co-Chair the MLS enhancement Working Group,

Dr Archak co-presented the check-point report. As member of Indian delegation, he presented the Delhi Framework on Farmers' Rights proposed by Government of India.

First 'Global Symposium on Farmers' Rights'

ICAR-NBPGR Co-hosted the first 'Global Symposium on Farmers' Rights' (GSFR) at the ICAR Convention Centre, National Agricultural Science Centre in New Delhi from September 12 to 15, 2023. The symposium was organized by the Secretariat of ITPGRFA. The proposal to hold the first GFSR was mooted by Government of India at the Ninth Session of the Governing Body of ITPGRFA held in India in September 2022, which was agreed by the FAO. GSFR was attended by more than 500 delegates from 60 countries, including the National Focal Points of the International Treaty, more than 150 farmers and more than 100 foreign participants. Various issues pertaining to Farmers' Rights as set out in the Article 9 of the International Treaty were deliberated in five different technical sessions, two panel discussions and three special sessions. A special session on Farmers Forum was an important inclusion in the GSFR. The deliberations and suggestions resulted in a 'Delhi Framework on Farmers' Rights', as a proposal from India to the Treaty. The delegates also visited the phenomics, genomics and genebank facilities.

Reporting and inputs

- Information for SDG 2.5.1 submitted through Ministry of Statistics and Programme Implementation (MoSPI).
- Inputs provided related to DPPQS for revision of various definitions, to EXIM Committee, for revision of DIP Act 2014, to MEA on possibility of India making a contribution to the BWC Article X database, MoEF&CC on Global Biodiversity Framework Target 6 – Invasive Alien Species and also carried out PRA for 40 crops.

Research Projects (Project Code: Title, **PI,** Co-PIs **and** *Associates***)**

Programme 1: Exchange of Plant Genetic Resources with Foreign Countries (Import/ Export) their National Supplies to the Scientists/Users in the Country along with related Information and Documentation of these Activities in the form of Plant Genetic Reporter On-line Publication : **PGR/GEPUBUR-DEL -01.00** (PL: Vandana Tyagi till 30.06.2023 ; Dr Sunil Archak w.e.f 01.07.2023)

PGR/GEPU-BUR-DEL-01.01: Import, export, inland supply and survey of literature for procurement of elite/ trait specific PGR in cereals, oilseeds, grain legumes, millets and sugar yielding crops and documentation. (**PI- Vandana Tyagi** ; Co-PIs - Pratibha Brahmi, Puran Chandra; *Associates- S P Singh (till 31 July 2023), Surender Singh, PC Binda*)

PGR/GEPU-BUR-DEL-01.02: Import, export, inland supply and survey of literature for procurement of elite/ trait specific PGR in vegetable crops, potential crops, plantation crops, forages and fibre crops and documentation. (**PI-S K Yadav**; Co-PI - Pragya; *Associates-S P Singh (till 31 July 2023), Surender Singh, PC Binda*)

PGR/GEPU-BUR-DEL-01.03: Import, export, inland supply and survey of literature for procurement of elite/ trait specific PGR in fruits, ornamentals, medicinal & aromatic plants, spices & condiments, tubers, narcotics and beverages and documentation. (**PI – Pragya**; Co-PI – S K Yadav; *Associates- SP Singh (till July 2023), Surender Singh, PC Binda*)

Programme 2: PGR management policy and back up research: **PGR/GEPUBUR-DEL -02.00** (PL: Pratibha Brahmi till 31.08.2023) Dr Sunil Archak (w.e.f. 01.09.2023)

PGR/GEPU-BUE-DEL-02.01: Analysis of emerging policy issues on agro-biodiversity management and preparation of technical inputs for use by policy makers/Indian delegations at national and international meetings/ negotiations **PI: Pratibha Brahmi;** till August 31, 2023 **Dr Sunil Archak w.e,f 1.09.2023**), Veena Gupta till August 31, 2023, Kavita Gupta, Vandana Tyagi, Pragya till August 31, 2023, Puran Chandra, S Rajkumar, Kuldeep Tripathi ,Vartika Srivastava and Rajeev Gambhir

PGR/GEPU-BUE-DEL-02.02: Policy Issues Related to Biosecurity **PI: Dr Celia Chalam**, Co-PIs: Kavita Gupta, Pratibha Brahmi, (till August 31, 2023), KS Hooda and Monika Singh

3 DIVISION OF PLANT QUARANTINE

सारांशः 1,49,401 आयातित जर्मप्लाज्म परिग्रहणों (गैर–ट्रांसजेनिक) के साथ–साथ विभिन्न फसलों और उनके वन्य सम्बन्धियो के अंतरर्राष्ट्रीय परीक्षणों के नमूनों को संगरोध मंजूरी के लिए संशोधित किया गया। इन नमूनों में ट्रू बीज, जड़ वाले पौधे, कलम, प्रकंद, सकर्स, बल्ब, नट और उत्तक संवर्धित पौधे शामिल थे। संक्रमित नमूनों (1,454) में कई विदेशी कीटों सहित कीड़े (298), निमेटोड (659), कवक (356), वायरस (102) और खरपतवार (39) शामिल थे। 1,454 संक्रमित/दूषित नमूनों में से 1,401 को भौतिक–रासायनिक तरीकों जैसे धूमन, एक्स–रे रेडियोग्राफी, कीटनाशक उपचार, यांत्रिक सफाई और बढ़ते परीक्षण के माध्यम से बचाया गया था, जबकि 53 संक्रमित नमूनों को बचाया नहीं जा सका, इसलिए खारिज कर दिया गया। इन अस्वीकृत नमूनों में चावल के 18 नमूने ब्राजील (14) और चीन (4) टीलेसिया बार्कलेना से संक्रमित थे। पीपर माइल्ड मोटल वाइरस (पीएमएमओवी) और तंबाकू माइल्ड ग्रीन मोजेक वायरस के कारण संयुक्त राज्य अमेरिका से मिर्च के 30 नमूने सहित 35 नमूने शामिल थे एवं टोमैटो मोजेक वायरस (ToMV), टोमैटो मोटल मोजेक वायरस (ToMMV) और टोमैटो ब्राउन रगोज फ्रूट वायरस (ToBFRV) के कारण टमाटर की 5 परिग्रहण संक्रमित थे। विभिन्न देशोंध्स्रोतों से आयातित विभिन्न दलहनी फसलों के विदेशी जर्मप्लाज्म के कुल 587 नमूने पोस्ट–एंट्री संगरोध (पीईक्यू) ग्रीनहाउस में उगाए गए थे और वायरस से मुक्त परिग्रहणों को मांगकर्ताओं को जारी किया गया। निर्यात के लिए विभिन्न फसलों के कुल 2,832 नमूने संसाधित किए गए, जिनमें से 45 संक्रमित नमूनों को बचा लिया गया और 24 फाइटोसैनिटरी प्रमाणपत्र जारी किए गए। बीज स्वास्थ्य परीक्षण के लिए स्वदेशी रूप से विकसित जीई सरसों के बीज (4) और बीटी कपास के नमूने (60) के चौंसठ नमूने प्राप्त हुए। कीटोमियम स्पीसीज. तीन में पाया गया, फ्यूसेरियम ऑक्सीस्पोरम दो में पाया गया और क्लैडोस्पोरियम स्पीसीज चार परिग्रहणों में पाया गया। नमूनों को राष्ट्रीय जीनबैंक में संरक्षित किया गया। बीज स्वास्थ्य परीक्षण (एसएचटी) के तहत, राष्ट्रीय जीनबैंक में कीट–मुक्त संरक्षण हेतु जर्मप्लाज्म संरक्षण प्रभाग के माध्यम से कुल 10,252 नमूनो की स्वदेशी रूप से एकत्रित या प्रवर्धित बीज सामग्री प्राप्त की गई एवं कुल 2447 नमूने कवक (270), कीट (1522), निमेटोड (574) और खरपतवार (81) से संक्रमित/दूषित पाए गए। इसके अलावा, 101 क्रायो नमूनों पर कार्रवाई की गई, जिनमें से दो फंगल रोगजनकों से संक्रमित थे और उन्हें बचा लिया गया।

Summary: A total of 1,49,401 samples of imported germplasm accessions (non-transgenic) as well as international trials/ nurseries of various crops and their wild relatives were processed for quarantine clearance. These samples included true seeds, rooted plants, cuttings, rhizomes, suckers, bulbs, nuts and tissue culture plantlets. The infested/ infected samples (1,454) comprised insects (298), nematodes (659), fungi (356), viruses (102) and weeds (39) including several exotic pests. Of the 1,454 infested/ infected/ contaminated samples, 1,401 were salvaged through physico-chemical methods *viz*., fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test while 53 infected samples could not be salvaged, hence rejected. These rejected samples included 18 samples of rice due to *Tilletia barclayana* from Brazil (14) and China (4). Thirty-five accessions including 30 accessions of chilli from USA due to pepper mild mottle virus (PMMoV) and tobacco mild green mosaic virus (TMGMV); 5 accessions of tomato due to tomato mosaic virus (ToMV), tomato mottle mosaic virus (ToMMV) and tomato brown rugose fruit virus (ToBFRV). A total of 587 samples of exotic germplasm of different legume crops imported from different countries/ sources were grown in post-entry quarantine (PEQ) greenhouses and the harvest of the plants free from viruses was released to the indenters. A total of 2,832 samples of various crops were processed for export of which 45 infested samples were salvaged and 24 Phytosanitary Certificates were issued. Sixty-four samples of indigenously developed GE mustard seed (4) and Bt cotton samples (60) were received for seed health testing. *Chaetomium* sp. was detected in three, *Fusarium oxysporum* detected in two and *Cladosporium* sp. was detected in four accessions. The samples were released for conservation in National Genebank. Under seed health testing (SHT), a total of 10,252 samples of indigenously collected or multiplied seed material were received through Division of Germplasm Conservation for pest-free conservation in the National Genebank and total 2,447 samples were found infected/ infested/ contaminated with fungi (270), insect pests (1,522), nematodes (574) and weeds (81). In addition, 101 cryo samples were processed of which two were infected with fungal pathogens and were salvaged.

3.1. Import Quarantine

3.1.1. Quarantine examination

A total of 1,49,401 samples comprising germplasm accessions, nurseries/ trial breeding material of various crops including both true seed and vegetative propagules were processed for the detection of associated exotic insect pests, mites, plant parasitic nematodes, plant pathogens (fungi, bacteria, viruses) and weed seeds by various detection techniques. Of the import samples, 1,692 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids. Of these, 298 samples

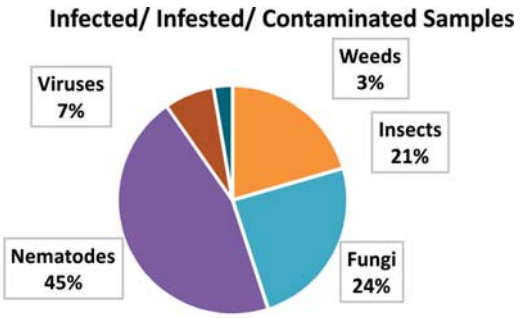


Fig. 3.1. Infected/ infested/ contaminated samples detected through quarantine examination

Medicago trunculata | *Carrichtera annua* | *Medicago scutellata* | *Phalaris paradoxa* | *Raphanus raphanistrum*

Fig. 3.2. Weeds of quarantine significance intercepted during quarantine processing

were found infested with insects/ mites, including 76 with hidden infestation; 659 samples infected with nematodes, 356 infected with fungi, 102 with viruses and 39 with weeds (Fig. 3.1). The photographs of some of the quarantine weeds are given in Fig. 3.2.

3.1.2. Salvaging of infested/ infected/ contaminated germplasm

Of the total 1,454 infested/ infected/ contaminated samples, 1,401 were salvaged by various disinfestation/ disinfection techniques/ treatments like mechanical cleaning to remove damaged/ abnormal seeds, soil clods, plant debris, etc., fumigation with ethylene dichloride-carbon tetrachloride (EDCT) mixture at 320 mg L^{-1} for 48 h or aluminium phosphide fumigation (phosphine at 2 g cu m^{-1} for 72 h) at 30°C under normal air pressure against insect infestation and hot water treatment (HWT) at 52°C for 30 minutes for various seed-borne bacterial pathogens and nematodes and X-ray screening for hidden insect infestation, pesticidal dip/ spray for vegetative propagules.Out of 298 insect infested samples, all were salvaged by X-ray radiography (76), fumigation (84) using aluminium phosphide (phosphine @ 2 g per cubic metre for 72 hrs)/ethylene dichloride carbon tetrachloride @ 320 mg/litre for 48 hrs and mechanical cleaning (221). Of these, 1,401 infected samples were salvaged by various disinfection techniques/ treatments such as fungicidal seed treatment and ethyl alcohol wash and remaining 53 infected samples were rejected. The rice samples infected with nematode (565) were salvaged by hot water treatment. Apple samples infected with nematode were salvaged by 0.25 percent formalin root dip treatment (94). A total of 39 samples contaminated with weed seeds were salvaged by mechanical cleaning.

3.1.3. Prophylactic treatments

A total 6,289 seed samples were subjected to fumigation with aluminium phosphide (phosphine @ 2 g per cubic metre for 72 hrs)/ ethylene dichloride carbon tetrachloride @ 320 mg/litre for 48 hrs and 4,671 vegetative propagules were given pesticidal dip/spray treatment against insect-pests. A total of 3,594 samples of paddy were given mandatory prophylactic hot water treatment. In order to prevent the introduction of new strains of tobamoviruses through seeds, all the introduced germplasm samples of chilli (526) and tomato (415) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate (Fig. 3.3).

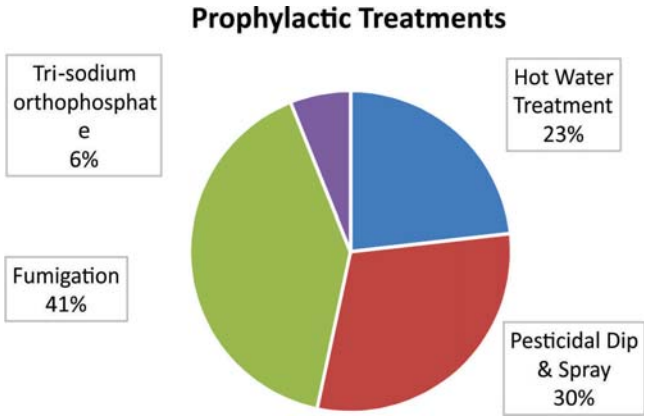


Fig. 3.3. Prophylactic treatments of introduced germplasm samples

3.1.4. Growing out test for detection of viruses

A total of 587 samples of exotic germplasm comprising *Glycine max* (324), *Pisum sativum* (44) and *Vicia faba* (219) were grown in PEQ greenhouses at Headquarters. Also 273 accessions of soybean accessions grown at ICAR-IISR, Indore were inspected. The seedlings were inspected for the presence of viral symptoms. The plants showing viral symptoms were carefully covered with muslin cloth bags. Leaf samples showing virus-like symptoms and representative healthy-looking samples were tested for viruses using specific antisera to various seed-transmitted viruses by enzyme-linked immuno sorbent assay (ELISA), electron microscopy and reverse-transcription-PCR. The interceptions are presented in Table 3.1.

Table 3.1: Pests intercepted in the exotic germplasm during 2023

Pests	Host	Source/ Country
Insect pest		
**Bruchus dentipus*	*Vicia faba*	Lebanon
Bruchus lentis	*Lens culinaris*	Lebanon
Bruchus pisorum	*Pisum sativum*	Czech Republic
Immature form of bruchid	*Lathyrus sativus*	Morocco
Rhizopertha dominica	*Oryza sativa*	Bangladesh, Philippines
	Triticum aestivum	Lebanon
	Hordeum vulgare	USA
Sitotroga cerealella	*O. sativa*	Philippines
**Sitophilus granarius*	*H. vulgare*	Morocco
Sitophilus oryzae	*O. sativa*	Bangladesh, Brazil, Philippines
Tribolium castaneum	*T. aestivum*	Lebanon
	Zea mays	Thailand
Pathogen		
Alternaria brassicicola	*Brassica oleracea* var. *botrytis*	USA
	Sinapis alba	Germany
Bipolaris sorokiniana	*T. aestivum*	Lebanon
Bipolaris sorghicola	*Momordica charantia*	Thailand
Botrytis cinerea	*Capsicum annuum*	The Netherlands
Colletotrichum capsici	*C. annuum*	Taiwan
Cercospora kikuchii	*Glycine max*	Zambia
Cladosporium sp.	*H. vulgare*	Mexico
#Claviceps purpurea	*H. vulgare*	USA
Fusarium oxysporum	*Abelmoschus esculentus*	Nigeria
	Brassica oleracea var. *botrytis*	USA
	C. annuum	Taiwan, Netherlands
	Cucumis sativus	France
	Lens culinaris	Lebanon
	M. charantia	Thailand
F. semitectum	*Lycopersicon esculentum*	USA
F. solani	*Lagenaria siceraria*	USA
	L. esculentum	The Netherlands
Fusarium verticillioides	*C. annuum*	Taiwan
	Chenopodium quinoa	UAE
	H. vulgare	USA
	L. siceraria	USA
	M. charantia	Thailand
	O. sativa	Bangladesh, Brazil, Philippines
	T. indica	Mexico
	Z. mays Thailand, USA	Guatemala, Indonesia, Mexico, Philippines,
Nigrospora sp.	*M. charantia*	Thailand
Phoma exigua	*M. charantia*	Thailand
	L. siceraria	USA
#Phoma lingum	*C. annuum*	Taiwan

Pests	Host	Source/ Country
Tilletia barclayana	*O. sativa*	Bangladesh, Brazil, China
Ustilaginoidea virens	*O. sativa*	Philippines
#*Verticillium albo-atrum*	*Brassica oleracea* var. *botrytis*	USA
	L. siceraria	USA
	L. esculentum	Netherlands
#*Xanthomonas campestris* pv. *campestris*	*Sinapis alba*	Germany
#*X. campestris* pv. *carotae*	*Daucus carota*	USA
Viruses		
#alfalfa mosaic virus	*G. max*	USA
bean common mosaic virus	*G. max*	USA
*bean pod mottle virus	*G. max*	USA
#bean yellow mosaic virus	*G. max*	USA
*#grapevine fanleaf virus	*G. max*	USA
*#pepper mild mottle virus	*C. annuum*	USA
southern bean mosaic virus	*G. max*❖	USA
soybean mosaic virus	*G. max*	USA
*tobacco mild green mosaic virus	*C. annuum*	USA
#tobacco ringspot virus	*G. max*	USA
#tobacco streak virus	*G. max*	USA
tomato black ring virus	*G. max*❖	USA
*tomato brown rugose fruit virus	*Solanum lycopersicum*	Taiwan
#tomato mosaic virus	*S. lycopersicum*	Taiwan
*tomato mottle mosaic virus	*S. lycopersicum*	Taiwan
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Bangladesh, Brazil, China, Philippines, USA, Vietnam
Pratylenchus penetrans	❖*Malus domestica*	Australia, South Africa, Uzbekisthan
Meloidogyne incognita	*M. domestica*	South Africa, Australia
Aphelenchus avenae	*M. domestica*	South Africa, Uzbekisthan
Weeds		
Carthamus lanatus	*T. aestivum*	Australia
**Chenopodium oahuense*	*Chenopodium quinoa*	Peru
Echinochloacolona, Echinochloa crus-galli	*O. sativa*	Bangladesh
#*Echinochloa crus-pavonis*	*O. sativa*	Philippines
Heliotropium europium	*H. vulgare*	USA
**Medicago trunculata*	*T. aestivum*	Australia
**Medicago scutellata*	*T. aestivum*	Australia
Melilotus alba	*C. quinoa*	Peru
**Phalaris paradoxa*	*H. vulgare*	Morocco
Polygonum aviculare	*C. quinoa*	Peru
#*Polygonum lapathifolium*	*H. vulgare*	Morocco
Rumex crispus	*H. vulgare*	Morocco
**Sinapsis arvensis*	*C. quinoa*	Peru

#Pest regulated under PQ Order, 2003
* Pest not yet reported from India
❖pest present in India but not recorded on the host on which intercepted

3.1.5. PEQ Inspection at Indenter's site

A total of 48 post-entry quarantine inspections of various crops imported from different countries were carried out at various indenter's sites during this period (Table 3.2). As a result of inspections, suspected samples were uprooted and properly destructed in the field.

Table 3.2: Details of post entry quarantine inspections (PEQI) undertaken at indenter's site

IQ No.	IP No.	Crop	Sample	Indentor
308/2022	353/2022	*Triticum aestivum*	4,283	Suraj Cropscience Ltd
309/2022	355/2022	*T. aestivum*	1,199	Ankur Seeds Pvt Ltd
332/2022	409/2022	*T. aestivum*	470	Krishidhan Seeds Pvt Ltd
307/2022	348/2022	*T. aestivum*	709	Ajeet Seeds Pvt Ltd
330/2022	394/2022	*T. aestivum*	727	Nirmal Seeds Pvt Ltd
357/2022	386/2022	*Citrullus lanatus*	03	
331/2022	408/2022	*T. aestivum*	24	ITC Pvt Ltd
277/2022	369/2022	*Vicia faba*	460	ICARDA, Amlaha
278/2022	370/2022	*Lathyrus sativa*	1,200	
279/2022	371/2022	*Lens culinaris*	1,626	
280/2022	372/2022	*T. durum*	532	
281/2022	373/2022	*T. aestivum*	2,541	
282/2022	374/2022	*H. vulgare*	818	
283/2022	375/2022	*Cicer arietinum*	818	
322/2022	426/2022	*C. arietinum*	10,100	PAU, Ludhiana
212/2022	130/2022	*Hordeum vulgare*	1,167	AB InBrv Ltd
310/2022	358/2022	*T. aestivum*	12,616	BISA, Ludhiana
311/2022	368/2022	*T. aestivum*	232	PAU, Ludhiana
300/2022	319/2022	*T. aestivum*	1,864	Bioseed Research Ltd
297/2022	314/2022	*T. aestivum*	2,284	Pan Seeds Pvt. Ltd
301/2022	330/2022	*T. aestivum*	2,927	Eagle Seeds and Biotech Ltd
303/2022	336/2022	*T. aestivum*	914	Ruchi Hi Rich Seeds Pvt Ltd
302/2022	331/2022	*T. aestivum*	3,284	Kaveri seeds Pvt. Ltd
304/2022	340/2022	*T. aestivum*	3,506	Rasi Seeds Pvt Ltd
298/2022	315/2022	*T. aestivum*	2,864	Nuziveedu Seeds Pvt Ltd
361/2022	455/2022	*T. aestivum*	196	ICAR-IIWBR, Karnal
306/2022	346/2022	*T. aestivum*	23,907	
333/2022	417/2022	*T. aestivum*	464	ICAR-IARI, New Delhi
334/2022	418/2022	*T. aestivum*	220	
335/2022	419/2022	*T. aestivum*	196	
316/2022	376/2022	*Zea mays*	4	ACSEN Hy Veg, Pvt
217/2022	168/2022	*Vasconcellea* spp.	02	VNR seeds Pvt Ltd
352/2022	435/2022	*Capsicum annuum*	04	Comienzo Agri Science Ltd.
353/2022	436/2022	*S. lycopersicum*	06	

IQ No.	IP No.	Crop	Sample	Indentor
224/2022	137/2022	*Malus domestica*	25	Seven Star Fruits Pvt. Ltd.
328/2022	405/2022	*M. domestica*	05	
329/2022	411/2022	*M. domestica*	06	
320/2022	423/2022	*C. annuum*	19	Nath Biogene Ltd.
321/2022	424/2022	*S. lycopersicum*	21	
18/2023	504/2022	*C. annuum*	200	Syngenta India Limited
255/2022	270/2022	*Capsicum* sp.	499	AlpGIRI Seeds
163/2022	580/2021	*Citrullus* sp.	486	
113/2022	520/2021	*Zea mays*	236	
246/2022	298/2022	*S. lycopersicum*	16	Bharat Nursery Pvt. Ltd.
247/2022	299/2022	*C. annuum*	14	
248/2022	300/2022	*S. lycopersicum*	07	Noble Seeds Pvt. Ltd.
249/2022	301/2022	*C. annuum*	05	
350/2022	275/2022	*S. lycopersicum*	09	Nuziveedu Seeds Pvt. Ltd.
317/2022	81/2022	*Z. mays*	3,750	Syngenta India Ltd.
49/2022	398/2022	*Z. mays*	2,385	
251/2022	344/2022	*C. annuum*	328	Nunhems India Pvt Limited
53/2023	324/2022	*Citrullus lanatus*	15	Noble Seeds Pvt. Ltd.
54/2023	518/2022	*Abelmoschus* sp.	48	
338/2022	253/2022	*C. annuum*	08	Mahyco Pvt Ltd.
359/2022	388/2022	*C. sativus*	01	Nirmal Seeds Pvt Ltd
360/2022	389/2022	*Momordica charantia*	04	
356/2022	385/2022	*Cucurbita moschata*	03	
357/2022	386/2022	*C. lanatus*	03	
152/2022	99/2022	*Oryza sativa*	105	Savannah Seeds Pvt Ltd
186/2022	192/2022	*O. sativa*	252	
260/2022	209/2022	*O. sativa*	40	
404/2022	496/2022	*O. sativa*	223	
60/2023	508/2022	*O. sativa*	360	
149/2023	004/2023	*O. sativa*	58	
24/2023	487/2022	*S. lycopersicum*	6	Bayer Crop Science Ltd
25/2023	488/2022	*C. annuum*	9	
85/2023	18/2023	*S. lycopersicum*	2	
88/2023	131/2023	*S. lycopersicum*	8	
123/2023	86/2023	*C. annuum*	24	
124/2023	144/2023	*C. annuum*	6	
148/2023	491/2022	*C. annuum*	6	
161/2023	179/2023	*C. annuum*	2	
163/2023	025/2023	*S. lycopersicum*	3	
173/2023	248/2023	*M. charantia*	8	
389/2022	407/2022	*A. esculentus*	658	
271/2022	349/2022	*S. lycopersicum*	21	
272/2022	350/2022	*C. annuum*	19	
57/2023	87/2023	*Z. mays*	2500	
135/2023	132/2023	*Z. mays*	124	

IQ No.	IP No.	Crop	Sample	Indentor
23/2023 38/2023	493/2022 444/2022	*Z. mays* *Capsicum* sp.	30 199	Mahyco Pvt Ltd
146/2023	198/2023	*M. charantia*	45	Nath Biogene Ltd.
49/2023 67/2023	45/2023 26/2023	*Capsicum* sp. *A. esculentus*	10 80	Nunhems India Pvt. Ltd.
179/2023 180/2023	208/2023 209/2023	*B. o.* var. *botrytis* *S. lycopersicum*	71 82	Noble Seeds Pvt Ltd.
14/2023 27/2023	437/2022 531/2022	*C. annuum* *S. lycopersicum*	200 4	Nuziveedu Seeds
197/2022	264/2022	*Sorghum bicolor*	5	Ankur Seed Pvt Ltd
349/2022 19/2023	398/2023 512/2022	*Z. mays* *Z. mays*	200 3748	Syngenta India Ltd
33/2023 34/2023 150/2023 151/2023	532/2022 533/2022 51/2023 52/2023	*Z. mays* *Z. mays* *Z. mays* *Z. mays*	2008 345 21 30	Syngenta India Ltd
352/2022	435/2022	*C. annuum*	4	Comienzo Agri Science Ltd.
263/2023	190/2023	*Gossypium firsulum*	38	Ankur Seeds Pvt. Ltd.
159/2023	196/2023	*C. moschata*	68	Ruchi Hi-Rich Seeds Pvt. Ltd.
65/2023	07/2023	*B. oloracea* var. *capitata*	200	Syngenta India Ltd

3.2. Export Quarantine

A total 2,832 samples were exported to twelve countries viz., Portugal, Canada, Uzbekistan, Senegal, Burkina Faso, Germany, Namibia, Philippines, The Netherlands, Bangladesh, Mexico and Spain. Total 207 samples were X-rayed of which seven were infested with hidden infestation of bruchids. Forty-five samples were found infested by storage insects which were salvaged by fumigation using aluminium phosphide (phosphine @ 2 g per cubic metre for 72 hrs). Prophylactic treatment with fumigation was given to 872 samples. Four samples of *Amaranthus* sp. found infected with *Alternaria ameranthi*, *Bipolaris tetramera* and *B. sorokiniana* pathogens. Two samples of *Vigna unguiculata* found infected with *Fusarium oxysporum* and *Colletotrichum capsici* and were salvaged. Two samples each of mothbean and mungbean were found contaminated with *Digitaria sanguinalis* and *Eleusine indica,* respectively (Table 3.3) and all contaminated samples were salvaged by mechanical cleaning. A total of 24 phytosanitary certificates were issued.

Table 3.3: Detection of pests in germplasm samples for export during 2023

Pest Detected	Crop	Export to
Insect		
Callosobruchus maculatus	*Vigna unguiculata*	Namibia
Callosobruchus sp.	*V. radiata*	Senegal
Callosobruchus sp.	*V. aconitifolia*	Senegal, Burkina Faso
Rhizopertha dominica	*Triticum aestivum*	Bangladesh, Mexico
Sitotroga cerealella	*T. aestivum*	Bangladesh
Weeds		
Digitaria sanguinalis	*V. aconitifolia*	Senegal
Eleusine indica	*V. radiata*	Senegal

3.3. Seed Health Testing for Pest Free Conservation of Indigenously Collected Planting Material

A total 10,252 accessions of indigenously collected or multiplied seed material were received through Division of Germplasm Conservation for seed health testing (SHT) before pest-free conservation in the National Genebank. As a result of SHT, 2447 samples were found infected with different fungal pathogens (270), insects (1522), nematodes (574) and weed seeds (81).

Blotter test revealed detection and identification of many seed-borne fungi/ bacteria in 85 accessions of various crop germplasm. The important fungi detected include *Alternaria*

brassicicola,*Bipolaris oryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsici*, *Fusarium oxysporum*, *Gibberella zeae*, *Rhizoctonia solani* etc. and the details of pathogens detected are given in Table 3.4. A total of 60 samples rejected including *Triticum aestivum* infected with *T. indica* from Haryana (1) and Madhya Pradesh (1); *Oryza sativa* infected with *T. barclayana* from Andhra Pradesh (1), Chhattisgarh (11), Gujarat (1), Odisha (38), Telangana (1), Rajasthan (2), Tripura (1), Uttarakhand (1) and West Bengal (1) and one sample due to heavily contaminated with fungal saprophytes were rejected as they could not be salvaged.

A total of 81 samples of indigenously collected seed material and multiplied material at various centers were found contaminated with 14 types of weed seeds and all these samples were salvaged by mechanical cleaning. The details of pests detected are given in Table 3.4.

Table 3.4: Pests detected in material meant for pest free conservation

Pest	Host	Source State
Insects		
Acanthoscelides obtectus	*Phaseolus vulgaris*	Himachal Pradesh
	P. vulgaris	Manipur
Bruchidius angustifolius	*Sesbania* sp.	New Delhi
Bruchidius species	*Cassia tora*	Gujarat
	Vigna aconitifolia	Rajasthan
B. lentis	*Lens culinaris*	New Delhi
B. pisorum	*Pisum sativum*	Jammu & Kashmir, Himachal Pradesh
Callosobruchus analis	*Lathyrus sativus*	Bihar, New Delhi
	V. radiata	Maharashtra, Tamil Nadu
C. cajanus	*Cajanus cajan*	Kerala, Jharkhand, New Delhi
	Pisum sativum	New Delhi
C. chinensis	*Glycine max*	Madhya Pradesh, Arunachal Pradesh, Manipur
	Lens culinaris, L. sativus	Bihar
	Vigna mungo	Punjab
	V. unguiculata	Telangana
C. maculatus	*Cicer arietinum*	Haryana
	L. sativus	Bihar
	V. radiata	Telangana, Kerala
	V. unguiculata, V. mungo, Cajanus cajan	Telangana
C. phaseoli	*V. umbellata*	Manipur
Callosobruchus spp.	*V. unguiculata* ssp. *sesquipedalis*	Gujarat
	V. mungo	Maharashtra
	V. radiata	New Delhi
	V. unguiculata	Rajasthan
C. theobromae	*G. max*	Kerala
Caryedon tamarindus	*Tamarindus indica*	Maharashtra
Eggs & Immature form of Bruchid	*Lablab purpureus, V. mungo*	Maharashtra
	V. radiata	Kerala
	Abelmoschus esculentus, V. umbellata, Sesbania, Macrotyloma uniflorum	Telangana
	C. arietinum	Bihar

Pest	Host	Source State
	Cajanus scarabaeoides	Kerala
	L. culinaris	Bihar, Uttar Pradesh, Haryana
	L. purpureus, V. mungo	Maharashtra
	Pisum sativum, C. arietinum, L. purpureus	New Delhi
	V. radiata	New Delhi, Karnataka
	Phaseolus vulgaris, P. sativum	Jammu & Kashmir
Ephestia cautella	*Sesamum indicum*	Kerala
Lasioderma serricorne	*Helianthus* sp.	Tamil Nadu
Larva	*Arachis hypogaea*	Haryana
	Sesamum indicum	Kerala
Oryzaephilus surinamensis	*Zea mays*	New Delhi
Pectinophora gossypiella	*Gossypium* sp.	Kerala
Rhyiopertha dominica	*Avena sativa*	Bihar, Uttarakhand
	Oryza sativa	Chhattisgarh, Karnataka, Odisha, Telangana, Bihar, Andhra Pradesh, Tamil Nadu, West Bengal
	Triticum aestivum	New Delhi, Haryana, Karnataka
	Z. mays	New Delhi, Punjab
Sitotroga cerealella	*A. sativa*	Uttarakhand
	Coixlacryma-jobi	Mizoram
	O. sativa	Nagaland, Karnataka, Manipur, Bihar, Chhattisgarh, West Bengal, Odisha, Himachal Pradesh, Telangana, Tripura, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Maharashtra, Arunachal Pradesh, Gujarat, Assam
	Z. mays	Uttarakhand, Telangana, New Delhi
Sitophilus oryzae	*A. sativa*	Bihar
	O. sativa	Nagaland, Odisha, Chhattisgarh, West Bengal
S. zeamais	*Z. mays*	Manipur, Bihar, New Delhi, Karnataka, Arunachal Pradesh, Telangana
Spermophagusalbofaciatus	*A. esculentus*	New Delhi, Manipur
	Rosella sp.	Bihar
Tribolium castaneum	*O. sativa*	Chhattisgarh, Karnataka, Telangana, Odisha, Tripura, Andhra Pradesh, West Bengal
Pathogens		
Alternaria alternata	*Solanum melongena*	Delhi
Alternaria brassicicola	*Z. mays*	Telangana
Alternaria padwickii	*O. sativa*	West Bengal
Ascochyta sp.	*Rhynchosiacyanosperma*	Delhi
Bipolaris cynodanlis	*Ricinus communis*	Telangana
B. hawaiiensis	*Eleusine coracana*	Uttrakhand
B. oryzae	*Oryza sativa*	Assam, Chhattisgarh, Odisha, Telangana
B. rostrata	*O. sativa*	Odisha
Botryodiplodia theobromae	*Luffa aegyptiaca*	Delhi
	Trichosanthes sp.	Meghalaya

Pest	Host	Source State
Cercospora kikuchii	*Glycine max*	Arunchal Pradesh, Delhi, Madhya Pradesh, Maharashtra
Cercospora sp.	*Xanthium indicum*	Odisha
Chaetomium sp.	*Gossypium herbaceum*	Telangana
Cladosporium sp.	*G. herbaceum*	Delhi
Colletotrichum capsici	*Abelmoschus esculentus*	Kerala
	Trichosanthes cucumerina	Gujarat
	Capsicum annuum	Kerala
C. gloeosporioides	*A. esculentus*	Haryana
Diplodia maydis	*Z. mays*	Srinagar
Fusarium oxysporum	*C. annuum*	Srinagar
	Cucumis melo	Rajasthan
	Cucumis sativus	Delhi
	Gossypium herbaceum	Gujarat, Maharashtra, Tamil Nadu, Telangana
	Lens culinaris	Haryana
	Luffa acutangula	Tamil Nadu
	Psophocarpus tetragonolobus	Mizoram
	Solanum melongena	Delhi
	Vigna unguiculata ssp. *sesquipedalis*	Kerala
	Trichosanthes sp.	Meghalaya
F. semitectum	*O. sativa*	West Bengal
F. solani	*Brassica juncea*	Jammu and Srinagar
	C. annuum	Madhya Pradesh
	C. sativus	Delhi
	Momordica charantia	Rajasthan
	Sorghum bicolor	Punjab
F. verticillioides	*A. esculentus*	Uttar Pradesh
	B. juncea	Haryana
	C. annuum	Rajasthan
	C. sativus	Delhi
	Luffa aegyptiaca	Delhi
	O. sativa	Chhattisgarh, Punjab,Telangana, West Bengal
	Panicum sumatrense	Rajasthan
	Sesame indicum	Rajasthan
	Solanum torvum	Kerala
	Vigna unguiculata ssp. *sesquipedalis*	Kerala, Rajasthan
	Z. mays	Karnataka, Telangana
Gibberella zeae	*O. sativa*	Odisha
Macrophomina phaseolina	*Arachis hypogaea*	Haryana
Myrothecium roridum	*C. sativus*	Delhi
Myrothecium sp.	*Xanthium indicum*	Odisha
	C. annuum	Delhi
	Panicum miliaceum	Telangana

Pest	Host	Source State
Ophiostoma ulmi	*Luffa aegyptiaca*	Delhi
Pestalotia sp.	*Glycine max*	Kerala
Phoma exigua	*Benincasa hispida*	Kerala
Phoma sorghina	*O. sativa*	Chhattisgarh, West Bengal
Protomyces macrosporus	*Coriandrum sativum*	Srinagar
Puccinia helianthi	*Helianthus annuus*	Telangana
Rhizoctonia solani	*O. sativa*	Andhra Pradesh, Chhattisgarh, Odisha, Rajasthan, Telangana, Tripura,Uttrakhand, West Bengal
Tilletia indica	*Triticum aestivum*	Haryana, Madhya Pradesh
Ustilaginoidea virens	*O. sativa*	Assam,Chhattisgarh,Gujarat, Odisha,Telangana, West Bengal
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andhra Pradesh, Assam, Bihar, Chattisgarh, Gujarat, Jharkhand, Karnataka, Maharashtra, Manipur, Nagaland, Odisha, Puducherry, Tamil Nadu, Telangana, Tripura, West Bengal
Weeds		
Dactyloctenium aegyptium	*Z. mays*	Telangana
Echinochloa colona *Echinochloa crus-galli*	*Vigna unguiculata, O. sativa*	Rajasthan, Chhatishgarh, New Delhi, Odisha, Uttarakhand
Heliotropium subulatum *Heliotropium indicum*	*Vigna aconitifolia*	Kerala
Locthyrus aphaca	*Coriandrum sativum*	Jammu & Kashmir
	Lens culinaris	New Delhi
Medicago denticulata	*Lathyrus sativus*	Jharkhand
	L. culinaris	Uttarakhand
Melilotus alba *Melilotus indica*	*Triticum aestivum*	New Delhi
Phalaris minor	*Triticum aestivum*	Tamil Nadu
	Triticum aestivum	New Delhi
	Lathyrus sativus	Uttarakhand
Polygonum aviculare	*Avena sativa*	Uttarakhand
Rumex crispus	*Coriandrum sativum*	Jammu & Kashmir
	Triticum aestivum	New Delhi
	Avena sativa	Uttarakhand
Vicia hirsuta	*Lathyrus sativus*	New Delhi
Vicia sativa	*Coriandrum sativum*	Jammu & Kashmir
	Lathyrus sativus	New Delhi
	Lens culinaris	Uttarakhand

A total 1,450 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 98 samples were found infested while visual infestation of insect-pests was recorded in 1,424 samples. A total 1,552 samples were found infested by various insect-pests. The insect pests detected are given in Table 3.4. Out of total 1,552 infested samples, 65 were salvaged by X-ray radiography, cold treatment (399) and mechanically (1,385)

while 74 samples could not be salvaged hence rejected. A total of 574 samples were found infected with nematodes from sixteen different states / UT of the India.

In addition, 101 cryo-preserved samples or for cryo-preservation were received from TCCU for seed health testing of which two cryo samples were found infected with different fungi and all were salvaged. Nine samples were X-rayed to detect any hidden infestation of insect pests.

3.4. Supportive Research

3.4.1. Development of duplex PCR for simultaneous detection of *Colletotrichum acutatum* and *C. capsici*

The isolate of *Colletotrichum acutatum and C. capsici* was confirmed based on spore morphology and ITS gene sequencing. Species-specific primers (CaP1-F and CaP1-R) were designed from *glutamine synthetase gene* region to detect *C. acutatum* whereas *C. cpasici* primers designed from ITS regions were used from Kandan et al. (2016). The DNA was extracted from mycelial mat and PCR conditioned were standardized with annealing temperature of 65° C and an expected PCR product size of 180 bp and 450 bp were observed in *C. acutatum* and *C. capsici,* respectively (Fig. 3.4), but failed to amplify in other *Colletotrichum* spp. and other seed borne fungal pathogens. The detection sensitivity of the primer pairs was performed by dilution of genomic DNA and results revealed that it could detect up to 1 ng μl^{-1} of template DNA of the pathogens.

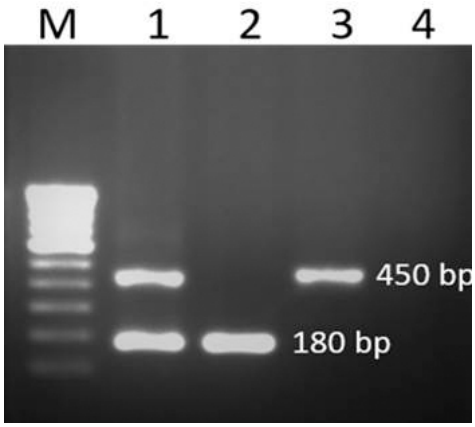


Fig. 3.4. PCR based amplification of seed borne fungal pathogens using *Colletotrichum acutatum* and *C. capsici* specific primers. L: 100 bp plus DNA ladder, 1: *C. acutatum* + *C. capsici*, 2: *C. acutatum*, 3: *C. capsici*, 4: Negative control

3.4.2. Impacts of water hyacinth (*Eichhornia crassipes*) on Indian wetlands

The study is based on the available/accessible literature in national and international peer reviewed journals and reports from various research organizations. Water hyacinth was introduced as an ornamental plant in several regions of the world including India. In most of the habitats of Africa and India, this species is still spreading even after century of its initial introduction. Recently water hyacinth has also been labelled as the world's worst weed and has garnered increasing international attention. Brahmaputra river has been severely affected by the water hyacinth. It has also blocked irrigation channels and obstructed the flow of water to crop fields. It slows water flow by 40 to 95% in irrigation channels was also reported in several parts of India. In West Bengal, water hyacinth causes huge annual loss of paddy by directly suppressing the crop, inhibiting rice germination and interfering with harvesting. It also pollutes the water and changes the water chemistry by decreasing oxygen level.

3.4.3. Detection, identification and validation of mungbean germplasm resistant to bean common mosaic virus (BCMV) using serological and molecular diagnostics

Five accessions *viz*., IC0418452, IC0394728, IC0392343, IC0610380 and IC0472089A of mungbean germplasm along with two susceptible checks (K851 and ML267) and one resistant check (LGG460) were screened against BCMV both under natural conditions in the field during Kharif 2023 and after artificial inoculation in controlled conditions. For detection of BCMV, DAC-ELISA and Reverse transcription - PCR (RT-PCR) were used. Five accessions viz., IC0418452, IC0394728, IC0392343, IC0610380 and IC0472089 showed immune response to BCMV infection both under natural and controlled conditions.

3.4.4. Molecular characterization of okra enation leaf curl virus (OELCuV) from wild okra (*A. moschatuss* ssp. *moschatus*)

Okra enation leaf curl virus (OELCuV) having DNA-A molecule along with betasatellite. In this study, an attempt was made to find out the diversity of begomovirus and its satellite nucleotide sequences derived from wild okra (*A. moschatuss* ssp. *moschatus*) infected samples exhibiting conspicuous symptom of okra enation leaf curl disease (OELCuD) using PCR-based detection technique on two wild okra symptomatic samples *viz.,* EC360855 and EC316077 collected from experimental farm of ICAR-NBPGR. Full length amplification of OELCuV satellite molecule and DNA-A was carried out using PCR and cloning of both randomly selected samples showed the presence of monopartite OELCuV. In both samples, presence of DNA-A molecule, betasatellite and alphasatellite were noticed. This is the first study which showed the presence of alphasatellite molecule of OELCuV from New Delhi region in wild okra (*A. moschatus* ssp. *moschatus*).

3.4.5. Detection, identification and validation of cowpea germplasm resistant to bean common mosaic virus (BCMV) using serological and molecular diagnostics

Four accessions of cowpea germplasm *viz*., IC199699, IC199701, IC202791 and IC202814 along with one susceptible and one resistant check were screened against BCMV both under natural conditions in the field during Kharif 2023 and after artificial inoculation in controlled conditions. For detection of BCMV, DAC-ELISA and Reverse transcription - PCR (RT-PCR) were used. These four accessions *viz*., IC199699, IC199701, IC202791 and IC202814 showed immune response to BCMV infection both under natural and controlled conditions.

3.4.6. Screening of germplasm for resistance to root-knot nematode

A total of 3,644 accessions of various agri-horticultural crops, *viz*., rice, chickpea, cucumber and chilli and mustard were evaluated for resistant source to a species of root-knot nematode, *Meloidogyne incognita* in pots with artificial inoculation. Based on number of root-galls induced by nematode, resistant accessions with less than 10 root-galls per plant were identified (Table 3.5).

Table 3.5: Germplasm of agri-horticultural crops evaluated for resistant to root-knot nematode, *Meloidogyne incognita*

Crop	No. of accessions screened	No. of resistant accessions found
Rice	1,000	Four (04)
Chickpea	2,200	One (01)
Cucumber	334	One (01)
Chilli	50	One (01)
Mustard	60	One (01)

3.4.7. Genome Wide Association Studies on Yellow Mosaic Disease Resistance in Cowpea Germplasm

A total of 1,127 cowpea germplasm accessions from the National Genebank, were screened for resistance against yellow mosaic disease under epiphytotic field conditions at two distinct locations (Hyderabad and Delhi). Out of these, 181 exhibited resistances to YMD, as they showed no symptoms in field screenings. Subsequently, the top 100 resistant accessions were selected for further validation of MYMIV resistance through whitefly-mediated screening, alongside 40 susceptible accessions. Whitefly-mediated transmission confirmed MYMIV resistance in 20 accessions, displaying a disease score of zero. Further, the study characterized the YMD-associated begomovirus by sequencing the full DNA-A genome of MYMIV, revealing a remarkable 99.02% genetic identity with the MYMIV isolate affecting cowpea in Pakistan. These 20 novel cowpea accessions with proven MYMIV resistance hold great potential for identifying and mapping resistance genes, offering valuable resources for resistance breeding programs. Genotyping by Sequencing (GBS) identified 17,703 high-quality Single Nucleotide Polymorphisms (SNPs) from a vast pool of 522,926 SNPs in the cowpea collections. The study assessed linkage disequilibrium across the entire cowpea genome, revealing an r2 value of 0.25. A comprehensive Multilocus Genome-Wide Association Study (MLGWAS) utilized six distinct models, including mrMLM, FASTmrMLM, FASTmrEMMA, pLARmEB, ISIS EM-BLASSO, and pKWmEB (with a LODe^3 threshold). These analyses identified three significant Quantitative Trait Nucleotides (QTNs) associated with MYMIV disease resistance. Notably, the pLARmEB model exhibited superior performance in QTN identification. In addition, this study conducted gene annotations for the most significant and consistent QTNs, underscoring their potential robustness across diverse environmental conditions. These findings offer invaluable insights for crop improvement programs, including the development of YMD-resistant cowpea varieties, Marker-Assisted Breeding (MAB), and the enhancement of national and international gene banks. Ultimately, this research contributes to safeguarding cowpea production against the devastating impact of YMD.

3.4.8. Potential quarantine pests for India in temperate fruit crops

Information on insects, mites, fungi, bacteria, viruses, viroids, phytoplasma and weeds of temperate fruits was compiled on the parameters *viz*., scientific name of the pest/ synonym(s), order/ family, pathway of introduction, host range, geographical distribution, economic losses/ physiological variation and phytosanitary risk.

3.5. Externally funded projects

3.5.1. National Programme for quarantine and GM diagnostics for genetically engineered plant material (Component A)

Health testing of GE plants indigenously developed by the public and private institutes prior to conserving in National Genebank

Four samples of indigenously developed GE mustard seed DMH-11 with DQ34/2023 was received from Delhi University for seed health testing and conservation in ICAR-NBPGR Genebank. Out of four accessions, three accessions (Hybrid DMH11, R line EH-2 modbs 2.99 transgenic, A line Varuna bn 3.6 transgenic MS) were intercepted with *Alternaria brassicicola* and *Xanthomonas compestris* pv. *compestris*. One sample (B line Varuna bn 3.6 non transgenic ML) found

infected with *Xanthomonas compestris* pv. *compestris*. The seeds were submitted to ICAR-NBPGR Genebank in pests-free state. Bt cotton samples (54 accessions) were received for seed health testing. *Chaetomium* sp.was detected in three accessions (Jaiho BGII Female, ACG-181-2BGII and ACG-180-2BGII) and *Fusarium oxysporum* was detected in two accessions (RC926 and RC927). Bt cotton samples (6 accessions) were received for seed health testing. *Cladosporium* sp. was detected in four accessions (IC-645921, IC-634539, SP-7688BGII and 14Q2F0063). The samples were released for conservation in National Genebank.

Development of diagnostics for viruses

Using the previoulsy developed simplex RT-PCR primers, efforts was made to develop triplex RT-PCR. Conditions for triplex RT-PCR protocol for the detection and differentiation of soybean infecting viruses namely BPMV, CLRV, RpRSV, SMV and ToRSV in all the possible triplex combinations (Total 10 combinations of Triplex RT-PCR) were standardized and tested (Fig. 3.5).

Simplex RT-PCR for the detection of ArMV, BYMV, GFLV

Simplex RT-PCR protocols for the detection of arabis mosaic virus (ArMV), bean yellow mosaic virus (BYMV) and grapevine fan leaf virus (GFLV) infecting soybean was developed. The new primers ArFP1&RP1, BYMFP1&RP1 detectedupto 10^{-4} cDNA dilution of target ArMV and BYMV. The primer pair GFLFPR1 and GFLRP1 detected the serially diluted cDNA upto 10^{-5}. The specificity of all three primer pairs were established by testing them against other viruses infecting soybean (Fig. 3.6).

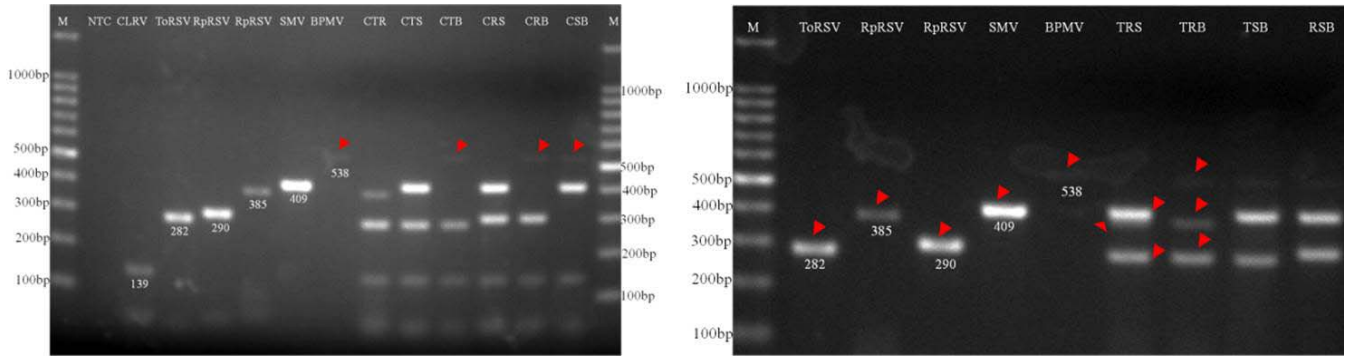


Fig. 3.5. Triplex RT-PCR for the detection of BPMV, CLRV, RpRSV, SMV and ToRSV. CTR- CLRV with ToRSV, RpRSV, CTS- CLRV with ToRSV, SMV, CTB- CLRV with ToRSV, BPMV, CRS- CLRV with RpRSV, SMV, CRB- CLRV with RpRSV, BPMV, CSB- CLRV with SMV, BPMV.TRS- ToRSV with RpRSV, SMV, TRB- ToRSV with RpRSV, BPMV, TSB-ToRSV with SMV, BPMV, RSB –RpRSV with SMV, BPMV

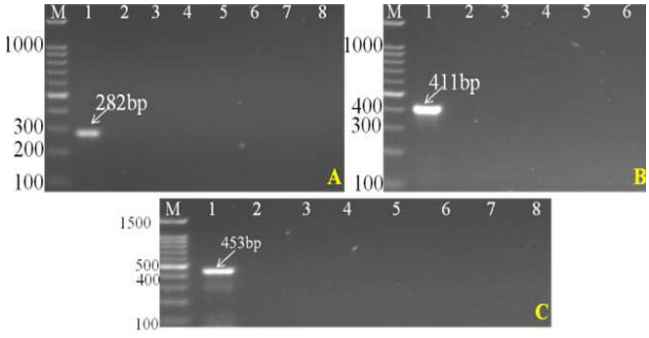


Fig. 3.6. Specificity of primer pairs ArFP1&RP1, BYMFP1&RP1 and GFLFP1& GFLRP1 against other viruses infecting soybean. A. ArMV. M- 100 bp ladder, 1-ArMV, 2-BYMV, 3- GFLV, 4- BPMV, 5-CLRV, 6- RpRSV, 7- SMV, 8-ToRSV. B-. BYMVM-100 bp ladder, 1- BYMV, 2- ArMV, 3-GFLV, 4- BPMV, 5-CLRV, 6- RpRSV, 7- SMV, 8- ToRSV. C. GFLV. M- 100 bp ladder, 1-GFLV, 2- ARMV, 3-BYMV, 4-BPMV, 5-CLRV, 6- RpRSV, 7- SMV, 8- ToRSV

Development of diagnostics for Nematodes

Optimized PCR protocol for the detection of *Meloidogyne enterolobii* using ITS primers. Soil samples were collected from guava orchard, Ayakudy, Tamil Nadu. The PCR amplicons was sequenced and the same has been deposited in NCBI Genebank Accession no. OQ826656 (Fig. 3.7).

Development of diagnostics for plant pathogenic fungi

- Duplex PCR developed for simultaneous detection of *Diaporthe phaseolorum* and *Peronospora manshurica*in soybean (Fig. 3.8).
- Developed two sets of species-specific molecular markers for detection of *Tilletia barclayana* infecting rice (Fig. 3.9).

Development of diagnostics of Bacteria

Procured two bacterial cultures, *Xanthomonas compestris* pv. *vesicatoria* and *X. compestris* pv. *malvacearum* from Indian

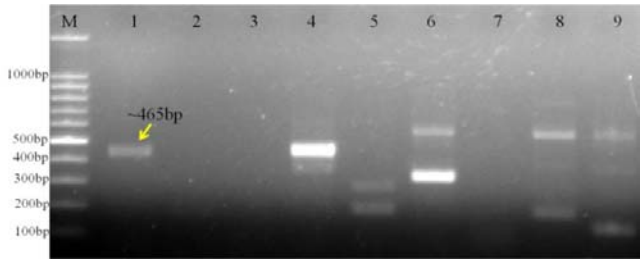


Fig. 3.7. PCR analysis of nematode samples using universal primers. M-100bp Ladder. Lanes 1-4- *M. enterolobii* ITS primer, Lanes 5-8- *M. enterolobii* D2A and D3B primers, Lane 9-*Pratylyncus* spp. ITS primer

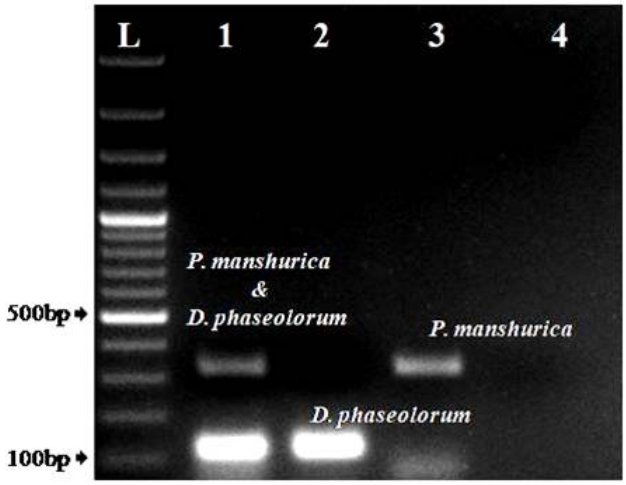


Fig. 3.8. Duplex PCR for detection of *D. phaseolorum* and *P. manshurica* in soybean

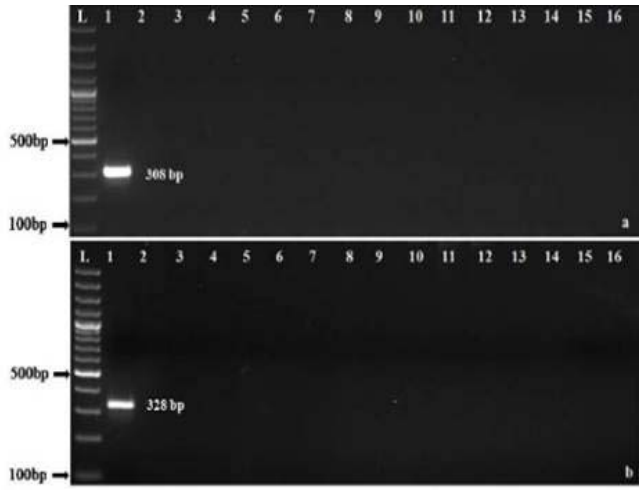


Fig. 3.9. Species-specific molecular markers developed for *Tilletia barclayana* infecting

Type Culture Collection (ITCC) and *Burkholderia glumea* received from Division of Plant Pathology, IARI, New Delhi. Designed of specific primers for *Xanthomonas citri* pv. *malvacearum*.

DIVISION OF PLANT QUARANTINE

Development of diagnostics for Insects

- Developed DNA barcode for *Callasobruchus maculatus*, *Callasobruchus chinensis*, *Sitophilus oryzae*, *Rhizopertha dominica*, *Bruchuslentis* and *Tribolium castaneum* (Fig. 3.10).

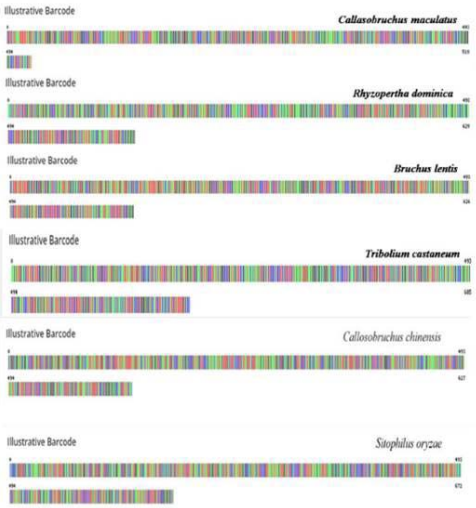


Fig. 3.10. DNA barcode developed for insects

- Developed three sets of species-specific molecular markers for detection of *Rhizopertha dominica* (Fig. 3.11).

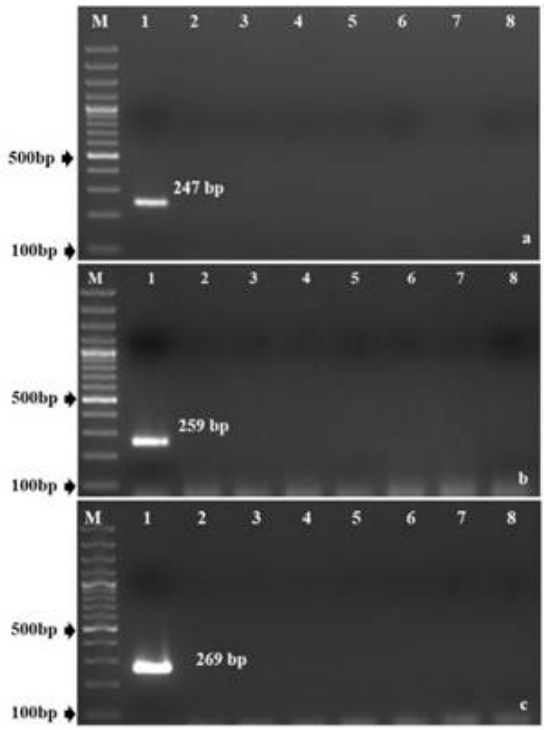


Fig. 3.11. Species-specific molecular markers for *Rhizopertha dominica*

3.5.2. Mainstreaming rice landraces diversity in varietal development through genome-wide association studies: A model for large-scale utilization of genebank collections of rice (Component II)

Phenotyping of rice landraces against sheath blight (Rhizoctonia solani) under artificially inoculated conditions

For large scale phenotyping of rice landraces against Sheath blight (SB) caused by *Rhizoctonia solani* under artificial inoculation in field condition, 1844 accessions with 5 checks *viz.* C1-Pusa 44, C2-IR 64, C3-Swarna, C4-Jaya and C5 Pusa Samba 1850were sown, only 1463 accessions could get established (Fig. 3.12). Artificial inoculation of *R. solani* colonized typha pieces five plants per accession (1463 acc.) was done at the maximum tillering stage. The observation revealed that the incubation period varied from 3-10 days. The relative lesion length was calculated in relation to plant height which ranged from 7.71 - 66.16 cm. according to 0-9 standard evaluation system scale (<20-R, 20-30-MR, 31-45-MS, 46-65-S and 65-HS>) adopted by IRRI. There are only eleven accessions *viz.*IRGC-1413 (7.71%), IRGC-1685 (7.74%), RL-4630 (8.00%), IRGC-460 (8.05%), RL-3930 (8.29%), RL-9719 (8.34%), IRGC-231 (8.49%), IRGC-1069 (8.54%), RL-9930 (8.55%), IRGC-1642 (8.70%) and IRGC-1388 (8.75%) that showed resistance against sheath blight and remaining accessions were either susceptible or highly susceptible (Fig. 3.12).

3.5.3. Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery (Subproject-3; Component-4) Identification of biotic stress (Root rot) tolerant sesame genotypes

A total of 1771 accessions of sesame germplasm have been evaluated during *Kharif* 2023 against dry root rot (*Macrophomina phaseolina*) under natural field conditions and 389 accessions were found infected with *M. phaseolina*. Association of dry root rot has been confirmed by isolation of pathogens. The identity of pathogen i.e. *M. phaseolina* was confirmed by classical taxonomy and sequence of ITS gene.

3.5.4. Mainstreaming of sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Sub-Project 3: Component 1 Phyllody

A total of 1360 accessions of sesame germplasm have been evaluated against phytoplasma under field conditions during kharif 2023 and 511 accessions were found to be highly resistant. A total of 84 accessions found free from phyllody disease in different locations are being evaluated under artificial conditions using dodder transmission. Association of phyllody with phytoplasma has been confirmed using nested PCR. Also, transmission of phytolasma from sesame to *Catharanthus roseus* was successful using various grafting methods and association of phytoplasma has been confirmed using nested PCR. Phyllody samples collected from various locations across the country were tested and presence of phytoplasma was confirmed using nested PCR.

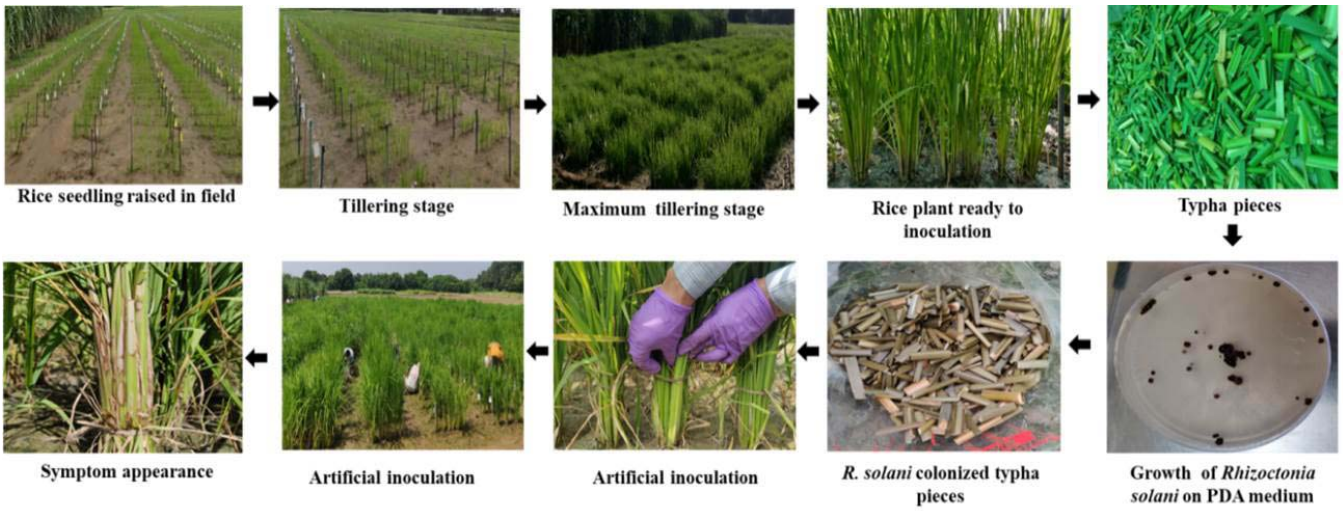


Fig. 3.12. Schematic picture represents phenotyping against Sheath blight (*R. solani*)

Research Programme (Code: Title**, PI,** CoPIs and*Associates***)**

PGR/DPQ- BUR-DEL-01.01 Detection and identification of fungi and bacteria in quarantine and supportive research (**Jameel Akhtar**, Pardeep Kumar, Bharat Raj Meena (till March 29, 2023) and *Ashok Kumar Maurya), Smita Lenka* (from Sept. 5, 2023)

PGR/DPQ-BUR-DEL-01.02 Detection and Identification of Viruses in Quarantine and Supportive Research. (**V Celia Chalam,** Pooja Kumari, *AK Maurya), Smita Lenka* (from Sept. 1, 2023)

PGR/DPQ-BUR-DEL-01.03 Detection and Identification of Insect and Mite Pests in Quarantine and Supportive Research (**Kavita Gupta,** *DS Meena*)

PGR/DPQ-BUR-DEL-01.04 Detection and Identification of Nematode Pests in Quarantine and Supportive Research (**Zakaullah Khan,** Bharat H Gawade)

PGR/DPQ-BUR-DEL-01.05 Detection and Identification of Intercepted Weeds in Quarantine and Supportive Research (**MC Singh,** MB Priyadarshi and *DS Meena*)

PGR/DPQ-BUR-DEL-01.06: Quarantine treatments for disinfestation/ disinfection of germplasm under exchange against different pests and supportive research **(Bharat H Gawade**,Kavita Gupta, MC Singh, KS Hooda, Jameel Akhtar, Pardeep Kumar, Bharat Raj Meena (till March 29, 2023), Pooja Kumari, *Ashok Kumar Maurya* and *DS Meena*)

PGR/DPQ-BUR-DEL-01.07: Seed-health testing for conservation of indigenous germplasm free from pests **(Pardeep Kumar**, VC Chalam, Kavita Gupta, MC Singh, Zakaullah Khan, Jameel Akhtar, Bharat H Gawade, Bharat Raj Meena (till March 29, 2023), Pooja Kumari, Veena Gupta (till Aug 31, 2023), Sushil Pandey, Sandhya Gupta, *AK Maurya, DS Meena* and *Smita Lenka*) (from Sept. 1, 2023)

Externally Funded Projects

- National containment/ quarantine facility for transgenic planting material Phase IV Component A: **V Celia Chalam**, Kavita Gupta, Z Khan, Jameel Akhtar (DBT)
- Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Sub-Project 3: Identification of Biotic Stress (Phyllody & Dry Root Rot) Tolerant Sesame Genotypes (DBT)
  - **Component 1** Phyllody: **V Celia Chalam,** Kavita Gupta, Pardeep Kumar, Pooja Kumari
  - **Component 4** Dry Root Rot: **Pardeep Kumar**, V Celia Chalam; Kavita Gupta
- Leveraging genetic resources for accelerated genetic improvement of Linseed using comprehensive genomics and phenotyping approaches (DBT)
  - **Sub-Project 4: Component 6** -Evaluation of Linseed Germplasm for Major Biotic Stresses (*Alternaria* blight and Linseed bud fly **Kavita Gupta**, Mamta Singh.
- Mainstreaming of rice landraces diversity in varietal development through Genome wide association studies: A model for large scale utilization of genebank collection of rice (Phenotyping of rice landraces against sheath blight (*Rhizoctonia solani*) (DBT) Co-PI:Jameel Akhtar

4 DIVISION OF GERMPLASM EVALUATION

सारांशः सीआरपी–एग्रोबायोडायवर्सिटी परियोजना के अन्तर्गत विभिन्न कृषि–बागवानी फसलों के कुल 31,251 परिग्रहणों को कृषि–रूपात्मक लक्षणों (14,325 परिग्रहण), जैविक तनाव (4,919), अजैविक तनाव (2,722) और गुणवत्ता मापदंडों (9,285) के लिए मूल्याँकन किया गया था। गेहूं (3,393), खेसारी (3,792), सांवा (1,888), ट्रिटिकेल (1,180), मिर्च (1,000), तिल (763), जंगली विग्ना (300), मूंग (400), रेपसीड और सरसों (400), अलसी (268), मक्का (200) सब्जीवाली लोबिया (197), सोयाबीन (89), बाकला (70) और कुट्टू (85) के जननद्रव्यों का लक्षणवर्णन एवं मूल्यांकन किया गया। विभिन्न जैविक तनावों के विरुद्ध कुल 4,919 परिग्रहणों का मूल्यांकन किया गया। इनमें स्पॉट ब्लॉच के लिए जौ कोर संग्रह के 678 परिग्रहणशामिल थे। एस्चोकाइटा ब्लाइट के लिए 100 जंगली चना परिग्रहण, और YMD प्रतिरोध के लिए 14 सोयाबीन परिग्रहण, MLB प्रतिरोध के लिए 111 मक्का परिग्रहण, chiLCD के लिए 180 मिर्च परिग्रहण, पौडेरी मिल्डेव के लिए 208 मटर परिग्रहण, अल्बुगो कैंडिडा के विभिन्न आइसोलेट्स के विरुद्ध 311 ब्रैसिका परिग्रहण। सफेद रतुआ रोग, चॉकलेट स्पॉट प्रतिरोध के लिए बाकला की 23 प्रविष्टियाँ। इसके अलावा, अलसी में बड फ्लाई टॉलरेंस (195) और अल्टरनेरिया ब्लाइट (244) के लिए संदर्भ सेट विकसित किए गए और हॉटस्पॉट स्थानों पर उनका मूल्यांकन किया गया। अजैविक तनाव सहनशीलता के लिए, गर्मी सहनशीलता के लिए ब्रैसिका (402), संयुक्त गर्मी और सूखा सहनशीलता के लिए जौ कोर संग्रह (678) और गेहूं (647), टर्मिनल ताप तनाव के लिए अलसी कोर संग्रह (259) सहित कुल 2,722 परिग्रहणों का मूल्यांकन किया गया। सूखा सहनशीलता के लिए अलसी संदर्भ सेट (200), लवणता सहनशीलता के लिए मूंग कोर संग्रह (400) और जौ मिनी कोर संग्रह (110) और ठंड सहनशीलता के लिए मिर्च (26)। विभिन्न अनाजों (4,833), तिलहनों (2,425), फलियां (474), सब्जियों (578), फलों की कुल 8,556 प्रविष्टियाँ। (17) और संभावित फसलों (229) का मूल्यांकन महत्वपूर्ण जैव रासायनिक लक्षणों के लिए किया गया, जबकि फाइटोकेमिकल मूल्यांकन विभिन्न औषधीय और सुगंधित पौधों से संबंधित 318 परिग्रहणों के लिए किया गया था। कृषि–जैव विविधता–पीजीआर घटक–II पर सीआरपी के तहत, रबी 2022–23 के दौरान कुल 455 गेहूं परिग्रहणों का मूल्यांकन जैविक तनाव के लिए किया गया था और भारतीय सरसों के जननद्रव्य के 1,000 परिग्रहणों का मूल्यांकन स्क्लेरोटिनिया और ओरोबंकी सहनशीलता के लिए किया गया था। गुणवत्ता मानकों के लिए गेहूं के 411 परिग्रहणों का मूल्यांकन किया गया। अलसी में आनुवंशिक आधार वृद्धि के लिए पूर्व–प्रजनन किया गया। ईसापुर फार्म में फील्ड जीनबैंक में बहुउद्देशीय वृक्ष प्रजातियों को स्थापित करने के प्रयास किए गए हैं। कम उपयोग किए गए फलों, मेवों और चारे सहित आरईटी और बहुउद्देशीय वृक्ष प्रजातियों के जननद्रव्यों को एकत्र किया गया और 21 प्रजातियों के जननद्रव्यों को जोड़ा गया जिससे कुल एकत्रित प्रजातियों की संख्या 101 हो गई। इस अवधि के दौरान विभिन्न जननद्रव्य जागरूकता–उन्मुख कार्यक्रम जैसे बार्नयार्ड मिल्लेट्स विविधता, जननद्रव्य विविधता दिवस, पीजीआर जागरूकता सह–स्वच्छता अभियान, 'अपशिष्ट से धन' पर किसान गोष्ठी और 'स्वच्छता कार्यक्रम' का आयोजन किया गया। आईसीएआर संस्थानों, राजिये विश्वविध्यालयों और अन्य अनुसंधान संगठनों से संबंधित मांगकर्ताओं को विभिन्न फसलों की कुल 4,983 परिग्रहणों को प्रदान किया गया।

Summary: During 2023, a total of 30,951 acc. of various agri-horticultural crops were multiplied/characterized/evaluated for agro-morphological traits (14,025 acc.), biotic stress (4,919), abiotic stress (2,722) and quality parameters (9,285). Wheat (3,393 acc.), grasspea (3,792 acc.), barnyard millet (1,888 acc.), triticale (1,180 acc.), chilli (1,000 acc.), sesame (763 acc.),wild *Vigna* (300 acc.), mungbean (400 acc.), rapeseed and mustard (400 acc.), linseed (268 acc.), maize (200 acc.), vegetable cowpea (197 acc.), soybean (89 acc.), fababean (70 genotypes) and buckwheat (85 acc.) were characterized/ evaluated at ICAR-NBPGR, New Delhi. A total of 4,919 acc. comprising barley core collection (678 acc.) for spot blotch, wild *Cicer* sp. (100 acc.) for *Ascochyta blight*, mungbean core collection (400 acc.) and soybean (14 acc.) for YMD resistance, maize (111 acc.) for MLB resistance, chilli (180 acc.) for chiLCD and (286 acc.) for anthroenose, garden pea (208 acc.) for powdery mildew, *brassica* (311 acc.) against diverse isolates of *Albugo candida* causing white rust disease, fababean (23 entries) for chocolate spot resistance were evaluated. In addition, reference sets for bud fly tolerance (195 acc.) and *Alternaria blight* (244 acc.) in linseed were developed and evaluated at hot spot locations. For abiotic stresses tolerance, a total of 2722 acc. belonging to different crops were evaluated which comprised *Brassica* (402 acc.) for heat tolerance, barley core collection (678 acc.) and wheat (647 acc.) for combined heat and drought tolerance, linseed core collection (259 acc.) for terminal heat stress, linseed reference set for drought tolerance (200 acc.), mungbean core collection (400 acc.) for salinity tolerance, barley mini core collection (110 acc.) for salinity stress and chilli (180 acc.) for cold tolerance and (217 acc.) for heat tolerance. A total of 8,556 acc. of different cereals (4,833 acc.), oilseeds (2,425 acc.), legumes (474 acc.), vegetables (578 acc.), fruit sp. (17 acc.) and potential crops (229 acc.) were evaluated for important biochemical traits, while phytochemical evaluation was done for 318 acc. belonging to different medicinal and aromatic plants. During *rabi* 2022-23,under CRPAB-PGR Component- II, a total of 455 wheat acc.were evaluated for biotic stresses (yellow, black, brown rusts and powdery mildew); 500 acc. of lentil were evaluated for wilt, rot and salinity and 1000 acc.of Indian mustard were evaluated for Sclerotinia rot resistance and Orobanche tolerance and 411 acc. of wheat were evaluated for quality parameters.Pre-breeding for genetic base enhancement was done in flax.Efforts have been taken to establish multipurpose tree species in Field Genebank at Issapur farm. Germplasm of 21 species of RET and multipurpose tree species including underutilized fruits, nuts and fodder were collected and were added in Field Genebank. During the period, various germplasm awareness-oriented programs such as Barnyard Millet Fieldday, Germplasm Diversity Day, PGR Awareness cum cleanliness drive, Kisan Gosthi on 'Waste to Wealth' and 'Swachhata Programme' were organized. A total 4,983 acc. of various crops were supplied to indenters belonging to ICAR institutes, SAU and other research organizations.

4.1. Characterization and evaluation of cereal genetic resources

4.1.1. Characterization and evaluation of wheat germplasm

A total of 2,632 wheat acc. including repatriated germplasm from the Australian Genebank were grown for characterization and evaluation using 34 agro-morphological descriptors at NBPGR, Pusa Farm in ABD using 5 checks PBW-343, HD2733, PBW752, PBW757, HD2932. 761 acc. of *Triticum durum* were also evaluated using 5 checks HI-1531, HI8663, HI8627, UAS428, MACS4028 at Issapur Farm in ABD. There was a good range of variability for different traits in wheat germplasm. Promising acc. for some agronomic traits are given in Table 4.1.

4.1.2. Characterization of Triticale Germplasm Conserved in National Genebank

A total of 1,180 triticale acc. were characterized at Issapur Farm using 32 agro-morphological descriptors in ABD with 4 checks TL1210, TL2942, TL2995, TL2915 replicated in each block. Superior acc. identified for different agronomic traits are given in Table 4.1.

4.1.3. Characterization and evaluation of maize germplasm

During *kharif* 2023, 200 maize acc. were characterized and evaluated for various traits and promising acc. identified are listed in the Table 4.1.

4.1.4. Characterization and evaluation of barnyard millet (*Echinochloa spp.*) germplasm

A total of 1,888 accession of barnyard millet (*Echinochloa spp.*) has been grown for their agro-morphological characterization in ABD with 4 checks. Phenotypic data were recorded based on 23 morphological descriptors.

4.2. Characterization and evaluation of pulses genetic resources

4.2.1. Characterization of wild *Vigna*

A total of 300 acc. of 34 wild *Vigna* species were characterized under protected conditions under ABD using 45 different agro-morphological descriptors (28 qualitative & 17 quantitative traits). The data was recorded at appropriate stages of crop growth when the characters were fully expressed. Acc. with superior traits were identified that can be utilized in the cultivated *Vigna* improvement program.

Table 4.1: List of promising acc. for important agro-morphological traits in cereals

Crop/species	Trait	Promising acc.
Triticum aestivum	Days to heading (< 73)	IC0321987, IC253015, IC0113224, IC111845, IC543356
	Grains per spike (> 93)	KOPERGAON BAXI, IC539315, IC445524, IC416198
	1000 grain weight (>60 g)	INDIA 92, IC0111655, PUSA 106, IC539315, IC0112035
T. durum	Days to heading (< 76)	IC335939, IC35088, IC335923, IC375867, IC277748, IC113731, IC335932, IC35089, IC535462, IC547663
	Grains per spike (> 81)	EC574108, EC445349, IC445528, EC295392, IC416292, EC295474, EC276887, IC596979, IC335620, IC277747
	1000 grain weight (>62g)	IC296483, IC335772, IC553919, IC464099, IC252569, IC296756, EC299082, EC277013, IC78841, IC252755
Triticale	Days to heading (< 75)	IC0544453, IC0544454, IC0544452, IC0604320, IC0544435, IC0606608, IC0543544, IC0543549, IC0543566, IC0543567
	Grains per spike (> 99)	IC0544280, IC0544026, IC0544309, IC0544221, IC0544022, IC0544047, IC0544286, IC0543885, IC0544031, IC0543717
	1000 grain weight (>59g)	IC0642663, IC0543861, IC0544151, IC0543856, IC0544037, IC0544153, IC0544062, IC0544291, IC0544049, IC0544056
Maize	Days to 50%Tasselling (<35)	IC280347, IC 280384, IC443805, IC447814
	Ears/Plant (>3)	IC297826, 297835, IC209808, IC297847, IC448825
	Plant Height (dwarf) (<120 cm)	IC337350, 1C344658, IC391315, IC344658, IC209791
	Plant Height (tall) (>250 cm)	IC262797, IC396871, 447196, IC524324, IC526499
	Ear Length (cm) (>18 cm)	IC417656, IC411777, IC568221, IC209783, IC624629
	Kernels/Row (>32)	IC331939, IC538031, IC209783, 1C617877
	100-grain weight (g) (>35)	IC556397, IC556403, IC209817, IC624629, EC 618174

4.2.2. Phenotyping of grasspea germplasm using agro-morphological descriptors

During Rabi 2022-23, a total of 3,792 acc. of grasspea were characterized. Among these, 2,786 (2,697 Indigenous and 89 Exotic) acc. collected from National Genebank(NGB) with 5 Checks (C1-Bari Khesari-3, C2-Mahateora, C3-Prateek, C4-Ratan, C5-Waise) were characterized for 21 agro-morphological descriptors at Issapur farm using ABD. Remaining 700 acc. received from ICARDA were characterized for 17 agro-morphological descriptors (5 Qualitative, 12 Quantitative) at Issapur farm in P-rep design. Besides this, 256 acc. from the South Asia Panel were also characterized.

4.2.3. Characterization of vegetable cowpea

During *kharif* 2022, a total of 197 acc. conserved in the NGB were characterized. This includes eight exotic (Australia, Nigeria, Italy & Philippines) and 189 indigenous collections (Collected from 21 states including union territories of India). These acc.were grown under protected conditions in an ABD and characterized using 36 distinct agro-morphological descriptors, comprising 19 qualitative and 17 quantitative traits, which were recorded at appropriate stages of crop growth (Fig. 4.1). Based on the mean performance of the acc. for targeted traits, acc. such as IC622563(28), IC546883(28), IC630384 (29), IC626171 (29), IC382942(30) and EC724293(31) showed early flowering. The acc. namely EC738116 (80.2 cm) observed with the maximum pod length with the highest pod weight (38.77 g). The maximum number of seeds per pod was reported in IC471939 (22) and IC630391 (21). The acc. such as IC614769, IC626141, IC630380, IC626155, IC630386, IC626157 were identified as Yellow Mosaic Disease (YMD) resistant.

4.2.4. Characterization and evaluation of mungbean germplasm

The 400 acc. were evaluated to identify the superior acc. having better nodulation (rhizobium) density and biomass under field conditions. A great range of variation was observed for the root nodule numbers/plant and fresh rood nodule weight. The average number of nodules for five plants ranged from 5.8 to 157.6, while total fresh nodule weight (5 plants) ranged from 0.02 to 4.11 g; and nodule dry weight (5 plants) ranged from 0.01 to 0.97 g. Variation in terms of coefficient of variation (%) was identified as 53.91, 72.39 and 63.62 for the number of nodules/plant, 5 plant fresh nodule weight and 5 plant dry nodule weight respectively.

4.2.5. Improvement of fababean for yield traits

Two Faba bean trials were conducted during *Rabi* 2022-23 at Issapur farm to evaluate and select superior genotypes for vegetable purpose and seed purpose. Trial I comprising of 35 pod-type genotypes including 5 checks was conducted in RBD with three replications. Among checks, Hudeiba-93 was the best for pod yield. Nine genotypes produced significantly higher pod yield than the best check (Table 4.2). In Trial-II, 35 seed type genotypes including 4 checks were evaluated in RBD with three replications. Among checks, Hashbenge was best for seed yield. Seven genotypes produced significantly higher seed yield than the best check (Table 4.3). These trials will be repeated during Rabi 2023-24 for confirmation of results and genotypes performing consistently superior will be introduced into AICRP for multi-location testing.

4.2.6. Fababean as intercrop

A field experiment was conducted during 2021-23 (second season) at Issapur Farm to test the feasibility and profitability of fababean intercropping in autumn sugarcane, winter maize and chickpea so that the area and production of fababean, a potential crop, can be enhanced especially in sugarcane belt of sub-tropical India. The main crops like sugarcane and maize were planted/sown in different staggered row spacing and fababean was introduced as intercrop in additive series. Whereas, in the case of chickpea,

Fig. 4.1. Characterization of vegetable cowpea

Table 4.2: Evaluation of Fababean (Pod type) for yield and yield attributes (second year)

Identity	Plant height (cm)	Branches/ plant	Days to 50% Flowering	Pods/ plant	Pod length (cm)	Pod width (mm)	Days to 80% maturity	Pod Yield (q/ha)	Test weight (g)
ET252777	93.11	4.89	63.33	23.00	9.69	13.74	132.67	**174.30**	67.29
ET272856	91.44	5.67	69.33	27.67	8.97	14.48	126.67	**165.95**	73.45
ET273780	124.22	6.16	72.33	25.00	11.17	15.54	129.00	**174.64**	73.31
ET273786	95.33	5.33	70.00	37.00	8.20	10.20	120.00	**143.32**	63.97
ET273787	95.00	4.50	69.00	28.33	11.47	15.16	122.33	**161.70**	60.85
ET273804	104.67	4.67	85.00	21.00	8.70	13.75	125.00	**158.29**	59.56
ET273808	128.00	7.00	81.00	24.00	**12.94**	13.83	127.00	**139.59**	**78.34**
ET273820	126.78	6.44	**54.67**	42.33	7.46	10.04	130.33	**139.03**	76.15
ET273822	102.78	4.78	74.67	30.00	11.07	14.17	127.67	**165.96**	53.47
Ascot	79.82	3.33	76.00	22.00	7.93	11.17	122.00	50.82	44.60
Hama 2	105.53	6.50	73.33	18.00	11.13	**14.72**	127.33	79.32	61.00
Hudeiba 93	117.67	**6.67**	71.33	41.62	**11.37**	12.69	**121.67**	**131.53**	**68.74**
HFB 1	116.00	5.89	**68.00**	**71.33**	7.09	10.06	129.67	90.48	37.92
Vikrant	**132.67**	6.33	78.33	59.67	7.86	11.71	132.00	90.10	37.54
TrialMean	107.58	5.29	78.72	28.40	10.01	13.22	127.55	110.74	65.34
CD (0.05)	7.66	0.40	6.77	5.01	1.43	1.47	2.78	6.77	9.58
CV (%)	4.40	4.70	5.32	10.91	8.82	6.89	1.35	3.78	9.07

Table 4.3: Evaluation of Fababean (Seed type) for yield and yield attributes (Second year)

Identity	Plant height (cm)	Branches/ plant	Days to 50% Flowering	Pods/ plant	Days to 80% maturity	Seed Yield (q/ha)	Test weight (g)
252783	108.67	3.56	72.67	29.00	125.33	**25.24**	74.98
252793	131.00	5.22	68.67	33.67	132.33	**26.59**	83.02
272840	104.00	5.33	**50.33**	33.33	**121.67**	**23.50**	76.62
272845	130.22	4.33	77.67	27.67	130.00	**23.17**	80.81
273797	103.11	4.33	73.00	32.00	**120.33**	**26.64**	74.55
273827	109.78	5.33	75.00	28.67	127.67	**23.13**	86.08
292853	107.44	4.44	66.00	26.00	**118.00**	**24.07**	60.14
Hashbenge	121.89	5.44	**66.00**	23.67	129.67	**20.58**	69.63
HFB-1	111.00	6.00	75.67	**36.67**	131.67	16.11	37.12
Rebya-40	139.78	4.56	68.67	22.33	127.67	19.37	78.55
SLL	80.67	4.67	91.67	19.00	**125.67**	18.97	**82.65**
Vikrant	**141.89**	**7.33**	73.67	23.00	132.67	13.85	39.48
TrialMean	114.60	5.26	70.69	27.58	125.65	18.22	75.15
CD (0.05)	3.26	0.40	3.92	6.36	2.33	1.40	5.27
CV (%)	1.76	4.75	3.43	14.27	1.15	4.76	4.34

fababean was sown as intercrop in replacement series under different geometry. There were thirteen treatment combinations as given in Table 4.4. The field experiment was laid out in RBD with three replications. The varieties of fababean, sugarcane, chickpea and maize were HFB 1, Co 0238, Pusa 547 and Meethas, respectively. All the component crops were planted/sown in the month of November, 2021. The green pod of fababean was harvested for vegetable purposes. Intercropping fababean in winter maize and chickpea drastically reduced the yield of maize green cobs

Table 4.4: Performance of fababean intercropped in autumn sugarcane, chickpea and winter maize (sweet corn).

Treatments	Sugarcane							Fababean	Chickpea	Cane	B:C
	Tillers (000'/ ha)	Plant height (cm)	NMC (000'/ ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Cane yield (t/ha)	Green pod yield (t/ha)	grain yield (q/ha)/Maize green cobs (t/ha)	equivalent yield (t/ha)	
Sole Sugarcane 75 cm	148.22	289.4	88.27	257.7	2.46	1261	91.29	-		91.29	2.71
Sole Sugarcane 90 cm	107.04	294.1	81.93	259.1	2.48	1268	86.75	-		86.75	2.77
Sole Sugarcane 75 cm + faba bean (1:2)	133.56	299.0	92.17	262.5	2.48	1271	93.42	15.46		136.12	2.76
Sole Sugarcane 90 cm + faba bean (1:2)	106.30	296.8	87.33	265.2	2.55	1313	91.88	14.87		132.95	2.89
Sugarcane (30:120)+ Faba Bean (2:3)	131.56	294.4	97.50	265.5	2.50	1296	109.11	13.60		146.67	3.05
Sugarcane (45:135)+ Faba Bean (2:4)	112.78	291.9	89.90	264.4	2.51	1300	101.44	13.77		139.48	3.01
Chickpea + faba bean (2:2) - sugarcane	76.11	268.1	78.90	234.6	2.34	1036	69.33	8.65	3.56	98.65	2.14
Chickpea + faba bean (3:3) - sugarcane	81.94	263.5	77.50	233.5	2.30	1037	69.22	8.44	4.21	98.93	2.15
Sole chickpea - sugarcane	76.11	264.6	76.93	225.1	2.29	1018	67.56	-	11.45	84.95	2.11
Maize + faba bean (1:1) - sugarcane	65.28	259.8	72.83	228.9	2.28	1008	68.89	10.21	12.29	131.02	2.47
Maize (30:90) + Fababean (2:2) - sugarcane	73.61	254.1	73.63	219.1	2.25	1021	69.10	10.86	19.29	151.64	2.78
Sole maize - sugarcane	66.94	257.2	70.40	221.0	2.21	1016	66.41	-	29.49	147.86	3.24
Sole fababean - sugarcane	73.33	264.0	76.07	230.1	2.37	1085	74.78	15.06		116.38	2.32
SEM	6.68	7.75	4.43	7.6	0.06	44	4.28	0.56			
CD	16.72	19.40	11.10	19.0	0.15	110	10.72	1.41			

(35.5 to 58 %) and chickpea grain yield (63.2 to 68.9 %) over sole maize and chickpea, respectively, in addition to lower fababean green pod yield. However, winter maize – sugarcane system fetched the highest income with the highest B:C ratio of 3.24. Among the treatments on intercropping, Fababean, as intercrop in sugarcane was found most profitable, not only it produced additional yield of intercrop (fababean) but also enhanced sugarcane yield. Intercropping fababean with sugarcane (planted in staggered spacing of 30:120 cm) with three rows of fababean on 120 cm space between sugarcane rows yielded 13.6 t/ha green pods of fababean as compared to sole fababean (15.06 t/ha), and the highest sugarcane yield (109.1 t/ha) that resulted into cane equivalent yield of 146.7 t/ha with B:C ratio of 3.05, cane yield was significantly higher to the tune of 20% over sole sugarcane (75 cm). The increase in sugarcane yield was due to enhancement in yield attributes of sugarcane (NMC, cane length and single cane weight). It was also observed that sugarcane yield was higher (2.3 to 5.9 %) in sugarcane (75 cm) + fababean (two rows) and sugarcane (90 cm) + fababean (two rows) intercropping system, respectively, over sole sugarcane (75 cm and 90 cm) due to the intercrop (fababean). Fababean as intercrop might

have improved the rhizospheric and atmospheric micro-environment conducive to sugarcane growth. Thus, intercropping fababean with sugarcane was profitable and fetched additional income to the farmer.

4.3. Characterization, evaluation and documentation of oilseeds genetic resources

4.3.1. Characterization and evaluation of Brassica germplasm

Rapeseed-mustard germplasm (900 acc.) were evaluated for morphological traits, validation (400), and vegetable type (73). Validation of 400 Indian mustard germplasm was done at NBPGR Farm, New Delhi in ABD with 5 checks and found promising set for early maturity, primary branches, silliqua on main shoot, bold seeded, high oil content (>45%) (Table 4.5).

4.3.2. Identification of trait-specific germplasm in sesame and validation of core set

Sesame germplasm core set (763 accs. comprising EC-269 & IC-494 accs.) representing 20 countries and 23 states within India has been developed and validated phenotyping of 6500 acc. and the trait-specific reference set also developed for different agro-morphological traits (Table 4.5, Fig 4.2).

4.3.3. Identification of trait-specific germplasm in linseed

The reference sets (268 acc.) for agro-morphological traits - early flowering & maturity (75 acc.), bold seeds & capsules (59 acc.), technical height (44 acc.), TSW (29 acc.), capsules/plant (24 acc.) seeds/capsule (10 acc.) and early plant vigour (27 acc.) were developed after multi-environment phenotyping of 2800 acc. for 4 seasons (2018-19 to 2021-22) and validated at NBPGR farm, IARI, New Delhi (Fig. 4.5).

4.3.4. Validation of soybean genotypes for early maturity at ICAR-NBPGR, New Delhi

A set of earlier identified 89 soybean acc. were evaluated for their flowering and maturity in ABD along with three checks NRC 130, NRC 138 and JS 20-34. The promising early maturing acc. are shown in Table 4.5, Fig. 4.3.

Table 4.5: List of promising acc. for important agro-morphological traits in oilseeds

Crop/species	Trait	Promising acc.
Rapeseed mustard	Early maturing (<98 days)	EC389888 (86), EC766298(95), IC399887 (96), **Best Check:RH 30 (121)**
	Main shoot length (>125cm)	EC766276 (137), IC491617 (130.7), EC765692 (130.5), EC262154 (130.4), IC267705 (126.7), IC121668 (128.3), **Best Check:PM 28(96.12)**
	Silique on main branch (>90)	EC766292 (87.7), EC262154 (97), IC422161 (95), IC491556 (92.3), IC491617 (90.6), **Best Check:PM 32 (75.83)**
	Seeds/silique (>20)	EC766092, EC333580, EC657071,IC422177 (21), **Best Check: Pusa Tarak (16.6)**
	Silique length(>6 cm)	IC261633 (6.2), IC296827 (6.2), **Best Check:Pusa Bold (4.5)**
	1000 Seed wt. (>5.5g)	IC267699 (6.1), IC386740(5.9),174-1(5.9), IC422161 (5.6), **Best Check : Pusa Tarak (4.5)**
Sesame	Determinate Type	IC23322, IC204145, IC204321, IC52359, IC383307
	Dwarf type (75 cm)	EC346897, IC145534, IC131840
	Mono stem	IC418023, EC370992,EC346441, IC129711, EC346784
	Capsules/plant (>260)	EC370872, EC350647, IC132600, IC385281, IC73165, IC383325, IC129711
	Days to maturity (70-65 d)	IC511072, EC346863, EC346748, EC346713, IC500289, IC204044, IC205637
	Seed test weight (>4 g)	IC132000, IC131783, IC511072, IC306066
	Multi capsule (3-5/axil)	IC132357, IC204855, IC281101, IC16240, IC205787, IC205637, EC 347109
	Yield per plant (>30 g)	IC43002, IC383284, EC351897, IC205729, EC335011, IC203953, IC418034
Soybean	Extra early genotypes (<85days)	EC1037650, EC0034081, EC0034401, EC1037782, EC1037786, EC1037646, EC0034359, I-1986, EC0039500, EC37104, IC0262159, EC0034343, EC1037635, IC0501341, EC1037637, EC993214
	Early genotypes (86-95 days)	EC0038125, EC0037078, IC0007840, IC0501588, EC0572136-1, I-521, IC0501224, EC0457120, EC0034402, I-1000, IC0012886, I-77, EC0572136-2, EC0039061, EC771219, EC993555
	Days to podding (< 85 days)	EC1037782, EC1037646, EC37104, EC1037650, EC0034081, EC0034401, EC0034359, EC1037786, EC1037637, EC34107, EC0034343, EC1037635, EC993214, I-77, EC771219

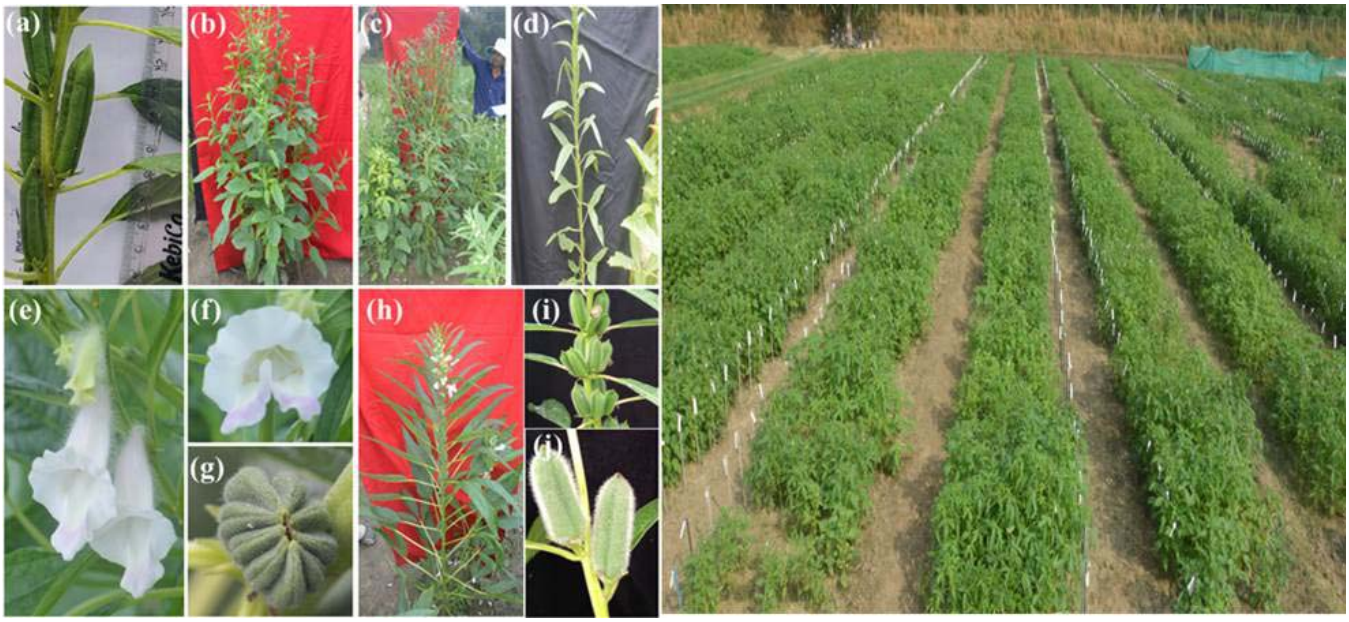
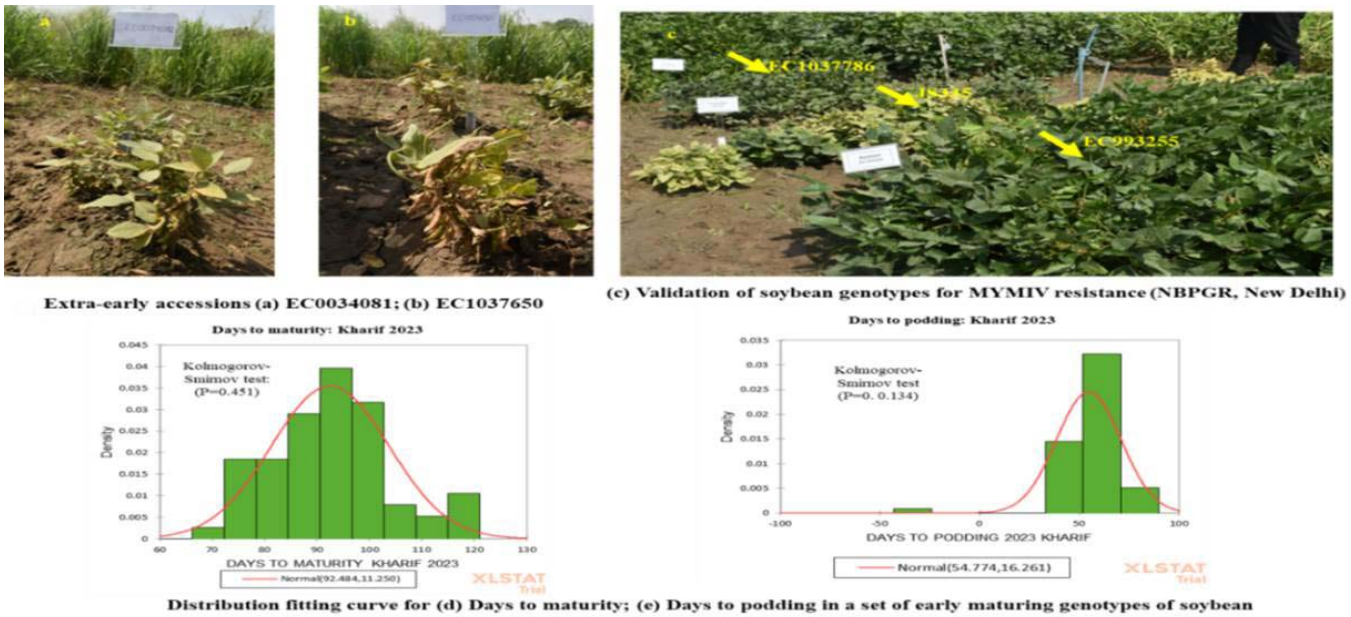


Fig. 4.2. Trait specific sesame germplasm.*a- Capsule length, b-Primary and secondary branching, c-Plant height, d-monostem, e- Corolla hairiness, f-Corolla with 2-lips, g-Locules per capsule, h-Short internode length, i-Casules per leaf axil, j-Capsule hairiness and Field View*



Extra-early accessions (a) EC0034081; (b) EC1037650

(c) Validation of soybean genotypes for MYMIV resistance (NBPGR, New Delhi)

Distribution fitting curve for (d) Days to maturity; (e) Days to podding in a set of early maturing genotypes of soybean

Fig. 4.3. Variability in soybean germplasm for maturity, days to podding and MYMIV tolerance

4.4. Characterization and evaluation of germplasm for core development in Chilli

One thousand acc. of chilli were grown for characterization and evaluation of various agro-morphological traits during spring-summer season, 2023 at ICAR-NBPGR, New Delhi (Fig. 4.4). Chilli acc. promising for various traits are listed in Table 4.6. Acc. IC265199 was recorded with the maximum number of fruits per exil i.e. 15 fruits/exil. One of the acc., EC405259 was identified with cherry tomato-like small round fruits which were highly pungent in taste. The accession EC362911 was identified with ornamental type small bushy plant habit producing many small light purple colour fruits and the accession IC353464 with long purple highly pungent fruits.

Fig. 4.4. Unique acc. of capsicum

Table 4.6: Promising acc. of chilli for agro-morphological traits

Trait	Promising Acc.
Days to 50% flowering (<30 days)	IC628679 (20), EC165831 (22), EC600015 (22), EC405259 (23), EC399552 (25), EC772771 (25.0), IC572471 (28),IC208595 (28), IC360866 (28.0), IC119485 (28), IC445618 (25.0), EC773142 (28.0), EC772772 (29), IC631916 (30), **Ckeck-Pusa Jwala (34)**
>5 flowers per inflorescence	IC265199 (15), EC769427 (12), IC099920 (9), IC119549 (8), EC769386 (7), IC119523(6), EC772705(6), EC392686 (8), IC116504 (6), **Check-Pusa Jwala (1-2)**
No. of fruits per plant	IC594882 (480), IC540997 (480), IC342449 (480), IC119205 (460), IC594881 (460), **Check-Pusa Jwala (275)**
Fruit length (cm)	EC784559 (11.9), IC572464 (11.8), EC806786 (11.8), IC505236 (11.7), EC806789 (11.7), EC784548 (11.6), EC737658 (11.5), EC784558 (11.4), EC784549 (11.3), EC773734 (11.3), IC119380 (11.2), EC402101 (11.2), IC326103 (11.2), EC784565 (11.2), EC784550 (11.2), IC112397 (11.1), EC787664 (10.9), EC784543 (10.9), EC777484 (10.9), IC313037 (10.9), EC787666 (10.9)**Check- Pusa Jwala (7.9)**
Pedicel length (cm)	EC378684 (7.6), IC594891 (6.3), EC784542 (5.6), EC784556 (5.4), EC784547 (5.3), IC505442 (5.3), EC784543 (5.2), EC737658 (5.2), EC806786 (5.2), **Check-LCA620 (3.5)**

4.5. Germplasm evaluation for biotic stress

4.5.1. Screening of barley core collection for spot blotch resistance

To find new resistance sources, the barley core collection (678 acc.) was screened under artificial epiphytotic conditions against *Bipolaris sorokiniana* at a hot spot location- Varanasi for the second consecutive year (*Rabi* 2022-23). Disease assessment was done by recording the disease severity on leaves at three different crop growth stages *viz.* flowering, milk and hard dough stage by employing the standard double-digit scale (00-99). The reaction of barley acc. against *B. sorokiniana* during two consecutive years of testing (2021-22 and 2022-23) revealed one accession namely, IC0533383 to be highly resistant and 2 acc. (EC0667512 and EC0667513) as moderately resistant to spot blotch based on the area under disease progress curve (AUDPC).

4.5.2. Screening of 100 wild *Cicer* species for *Ascochyta* blight

100 wild *Cicer* species, mostly from *C. reticulatum*, including 57 promising acc. of cultivated chickpea were screened for Ascochyta blight under artificial conditions to identify AB resistant sources. Four chickpea germplasm *viz*., IC275447, IC117744, EC267301, IC248147 and EC220109 which were earlier identified *Ascochyta* blight resistant after large-scale screening, were utilized for crossing with promising chickpea cultivars. These lines were also used for crossing with *C. reticulatum*, the progenitor species of cultivated chickpea. Important agronomic and morphological trait-specific germplasm were grown for validation of the traits to be utilized in pre-breeding programs.

4.5.3. Screening of mungbean for resistance to yellow mosaic disease (YMD)

The mungbean core set (400 acc.) was evaluated for yellow mosaic disease (YMD) in hot spot location (Delhi) under field conditions. Infector rows were planted in a regular interval for uniform spread of the disease. The required parameters were taken to quantify disease severity and disease incidence for all the acc.. The promising 12 acc. were also validated using the artificial infection using virulent whitefly (for MYMV) and agro-inoculation (for MYMIV).

4.5.4. Screening of maize germplasm for MLB resistance

A set of 111 derived lines from acc. (IC 283431, DC/S/I-23, DC/S/I-06, IC 617877, IC 617880, IC 656106) along with four checks *viz*.; CM-500 (susceptible), CM-600 (susceptible), DML-1390 (IC0620960) (resistant) and DML 1851 (IC0621040) (resistant) were evaluated in single row plot of 2m length at a spacing of 20 cm×75 cm during *Kharif* 2023 under artificial epiphytotic conditions at Delhi for exploring durable resistance to Maydis leaf blight (MLB) [*Bipolaris maydis* [(Nisikado & Miyake) Shoem] following ABD. The disease severity was recorded following a uniform rating scale of 1-9 ($\leq$3.0 = Resistant; >5.0 = Susceptible/highly susceptible) (Hooda et al., 2018). The disease data were analyzed in an augmented complete block design package developed by CIMMYT. The data analysis revealed that 12 lines *viz*.; 246-1 (1.8), 246-11 (2.0), 246-37 (2.0), 246-8 (1.9), 247-11 (1.8), 247-18 (2.3), 248-27 (1.4), 249-41 (2.1), 250-01 (1.2), 250-02 (1.1), 250-06 (1.9), 250-10 (2.1) were resistant to MLB (Score $\leq$3.0) compared to resistant checks viz.; IC0620960 (DML-1390) (Score 1.2), IC0621040 (DML-1851) (Score 1.5) and susceptible checks *viz*.; CM 500 (6.6) and CM 600 (7.7). The lines will be again exposed to artificial inoculated diseased conditions in subsequent yearsto confirm the resistance exhibited by these lines.

4.5.5. Screening of chilli germplasm against ChiLCD, mites and thrips

Among 180 acc. of chilli, 19 acc. namely EC769427, EC771555, EC737650, EC382017, EC559423, EC559426, EC692283, EC759975, EC784549, ECEC787662, EC787667, EC894553, EC362911, IC119427, IC119526, IC243314, IC353466, IC588539, IC607252, IC643853, IC594881, EC894553, EC784549, IC11927, IC119748, EC787119 (*C. frutescens*), EC787133 (*C. baccatum*), EC772795 (*C. baccatum*) were validated in third-year trial and identified as resistant to ChiLCD. The acc. IC643853, IC594881, EC769438, EC737650, EC771555, EC362911,CH781, CH532, EC772795 (*C. baccatum*) were identified as resistant to mites and thrips

4.5.6. Screening of garden pea germplasm against powdery mildew

A set of 208 germplasm acc. were screened against powdery mildew under natural field conditions. Phenotyping and genotyping results revealed that six acc. viz., EC598632, EC598656, IC279217, EC598616, EC598687 and EC387624 were resistant to powdery mildew.

4.5.7. Screening of brassica germplasm against diverse isolates of *Albugo candida* causing white rust disease

During *Rabi* 2022-23, phenotyping of 311 exotic and indigenous collections of *Brassica juncea* was done against eight diverse isolates of *A. candida* representing geographically distant locations, New Delhi (*Ndl*), Ludhiana (*Ldh*), Bharatpur (*Bpr*), Hissar (*Hsr*), Pantnagar (*Pnt*), Ranchi (*Ran*), SK Nagar (*Skn*) and Wallington (*Wlg*) at cotyledonary and true leaf stages under environment-controlled artificial inoculation. Five acc. were identified as highly resistant against multiple isolates

namely, IC265495 against *Ldh, Ndl* and *Skn* isolates, IC443623 against *Hsr, LdhNdl* and *Wlg* isolates, EC766061 against *Hsr*, *Ndl, Pnt* and *Ran* isolates, EC766193 against *Hsr*, *Ldh*, *Ndl*, *Pnt* and *Ran* isolates and EC766595 against *Bpr*, *Hsr*, *Ndl*, *Pnt, Ran* and *Skn* isolates. Out of eight isolates tested against indigenous and exotic collections, IC443623 showed a highly resistant response against four isolates i.e., *Ab-Hsr*, *Ab-Ldh*, *Ab-Ndl* and *Ab-Wlg*. Whereas, EC766595 showed a highly resistant reaction against six isolates i.e., *Ab-Bpr*, *Ab-Hsr*, *Ab-Ndl*, *Ab-Pnt Ab-Ran* and *Ab-Skn*. Further, all these acc. are highly resistant to *Ab-Ndl* isolate. These new sources of resistance against diverse isolates of *A. candida* will help to create a strong credential for discerning and mapping resistance-linked gene/QTL for sustainable management of white rust disease.

4.5.8. Evaluation of soybean germplasm for MYMIV at ICAR-NBPGR, New Delhi

A set of 14 soybean genotypes comprising 9 germplasm acc. and 5 checks were evaluated for MYMIV (mungbean yellow mosaic India virus) disease reaction in a replicated RBD. Three resistant (SL958, SL955 and Pusa 9712) and one susceptible check (JS335) as infector was planted after every three rows to ensure a uniform spread of the inoculation. Acc. EC993255, EC1037786 and I-1000 showed resistance to MYMV. Accession EC1037786 exhibited early maturity (< 85 days) coupled with MYMIV resistance.

4.5.9. Evaluation of linseed germplasm for resistance to bud fly (*Dasyneura lini* Barnes) infestation and development of Reference set

Under the Linseed network project "Leveraging genetic resources for accelerated genetic improvement of linseed using comprehensive genomics and phenotyping approaches", 2598 linseed germplasm acc. were screened for resistance to bud fly (*Dasyneura lini* Barnes) infestation at two natural hot-spot locations (Nagpur and Mauranipur) for 2020-21 and 2021-22 and a reference set of 195 acc. including 46 resistant, 94 moderately resistant and 55 moderately susceptible/susceptible germplasm was developed. The maximum bud fly incidence across all four environments ranged from 47.93% to 90.47%. Acc. EC0993391 and IC0633096 were identified as highly resistant (<5% bud fly damage) and IC0498795 and EC0099001 as resistant (<10% bud fly damage) and most stable genotypes over the eight tested environments for bud fly infestation.

4.5.10. Development and evaluation of Reference set for resistance to *Alternaria* blight in linseed germplasm

A reference set of 244 germplasm for *Alternaria* blight resistance identified through multi-location-year environments epiphytotic field conditions at hot spot locations (Kanpur and Raipur) was validated under the Linseed Network Project. In the field conditions at hot spot locations (Kanpur and Raipur), 14 acc. exhibited resistant reactions and 67 moderately resistant reaction against a mix inoculum of two isolates (Delhi and Kanpur) of *Alternaria lini*. Further, the screening under epiphytotic conditions at IARI, New Delhi revealed six genotypes namely-IC0385354, IC0499104, IC0523800, IC0591124, EC0718850 and IC0498580 as resistant against two isolates (Delhi and Kanpur). Among the wild type, 05 acc. (EC993387, EC1073070, EC1073113, EC1073116, EC1073127) exhibited resistant reactions at all the locations including artificial epiphytotic conditions at Delhi.

4.5.11. Evaluation of Fababean International Chocolate Spot Nursery

In this trial, 23 entries and 3 checks (Rebya-40, HFB-1, Vikarant) were evaluated in RBD with 3 replications during *Rabi* 2022-23 for resistance against chocolate spot disease. None of the entries possesses resistance to Chocolate spots. However, ET-226468, ET-226481, ET-226474 and ET-226469 have shown some tolerance to Chocolate spot disease. The experiment will be repeated during next crop season for confirmation of results.

4.6. Germplasm evaluation for abiotic stress

4.6.1. Development and evaluation of barley mini-core collection for salinity tolerance

A mini-core collection of barley germplasm was extracted from the barley core set germplasm (678 acc.). The mini-core collection was constituted of 107 acc..To identify novel donors imparting salt tolerance, barley mini-core collection comprising 107 *Hordeum vulgare* germplasm and 3 wild acc. from the National Genebank were evaluated under salt stress. The screening was done under salt stress (200 mM NaCl) at early growth and the adult plant stage based on morpho-physiological traits including salt uptake parameters. Further, the possible role of the candidate gene *Hordeum vulgare root abundant factor* (*HvRAF)*was studied by deciphering allelic variation and expression analysis in selected salt tolerant and susceptible acc.. Salinity caused a drastic reduction in growth and severely affected ion homeostasis resulting in a decline in grain yield by 65.35% compared to control. Acc. EC0578359, EC0578251, IC0547723, EC0123148, EC0299361, EC0177250 and IC0247671 were identified as the most promising salt-tolerant genotypes. Further investigation of allelic variation in *HvRAF* revealed a total of 26 SNPs, of which 10 were non-synonymous, 8 were synonymous and 5 were conserved. Haplotype variant analysis indicated two major haplotypic groups (Hap 1 and Hap 2) for *HvRAF,* of which Hap 2 was found to be more prevalent than Hap 1 (Fig. 4.5). Salt-tolerant phenotype exhibited the physiological basis of tolerance and upregulated

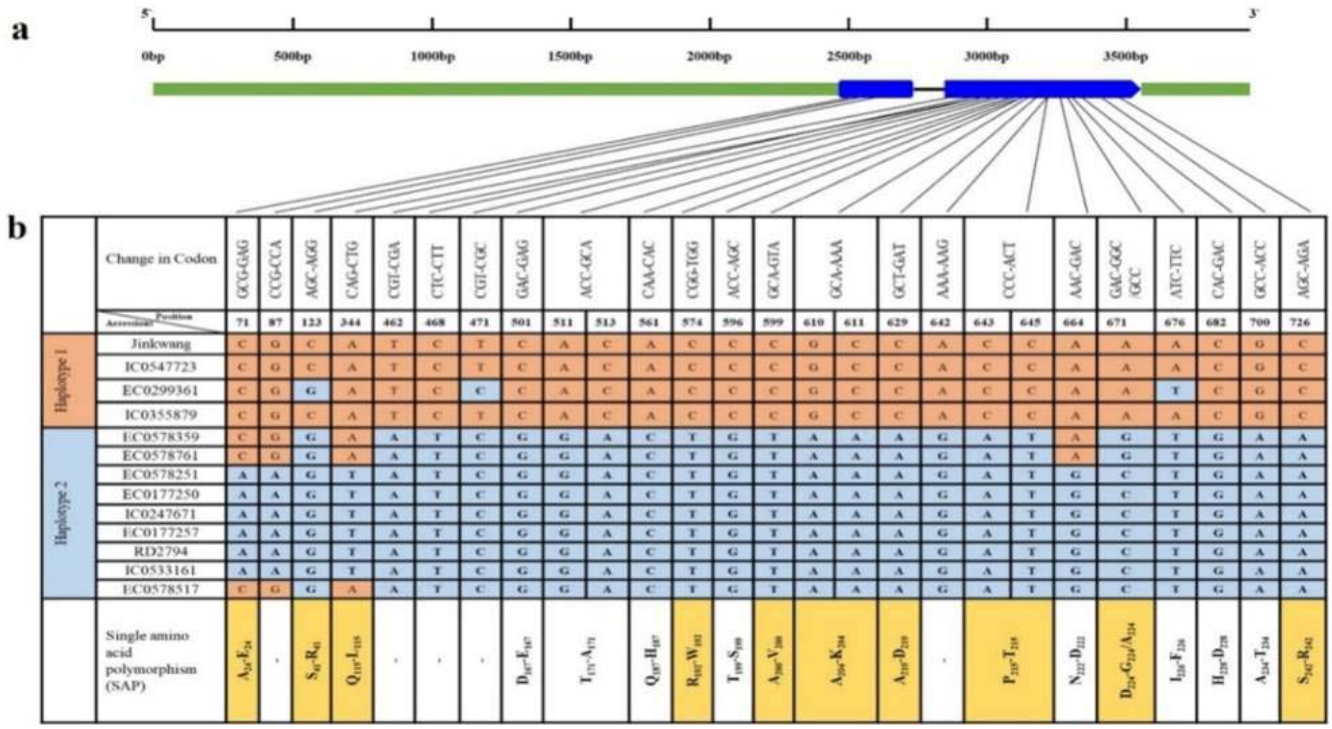


Fig. 4.5. Schematic representation of identification of two major haplotypes reconstructed for *HvRAF* gene across the selected panel of salinity tolerant and susceptible Barley accessions. (a) Gene structure of *HvRAF* representing the positional localization of SNPs in the exonic region; (b) The header of each column refers to base pair position of the variant relative to the start codon of *HvRAF* while the lowermost row represents the synonymous and non-synonymous single amino acid polymorphism (SAPs) highlighted in yellow coloured

expression of *HvRAF*, although none of the identified Hap groups could be associated with salt tolerance suggesting the governance of the trait by multiple loci.

4.6.2. Evaluation of barley core collection for terminal heat tolerance

Barley core collection (678 acc.) was evaluated for individual and combined heat and drought stress tolerance at ICAR-NBPGR, Issapur farm in ABD for the second consecutive year. Heat stress was imposed by growing plants under normal sown and late sown conditions and drought stress was imposed by withholding irrigation post-anthesis. Observations were recorded for various physiological (NDVI, canopy temperature, leaf area index, chlorophyll content, chlorophyll fluorescence) and agro-morphological traits. Promising germplasm for grain yield/plant: EC0578633, IC0397017, IC0445933 (>15 g) and hundred-grain weight: IC0138111, IC0138120, IC0138294 (>5g) were identified.

4.6.3. Screening of mungbean core collection for salinity stress tolerance

A total of 400 acc. of mungbean core collection were screened for salinity stress tolerance under hydroponics conditions. Standard nutrient media (Hoagland solution) was used for growing mungbean seedlings, and an incremental increase of salt (NaCl) concentration up to 150 mM was given for salinity stress. Along with the mungbean core collections prominent mungbean varieties *viz*. IPM2-14, IPM02-3, SML668, MH421 and PDM139 were repeated in each try to check the environmental variation. Salt stress was quantified based on the parameters *viz*. shoot drooping, shoot and root length, plant biomass and spectral-based parameters *viz*. Chlorophyll content Index, Total Chlorophyll (μg/cm^3), Greening Index, Normalized Difference Vegetation Index, Photochemical Reflectance Index, Plant Senescence Reflectance Index, Water band Index, etc. Some promising salt tolerant acc. viz. EC313926, EC396401, EC396402, EC398901, EC511376, IC118994, IC148541, and IC305293 were identified.

4.6.4. Evaluation of durum wheat germplasm for drought stress tolerance

A set of 455 wheat acc. along with five checks (HI-1531, HI8663, HI8627, UAS428, MACS4028) was evaluated at NBPGR Issapur farm in ABD during *Rabi* 2022-23. These acc. were grown under normal and drought-stress conditions. Data were recorded for 12 agro-physiological traits. Under drought condition, superior acc. over the best check (HI1531)

were identified, for example, grain yield (g): IC277751, EC549435, IC539231, IC542858, IC128381, IC542695, EC534566, IC542115, IC539331, IC128378; thousand grain yield (g): IC252755, IC277740, IC535647, IC335772, IC321846, IC542673, IC535819, IC574499, EC299111.

4.6.5. Multi-location evaluation of *dicoccum* wheat against drought, terminal heat and combined stress under NICRA project

Under the NICRA project, 192 acc. of *dicoccum* wheat germplasm were grown for evaluation against drought, terminal heat and combined stress at ICAR-NBPGR Pusa Farm, New Delhi and ARI, Pune in alpha lattice design with 2 replications using five checks, DDK1025, DDK1029, C306, Raj 3765, MACS2925. Observations were recorded for 16 agronomic and physiological traits. Promising germplasm identified under combined drought and heat stress conditions for grain yield are: IC593663, IC551397, IC551398, EC6839, IC138331, IC551399, IC402045, EC590345, EC577404, EC6909. During *rabi* 2023-24, identified promising germplasm (IC535302, IC47037, EC06912, IC535082, IC534587, EC577404, etc.) based on stress susceptibility index for grain yield will be grown and validated for deciphering the physiological and biochemical mechanism of stress tolerance.

4.6.6. Screening of chilli germplasm against abiotic stresses

In a preliminary study on cold tolerance in chilli (180 acc.), twenty-six acc. viz.,IC632426, IC632432, IC505225, EC777200, EC769427, IC119526, IC605260, IC119558, IC119427, EC559423, IC119385, IC119653, EC382017, IC280221, EC402110, IC502177, IC588539, IC505321, IC119581, EC559436, EC787667, IC265011, IC643853, EC362911, EC737650, IC594881 were found cold tolerant. Further, out of 217, 8 acc. of chilli viz., EC559447, EC559461, EC559671, EC773142, IC413846, IC537585, IC545737 and IC631918 were identified as heat tolerant in second-year evaluation trial conducted during summer 2023 which performed better for traits like yield per plant, number of seeds per fruit, canopy temperature, canopy temperature depression, pollen viability (%), photosynthetic rate, transpiration rate, chlorophyll content, malondialdehyde, peroxidase, catalase and superoxide dismutase.

4.6.7. Evaluation for terminal heat tolerance in Indian mustard

A total of 402 Indian mustard acc. including seven checks, PM 28, PM 32, Pusa Bold, Pusa Tarak, Pusa Krishna, Rajat and RH 30, were evaluated for terminal heat tolerance at ICAR-NBPGR Farm, New Delhi in Alpha lattice design under normal and late sown conditions during rabi 2022-23. The promising germplasm identified for terminal heat tolerance were: Yield per plant (35-40g): IC267696, EC766322, EC765823, IC374698 & IC398763; 1000 seed weight (>4.5g): IC399684, IC267696 in late sown conditions.

4.6.8. Evaluation of Reference set for drought tolerance in linseed germplasm

The drought tolerance reference set comprising 200 acc. (150 tolerant, 17 moderate and 33 sensitive) was evaluated under controlled conditions and in pots in a completely randomized design (CRD) in two replications for studying the root system architecture in well-irrigated and drought-stress conditions. High-yielding genotypes under drought-stressed and non-stressed conditions- Stress Tolerance Index (STI > 0.7): EC0041466, EC0455084, EC0541226, IC0096530, IC0096540, IC0096601, IC0356276, IC0385343, IC0385397, IC0498992, IC0499176, IC0525941, IC0526133, IC0606067, IC0629218, IC0629220 were identified. High throughput phenotyping technique using an Unmanned aerial vehicle (UAV/drone) was also attempted wherein multispectral imaging of the linseed germplasm will be used to interpret and analyze the phenotypic data of irrigated and rainfed fields.

4.6.9. Development and evaluation of the linseed core collection for terminal heat tolerance

The large-scale characterization for 36 traits of 2,576 linseed germplasm acc. was done for up to 6-year-location environments (4 seasons at Delhi and 2 seasons at Akola) to develop a multipurpose core collection maximizing genetic diversity and representativeness of the whole germplasm collection conserved at National Genebank. The core collection (259 acc.) has been sown under timely and late sowing conditions in alpha lattice design at two locations to identify potential heat-tolerant germplasm. Observations are being recorded for various physiological (NDVI, canopy temperature, leaf area index, chlorophyll content, chlorophyll fluorescence) and agro-morphological traits.

4.6.10. Development of Reference sets for salt tolerance in linseed germplasm

The Reference sets for salt tolerance in linseed germplasm were developed based on two-year evaluation data of two locations under saline and alkaline environments. The Reference set for salinity stress comprised 396 acc. and the Reference set for sodicity tolerance had 299 acc. including tolerant, moderately tolerant, moderately susceptible and susceptible genotypes.

4.7. Achievements under CRP-Agrobiodiversity

4.7.1. CRP-Agrobiodiversity (Wheat)

A total of 455 wheat acc. for initial screening and 46 acc. in the replicated trials were evaluated during *rabi* 2022-23

Table 4.7: Promising acc. identified in wheat germplasm

Traits	Locations	Promising acc.
Stem rust, brown rust and Powdery Mildew	IARI-RS, Wellington	IC138898, IC47800, EC11071, EC12941, EC11074, EC6909, EC577398, EC11386, EC577406, EC577409, IC448026, IC535110, IC535127, IC535129, IC535143, IC535151, IC35174, IC138475, EC609395 & EC299074
Yellow rust	IIWBR, Karnal	Validated entries (20 No.)- EC578115, EC578064, EC299111, EC299157, EC299171, EC577932, etc.
Yellow rust & Brown rust	PAU, Ludhiana	IC111820, IC309879, IC335525 , IC335573, IC35151, IC445404, IC445436, IC536037, IC534538, IC464099, EC276769, EC277359, EC299085, EC299178, EC299189, EC299283, EC299287, EC534545, EC463907, IC614988, IC614994
Quality traits: Protein content (> 15%)	IIWBR, Karnal	IC528991(16.87),IC533534(16.66), IC543302(15.53), EC574123(15.24), EC12332 (15.92), EC217803(16.07), EC217804(17.32), EC576954(16.04), EC577427(16.4), EC10596(15.05), IC47790(15.14)

for biotic stress traits, yellow rust and brown rust (PAU, Ludhiana), brown rust, black rust and powdery mildew (IARI, RS, Wellington), yellow rust and quality traits (IIWBR, Karnal) as listed in Table 4.9. Biochemical analysis of grain samples (411 acc.) from NBPGR, Delhi was carried out at IIWBR, Karnal for protein content and sedimentation value. Identified promising acc. are given in Table 4.7.

4.7.2. CRP-Agrobiodiversity (Mustard)

A total of 1000 acc. of *B. juncea* were screened for orobanche tolerance at SKNU, Jobner and HAU, Hissar under sick plot at field condition. Out of them 26 acc. i.e. IC491433, IC267538, IC491032, IC491584, IC249624, IC253075, IC398655, IC342780 etc. found tolerant to orobanche.Indian mustard germplasm (1000 acc.) were screened at PAU, Ludhiana and DRMR, Bharatpur during 2022-23 with an artificial stem inoculation technique and using susceptible check (NRCHB 101 and NRCYS 5-2). About 23 acc. at DRMR, Bharatpur and 13 acc. at PAU showed resistance to sclerotinia having PDI=0. The acc. IC264824 showed resistance for sclerotinia at both locations.

4.8. Biochemical Evaluation

4.8.1. Quality evaluation of germplasm of different crops

A total of 8,556 acc. of Cereals (5,244) including Rice (1,082) and wheat (3,751); oilseeds (2,425) including Brassica (150), Linseed (452), and sesame (1,823); legumes (450) including mungbean core and its microgreens (300) and Lathyrus (150), fababean (24); vegetable (578 accs. of Chilli); Fruits (17 accs. of *Aegle marmelos*) and potential crops (229) including Job's Tear (121), amaranth (40), chenopodium (68) were evaluated for various quality traits and the trait-specific acc. identified are listed in Table 4.8.

Table 4.8: Quality traits of different crops germplasm along with superior/promising acc.

Crop	Acc.	Traits	Range Std.dev	Mean± normal value	Best check/	Superior/promising acc.
Cereals						
Rice	1,082	Protein %	8.38-12.2	10.6 ± 0.46	BPT5204 (8.4)	Protein > 11% -IC386358, IC206830, IC518120, IC85930, IC205951, IC612377
		Starch %	71.2-77.3	74.2± 0.338	BPT5204 (75.6)	<72%- IC74751, IC435440, IC378783, IC380463
		Amylose %	14.8 -33.3	26.1 ± 3.36	BPT5204 (25.7)	Amylose >28% -IC516811, IC518677, IC206040, IC516811, IC203309
		Phytate %	0.121-1.18	0.527± 0.31	BPT5204 (0.613)	<0.2% IC455343, IC203451, IC466280, IC257019, IC123690
Wheat	3,725	Amylose %	7.20-32.6	22.7 ± 2.79	PBW771 16.1%	Amylose >29% -IC406690, IC26729, IC532179, IC128177, IC397959, IC0524298, IC82161, IC0252831, IC333187, IC252876,IC212145, ET201192, IC542076, IC427140 Amylose < 12%-EC339601, EC542277, PUB9416204, IWA 8609545, IC530075, IC296727, IC138419, IC0252849, IC528888

Crop	Acc.	Traits	Range Std.dev	Mean± normal value	Best check/	Superior/promising acc.
Oilseeds						
Brassica (Validation)	150	Oil%	25.72-45.93	40.34±4.62	Pusa Jaikisan (40.23)	EC766611 (45.93), IC766556 (45.31), EC766401 (44.48), EC766598 (44.43), EC766597 (44.15), EC199744 (44.13), IC422161 (43.47), IC371721 (44.12), EC766423 (43.87), EC634291 (43.83), IC355319 (43.53), IC521377 (43.46), EC766431 (43.30), EC347852 (43.12)
Linseed (Validation)	452	Oil%	33.14-47.45	38.12±6.97	JLS67 (45.02)	IC0585301, IC0498709, IC0385395 >45%
	361	Protein%	16.01-23.96	20.01±4.87	T-397 (21.35%)	IC0599399, EC0718823, IC0498404 >22%
Sesame	1201	Oil %	34.11-53.21	46.01±9.15	TMV-7 (53.54%)	EC346376> 53.5%
	1823	Protein (including validation)	13.01-26.33	20.86±8.85	RT346 (24.55%)	EC346577, IC0500856 >25%
	250	Phytic acid (validation)	0.006±2.03	1.34±0.52	IFCT, 2017 recommended	IC0511064<1%
Pulses						
Mung bean core	300	Total phenol (%)	0.10-0.34	0.22±0.04		
Dry seeds		FRAP assay (%)	0.09-0.42	0.20±0.05		
		Soluble Sugar (%)	0.36-0.82	0.55±0.08		
Mung bean core	300	Total phenol (%)	0.13-0.98	0.68±0.18		
Micro greens		FRAP assay (%)	0.22-0.98	0.53±0.15		
		Soluble Sugar (%)	0.22-0.99	0.75±0.17		
Mung bean core	300	Ca (ppm)	262.0-1322.5	688.9±134.3		IC426772 (1322.46), IC400162 (1112.32), IC119035 (1103.03)
		CO (ppm)	0.01-0.32	0.09±0.07		IC39454 (0.32), EC528093 (0.31), IC118998 (0.3), IC436534 (0.3), IC103878 (0.29), IC267672 (0.29)
		Cu (ppm)	2.85-11.25	6.23±1.36		IC118998 (11.25), IC488573 (10.82), IC424989 (9.71), IC257571 (9.22), IC314568 (9.15), IC436813 (9.14)
		Fe (ppm)	8.49-265.16	34.85±19.19		IC10932-5 (265.16), IC8854 (136.2), IC314925 (94.32), IC39493 (90.85)
		K (ppm)	4043.1-12562.9	9984.5± 1360.1		IC118979 (12562.9), IC626176 (12509.47), IC488879_1 (12452.09), IC507281 (12208.38), IC489062 (11991.03)
		Mg (ppm)	654.3-1712.4	1313.6± 150.7		IC488833 (1712.41), IC118998 (1681.62), IC597670 (1639.67), IC118979 (1635.94), IC355610 (1632.13)
		Mn (ppm)	6.66-28.56	15.65±3.50		IC283532 (28.56), IC53778 (27.91), IC102954 (25.85), IC43600 (25.6)
		Mo (ppm)	0.01-4.14	0.45±0.52		IC426772 (4.14), IC626176 (3.52), IC565295 (2.84)
		Na (ppm)	0.10-71.82	15.95±12.10		EC396125 (71.82), EC397140 (60.2), IC338882 (58.91), IC39391 (55.07), EC272454 (53.25)
		P (ppm)	2210.4-4808.0	3582.9± 378.7		IC488833 (4807.99), IC626176 (4555.38), PLM666 (4534.92), IC507272 (4487.94), IC118998 (4454.81)

Crop	Acc.	Traits	Range Std.dev	Mean± normal value	Best check/	Superior/promising acc.
		S (ppm)	187.3-2476.2	1669.7± 389.5		IC488833 (4807.99), IC626176 (4555.38), PLM666 (4534.92), IC507272 (4487.94), IC118998 (4454.81)
		Se (ppm)	0.01-0.87	0.17±0.14		IC314925 (0.87), IC39493 (0.86), EC528607 (0.65)
		Zn (ppm)	9.72-32.32	21.27±2.86		IC118998 (32.32), IC121200 (32.21), IC488833 (27.45), IC76492 (27.42)
Grasspea	150	Protein %	25.2-32.6	27.6 ± 1.39	Ratan (27.6)	>29% IC208430, IC0635672
		Starch %	26.2-39.0	32.9± 3.54	Ratan (32.0)	>38% IC0634654, IC421914
		Sugar %	3.87-8.83	6.48± 1.31	Narayangon (6.02)	> 8.0% IC208430, IC148364
		Phenol %	0.39-1.19	0.701 ± 0.19	Ratan (0.76)	> 1.0% IC421914
		Dietary Fiber %	6.75-19.9	15.1± 3.49	Ratan (13.2)	> 18% IC208430, IC0634662
		Ash %	1.76-3.81	2.58± 0.49	Prateek (3.11)	Prateek
		Iron mg/100g	6.45-16.4	10.1± 2.15	Mahateora (10.3)	Mahateora
		Zinc mg/100g	4.40-10.2	6.81± 1.12	Ratan (8.79)	Ratan
		ODAP mg/g	0.07-0.34	0.18± 0.06	Ratan (0.162)	<0.1 mg/g (IC0634755, IC0634654)
Vegetables						
Chilli	578	Capsaicin mg/g	1.04-6.78	3.43± 1.05	Pusa Jwala (2.985)	> 6mg/g IC593900
Fruits						
Aegle marmelos	17	Skull/cell thickness (mm)	1.12-3.21	2.29±0.51	2.5 (Normal Value)	IC639274 (<1.5 mm)
		Anti-oxidant (FRAP) %	0.054-0.116	0.090±0.02	NA	IC639282
		Total Phenols (%)	0.953-2.294	1.666±0.39	2.0 (Normal Value)	IC639276
Potential crops						
Job's tear	121	Protein %	11.1-23.3	16.2± 2.32	NC-3 (16.1)	>20% IC416884, IC332621, IC416897, IC334317, IC419466, IC540173
		Sugar %	0.554-1.95	1.02± 0.267	NC-3 (1.75)	NC-3
		Starch %	40.4-63.7	52.6± 3.76	Hemame(50.1)	>60% IC540256, IC540266, IC614052
		Dietary Fiber %	5.29-23.7	15.0-3.88	NC-3 (18.3)	<8% IC540256, IC89381, IC614052
		Crude fat %	1.81-6.41	2.91± 0.89	NC-3 (4.66)	>5% IC625390, IC591724, IC604159, IC540181
		Phenol%	0.181-0.962	0.371± 0.144	Hemame (0.350)	>0.9% IC374506, IC326203,
		Iron mg/100g	2.32-37.8	11.8± 6.96	NC-3 (12.6)	>30 mg/100g IC- 0643936, IC630437
		Zinc mg/100g	1.61-7.19	3.96± 1.21	NC-3 (3.56)	>6.0 mg/100g IC – 89389, IC89384
Amaranth	40	Protein %	8.93-15.93	12.72±1.84	RMA-7 (13.3)	EC169790 (15.93), EC289393 (15.51), EC345797 (15.31), EC198127(15.26)
		Lysine (g/16g N)	2.78-6.99	4.96±0.99	Suvarna (5.53)	IC258250 (6.99), IC540860 (6.55), IC540832 (6.07), EC289385 (5.59)
C. quinoa	35	Protein%	9.89-16.12	12.47±1.83	Himshakti (11.81)	IC363733 (16.12), EC507738 (15.80), EC507744 (14.76), EC507749 (14.68)
		Oil %	5.91-9.23	8.29±0.64	Himshakti (8.41)	EC896092 (9.23), EC896062 (9.21), EC896098 (9.21)
C. album	33	Protein%	11.67-15.80	13.88 ±1.38	Himbathua (15.21)	IC381106 (15.80), IC007957 (15.40)
		Oil %	6.65-7.87	7.42 ±0.36	Himbathua (7.84)	IC13420 (7.87), IC341701 (7.85)

4.8.2. Evaluation of fababean selections for low vicine-convicine and tannin contents

Seeds of 24 single plant progenies of white flower selections along with checks were harvested during *Rabi* 2021-22 and Rabi 2022-23, and analysed for validation of low Vicine–convicine and low tannin content. Vicine–convicine ranged from 0.19-0.49 and 0.17-0.47%, respectively, in comparison to check HFB-1 (0.65%). Selections ET226462-2 (0.19 and 0.17%), ET226412-2 (0.21 and 0.22%), ET226466 (0.29 and 0.30%), ET226559-1 (0.30 and 0.31%), ET226560-2 (0.30 and 0.31%), ET226489-2 (0.30 and 0.32%), ET226560-1 (0.31 and 0.31%), ET226483 (0.32 and 0.29%), ET226559-2 (0.32 and 0.33%), ET226574 (0.34 and 0.35%) and ET226520 (0.38 and 0.41%) were validated for low Vicine–convicine.Condensed tannin content was found low 0.005 to 0.09% Leucocyanidin equivalent (Rabi 2021-22) and 0.009-0.082% Leucocyanidin equivalent (Rabi 2022-23) in all the white flower selections in comparison to checks which have condensed tannin >0.62 % Leucocyanidin equivalent. Some of the promising acc. with negligible tannin content based on data included ET226560-1 (0.005%; 0.009%), ET226557 (0.011%; 0.016%), ET226509 (0.005%; 0.01%), ET226489-2 (0.016%;0.027%), ET226489-1 (0.016; 0.027), ET226412-1 (0.016; 0.021), ET226559-1(0.027; 0.038), ET226498 (0.021;0.027), ET226466 (0.027;0.029), ET226462-2 (0.022;0.038), ET226462-1 (0.043; 0.038), ET226412-2 (0.049;0.033), ET226408 (0.033;0.043), ET226468 (0.016; 0.027).

4.8.3. Effect of different Nitrogen levels on seed protein content in wheat acc. identified for high protein content

Wheat acc. (26) promising for high seed protein content along with four checks (C 306, Raj 3765, HD 2967 and DDK 1025) were evaluated under different nitrogen levels (0, 40, 80 and 120 kg N/ha) in Split Plot Design with four replications during Rabi 2021-22 to ascertain the stability of this quality trait. On an average basis, the application of nitrogen significantly influenced the protein content in grain from 12.73% in control to 13.89% at 120 kg N/ha (Table 4.9). Promising acc. EC576816, IC534892, EC577512, IC252668, IC539313, EC339632 and EC576792 were identified with high seed protein content (>14%) at low (control) N treatment. These acc. showed better performance at all N treatments including low nitrogen levels. Similarly, promising acc. with high protein were also identified for recommended N application treatment. Three acc. EC576816, IC534892 and EC577512 showed high protein content (more than 15%) at 120 kg N/ha. In some of the acc., the protein content was high at lower N doses compared to120 kg N/ha.

4.8.4. Phytochemical Evaluation of Medicinal and Aromatic Plants

Quality evaluation of 318 acc. of medicinal and aromatic plants including *Murraya koenigii* (23 accs.), *Ocimum species* (20 accs.), *Cymbopogon species* (51 accs.), *Bacopa monierii* (2 accs.), *Mucuna species* (25 accs.), *Costus speciosus* (3 accs.), *Abelmoschus moschatus* (2 accs.), *Zingiber zerumbet* (1)and *Fagopyrum* species germplasm (191 accs.) were performed. High value Bacoside acc. of *Bacopa monnieri* from Thrissur station were validated for Bacoside A content and two superior acc. IC554586 (3.59 -3.91%) and IC554588 (3.36 - 3.62%) were confirmed containing high Bacoside A content consequently over the four years of chemical analysis by HPTLC. Superior accession of *Zingiber zerumbet* (IC647593) was validated for high zerumbone content (79.40 – 82.00%) in rhizomes essential oil over the fourth consequent years. Results of quality evaluation of medicinal and aromatic plants germplasm are presented in Table 4.10 and Table 4.11 along with superior acc..The essential oil composition of aromatic crops germplasm analyzed by GC/FID which showed distinct major compounds and chemotypes are presented in Table 4.12.

4.9. Pre-breeding for genetic base enhancement

4.9.1. Genetic enhancement and creation of genetic variability in flax

The interspecific population (F_3) derived from a cross between cultivated variety, T397 of linseed (*L. usitatissimum*) and its wild progenitor, EC993389 (*L. bienne*) was assessed for the genetic diversity created through wide hybridization and selecting a few progeny lines with superior lines for different agro-morphological traits. A population comprising 805 selected plant-to-progeny lines were sown in ABD design along with seven checks including parents. Huge variability was recorded for the traits viz., Total plant height (PH) (38-112 cm), Technical plant height (TPH) (11-63 cm), Number of primary branches per plant (BPP) (4-26) and, capsule per plant (CPP) (19-1181). The values for best check (BC) and wild parent (W) for these traits ranged from 75.66 (W)-85.75cm (BC) for PH, 35.33(W)-46.13(BC) for TPH, 9.21(BC)-9.33(W) for BPP and, 176.83 (BC)-488.67 for CPP (Fig. 4.6). Individuals showing high values of these traits beyond the parental limits (Fig. 4.7) were selected further for isolation and fixation of the trait.

4.10. Establishment of Field genebank at NBPGR, Issapur Farm

In the year 2023, germplasm of RET and multipurpose tree species including underutilized fruits, nuts and fodder were collected from drier areas of Bundelkhand,

Table 4.9: Interaction effect of genotypes and nitrogen levels on protein content in wheat grain

Genotypes/N Level	Control	40 kg N/ha	80 kg N/ha	120 kg N/ha	Mean
EC577512	14.79	15.00	15.09	15.21	15.02
EC576792	14.00	14.04	14.18	14.18	14.10
IC531183	11.55	11.77	12.08	13.83	12.30
EC592592	11.59	12.08	12.16	12.82	12.16
IC252668	14.46	14.48	14.74	14.78	14.61
IC290234	13.94	13.96	14.04	14.09	14.01
IC144903	11.37	12.48	13.21	13.55	12.65
EC299095	12.32	14.26	13.87	13.91	13.59
IC539313	14.25	14.41	14.50	14.75	14.48
IC128150	13.48	13.54	13.96	14.00	13.74
EC11360	11.93	12.78	13.74	13.58	13.00
IC533610	12.51	13.54	14.38	14.65	13.77
IC542063	12.96	14.04	15.18	15.31	14.37
IC252440	11.64	12.17	12.71	13.01	12.38
EC577693	12.87	13.13	13.21	13.26	13.11
IC542799	13.25	13.43	14.75	13.83	13.81
IC252419	13.78	14.47	14.57	14.79	14.40
IC406688	12.43	14.74	14.74	14.31	14.05
EC576930	11.29	12.25	12.73	13.48	12.44
Kharchia	10.54	10.83	12.03	12.29	11.42
IC535330	11.33	12.38	13.65	13.87	12.81
EC576816	15.05	15.15	15.14	15.49	15.21
EC339632	14.04	14.66	14.91	14.96	14.65
IC145522	12.00	12.38	12.56	12.64	12.40
EC11258	12.03	12.69	13.69	14.09	13.13
IC534892	14.92	15.27	15.36	15.40	15.24
C 306	10.68	10.89	11.42	11.68	11.17
RAJ3765	12.85	13.44	13.56	13.75	13.40
HD2967	12.57	12.69	12.72	12.89	12.72
DDK1025	11.46	11.81	11.99	12.41	11.92
Mean	12.73	13.29	13.70	13.89	
CD	N level		0.11		
	Genotypes		0.18		
	Gen X Tr		0.37		

Gandhmardan hills of Eastern India, Siwalik hills and different institutes. Germplasm of 21 species were added in 2023 making the total number of species collected 101. Twelve acc. of *Dalbergia sissoo* germplasm, tolerant to fusarium wilt were established at 99% survival rate after 2 years of transplantation (Fig. 4.8). The new additions are given in Table 4.13.

4.11. Germplasm supply and seed multiplication

4.11.1. Germplasm supply

A total 4,980 acc. of various crops including wheat (598), barley (98), maize (187), Brassica (400), sesame (75), and linseed (9) were supplied to 15 indenters belonging to ICAR institutes, SAUs and other research organizations. In

Table 4.10. Quality Analysis of Aromatic Plants Germplasm

Plant Name (Acc.)(Common name)	Plant part used	Essential oilrange (%)	Superior Acc.
Murraya koenigii (23) (Curry leaf)	Leaves	0.80 - 2.33 (DWB)	IC635983, IC645821, IC635970, IC645814, IC644948
Cymbopogon martini (49) (Palmarosa)	Herbage	0.27 - 1.09 (FWB)	IW4478, IW4499-A, IW4505, IW4480, IW4501-A
Cymbopogon winterianus (1) (Javacitronella)	Herbage	0.68 - 0.71 (FWB)	-
Cymbopogon citratus (1) (Lemon grass)	Herbage	0.26 - 0.28 (FWB)	-
Abelmoschus moschatus(2) (Muskdana)	Seeds	0.20 - 0.28 (DWB)	-
Zingiber zerumbet (1) (Shampoo ginger)	Rhizomes	1.67 - 1.96 (DWB)	IC647593

Table 4.11. Fatty Acid Composition (%) of Seed Oils of Some Medicinal and Potential Crops

Fatty acid	*Mucuna pruriens* (25)	*Abelmoschus moschatus* (2)	*Costus speciosus* (3)	*Fagopyrum tataricum* (132)	*Fagopyrum esculentum* (59)
Palmitic acid	16.68 - 26.04	19.93 - 21.43	24.99 - 28.73	13.24 - 15.78	14.62 - 18.88
Oleic acid	22.88 - 69.85	41.90 - 52.18	24.39 - 29.60	32.30 - 41.08	29.53 - 39.35
Linoleic acid	8.88 - 34.19	19.59 - 22.18	26.87 - 32.12	35.61 - 42.64	34.73 - 43.86
Linolenic acid	0.18 - 5.50	-	0.98 - 3.42	1.74 - 3.67	1.30 - 3.32
Stearic acid	2.80 - 10.11	3.35 - 3.85	7.43 - 8.45	1.19 - 2.35	1.52 - 2.05
Arachidic acid	0.07 - 2.26	0.13 - 0.83	0.21 - 1.11	0.99 - 2.15	1.73 - 3.21

Table 4.12. Chemical Composition of Volatile Essential Oils from Aromatic Plants Germplasm

Plant Name (Acc.) (Common name)	Major Aroma Compounds Identified	Superior Acc.
Murraya koenigii (23) (Curry leaf)	(E)-β-Caryophyllene (31.21 -55.22%), α-Humulene, α-Selinene, (Z)-β-Farnesene, Caryophyllene oxide, Farnesol	IC645814, IC645847, IC635982, IC645803, IC645817
Cymbopogon martinii (49)(Palmarosa)	Geraniol (65.61-82.94%), Geranyl acetate, Farnesol (EZ), Linalool, Neryl acetate	IW4488, IW4514, IW4490, IW4508, IW4514-A
Cymbopogon winterianus (1) (Java Citronella)	Citronellal (68.30%), Geraniol, Citronellol,Geranyl acetate, Germacrene B, α-Cadinol	-
Cymbopogon citratus (1)(Lemon grass)	Geranial, Neral, Myrcene, Linalool, Geraniol	-
Zingiber zerumbet (1)(Shampoo ginger)	Zerumbone, α-Pinene, 1,8-Cineole, Camphene, Camphor, α-Humulene, Caryophyllene oxide, Humulene epoxide I	IC647593
Abelmoschus moschatus (2)(Muskdana)	Farnesyl acetate, Ambrettolide, Farnesol, Caryophyllene oxide, Nerolidol, (E)-β-Farnesene, (E)-β-Caryophyllene	-
Ocimum americanum (2)(Hoary basil, American basil)	Camphor, α-Pinene, β-Pinene, Myrcene, Camphene, ρ-Cymene, γ-Terpinene, Limonene	IC641778, IC641714
Ocimumbasilicum (9)(Sweet basil)	(E)- Methyl cinnamate, (E)-β-Ocimene, Linalool,(Z)- Methyl cinnamate, Methyl eugenol, α-Gurjunene	IC641769, IC641721, IC599357
Ocimum tenuiflorum (8)(Holy basil)	Eugenol, Methyl eugenol, Zonarene, α-Humulene, (E)-β-Caryophyllene, Caryophyllene oxide	IC641706, IC641750
Ocimum citriodorum (1)(Lemon basil)	Neral, Geranial, Linalool, (Z)-α-Bisabolene, (E)-β-Caryophyllene, Camphor, β-Selinene	IC624514

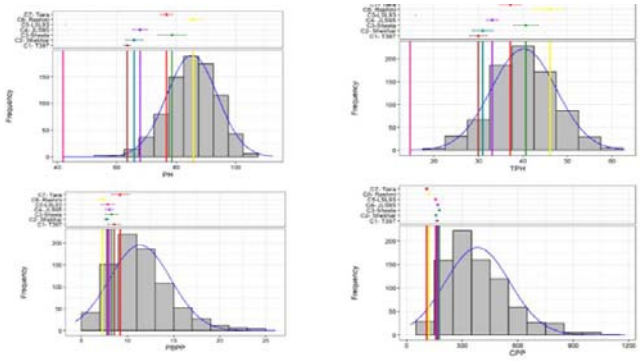


Fig. 4.6. Frequency distribution plots for potential traits in interspecific population of flax

Fig. 4.7. Representative picture depicting high number of capsule and branching per plant in flax

Table 4.13: List of tree species added to the field genebank at Issapur Farm

Type of tree species	Species collected, propagated/Established	Nos
Underutilized fruits	*Alangium salviifolium* (Ankul), *Milisua tomentosa* (Kari), *Eriobotrya japonica* (Loquat), *Syzygium salicifolia* and *Syzygium nervosum* (wild relatice of Jamun), *Artocarpus lacucha* (Badhal), *Dyospyrus melanoxylon* (Tendu), *Carissa carondas* (Karonda), *Myrica esculentum*, *Carya arborea,* thonless Bael, var Gomayasi (*Aegle marmelos*), *Limonia acidissima* (Kainth or wood apple), *Annona squamosa* (Custard apple)	13
Fodder tree	*Grewia optiva* (Dhaman, Beul, Bhimal)	1
RET and Medicinal tree	*Gardenia gummifera* (Bhurudu),	1
Edible Dye	*Bixa orelana*	1
Sampoo/Detergent	*Acacia concina*	1
Toy making	*Wrightia tinctoria*	1
Ply and pulp wood	*Casuarina equisetifolia*, *Chukrasia tabularis* (Indian red wood)	2
Timber	*Tectona grandis*	1

***Gardenia gummifera*, a threatened under-utilized fruit tree**

Unique germplasm of Mahua (*Madhuca latifolia*) with 4.5 cm seed length

Overview of the field genebank at Issapur after 2 years of establishment

Fusarium wilt tolerant germplasm of Shisham (*Dalbergia sissoo)*

Fig. 4.8. Unique acc. established in Field Genebank along with its overview at Issapur farm

addition, 1791 acc. of wheat germplasm and 1825 acc. of linseed were sent for evaluation under various collaborative projects.

4.11.2. Seed multiplication

123 acc. of linseed were multiplied and conserved under the long-term storage facility of National Genebank. 750 acc. of linseed and 678 acc. of barley germplasm were multiplied and conserved in medium-term storage.

Research Programme (**Code:** Title, **Programme Leader**)
Code: PGR/GEV-BUR/DEL-1.00: Characterization, evaluation and documentation of genetic resources of agri-horticultural crops **(RK Gautam)**
Code: PGR/GEV-BUR/DEL-1.01: Characterization, Evaluation and Documentation of Wheat, Barley and Triticale Germplasm **(Jyoti Kumari,** Vikender Kaur, Sundeep Kumar, Sandeep Kumar, S K Kaushik, Pardeep Kumar)
PGR/GEV-BUR/DEL-1.02: Characterization, Evaluation and Documentation of Maize Germplasm **(Ashok Kumar,** Jyoti Kumari, Ishwar Singh, K S Hooda, Sapna)
PGR/DGE-BUR-DEL01.03: Characterization, Evaluation and Documentation Of Pulses Germplasm **(Gayacharan,** Kuldeep Tripathi, Rakesh Bhardwaj, Jameel Akhtar, Z. Khan)
PGR/GEV-BUR-DEL.01.04: Characterization, Evaluation and Documentation of Oilseeds Germplasm **(Rashmi Yadav,** Sandeep Kumar,Vikender Kaur, Sapna, Jameel Akhtar, VS Meena, Mamta Singh, RK Gautam)
PGR/ DGE –BUR-DEL-01.05: Characterization, evaluation and documentation of vegetable, fruit and ornamental crops germplasm **[Vinod Kumar;** SK Yadav, Pragya, VS Meena, Bharat Gawade, Pooja Kumari, BR Meena, Rajkiran (on study leave), NL Meena (on study leave)]
PGR/GEV/BUR-DEL-01.06: Biochemical Evaluation of Field and Vegetable Crops Germplasm **(Rakesh Bhardwaj;** Sandeep Kumar, Manjusha Verma, Sapna, Nand Lal Meena(on study leave), VS Meena, Madhubala Priyadarshi)
PGR/ DGE-BUR-DEL-01.07: Characterization and Evaluation of Medicinal and Aromatic Plants Germplasm **(Archana Raina,** Ashok Kumar, Ishwar Singh, Rakesh Singh, K P Mohapatra)
PGR/GEV-BUR-DEL01.10: Characterization of Wild Species and Pre Breeding in Selected Crops **(Vinod Kumar,** Mohar Singh, Celia Chalam, MK Rana, KS Hooda, Gayacharan, Kuldeep Tripathi, Gowthami R, Era Vaidya, Narendra Negi, Kartar Singh)
PGR/GEV-BUR-DEL-01.11: Improvement of faba bean, buckwheat and spine gourd for yield and nutritional quality **(SK Kaushik,** Ishwar Singh, Sandeep Kumar, Mohar Singh, Mamta Arya, Vartika Srivastava)
PGR/GEV-BUR/DEL.01.12: Application of Statistical Techniques in Management of Information on Plant Genetic Resources **(HL Raiger)**
PGR/GEV-BUR/DEL.01.13: Augmentation, Characterization and Development of Field GenebankFor Multipurpose Tree Species Of The Semi-arid Subtropical Region Of India **(KP Mohapatra,** Puran Chandra, Sapna, Sandhya Gupta, SK Malik)

5 DIVISION OF GENOMIC RESOURCES

सारांशः 19 कृषि–बागवानी फसलों के उनतालिश (39) नमूनों के लिए डीएनए फिंगरप्रिंटिंग सेवा प्रदान की गई। जीनोम–वाइड एसोसिएशन स्टडी (जीडब्ल्यूएएस) दृष्टिकोण का उपयोग करके विभिन्न वांछनीय लक्षणों के लिए चावल, गेहूं और मोथ बीन में लक्षण मानचित्रण लागू किया गया। चावल में गुणवत्ता गुणों के लिए जीडब्ल्यूएएस से सुगंध, हेड राइस रिकवरी (एचआरआर) और चॉकनेस (पीजीसीः) जैसे विभिन्न गुणवत्ता लक्षणों के लिए 20 क्यूटीएन की पहचान की गई। इसी तरह, मोथ बीन के मामले में जीडब्ल्यूएएस से मल्टी–लोकस दृष्टिकोण का उपयोग करके 50% फूल विशेषता वाले दिनों पर महत्वपूर्ण फिनोटाइपिंग प्रभाव वाले चार जीनोमिक क्षेत्रों की पहचान की गई। गेहूं के मिनी कोर संग्रह में अनाज के आकार के लक्षणों के लिए जीडब्ल्यूएएस से, अनाज की लंबाई के लिए 4 चार और अनाज की चौड़ाई और अनाज की चौड़ाई–लंबाई अनुपात के लिए क्रमशः एक–एक महत्वपूर्ण क्यूटीएन की पहचान की गई। गेहूं में एक अन्य एसोसिएशन मैपिंग अध्ययन में, 20 विश्वसनीय क्यूटीएल अंकुर और वयस्क पौधे के तने के प्रतिरोध से जुड़े पाए गए। कुसुम के 3115 एनजीबी परिग्रहण संग्रह से एसएसआर मार्कर्स का उपयोग करके एक कोर जर्मप्लाज्म सेट (351 परिग्रहण) की पहचान से की गई है। इसी प्रकार, सीसेमम में भी 3360 परिग्रहणों से एक कोर सेट (1,193 ए. सी.) का गठन किया गया है। सीसेमम इंडिकम (सीवी स्वेता) का ड्राफ्ट जीनोम 79 मचानों में 290.64 एमबीपी के आकार में इकट्ठा किया गया। क्रोमोसोम–स्तरीय क्लोरोप्लास्ट जीनोम को ओराइजा मेयेरियाना वार इंडंडमानिका के लिए इकट्ठा किया गया। एसएसआर मार्कर उत्पन्न करने के लिए ब्राउनटॉप बाजरा का संपूर्ण जीनोम अनुक्रमण किया गया। लुफा स्पीसीज में लिंकेज विश्लेषण तथा सीएल लोकस से 4.6 सीएम की दूरी पर फलने की विशेषता से जुड़े एक एसआरएपी मार्कर की पहचान की गई। अलसी में ट्रांस्क्रिप्टोम अध्ययन से फूल आने के समय के नियमन से जुड़े जीन की पहचान की गई। विभिन्न फसलों की 21 खेपों के 53 नमूनों के लिए जीएमओ परीक्षण सेवाएँ प्रदान की गईं।

Summary: DNA fingerprinting service was provided for thirty-nine (39) samples of 19 agri-horticultural crops. Trait mapping using the genome-wide association study (GWAS) approach was implemented in rice, wheat, and moth bean for various desirable traits. GWAS in rice identified 20 QTN for various quality traits such as aroma, head rice recovery (HRR), and chalkiness (PGC %). Similarly, in moth bean GWAS using multi-locus approaches identified four genomic regions with significant phenotypic effects on days to 50% flowering trait. GWAS for grain shape traits in the mini core collection of wheat identified six QTNs, four for grain length and one each for grain width and grain width-length ratio. In another association mapping study in wheat, 20 reliable QTLs were found to be associated with seedling and adult plant stem rust resistance. A core germplasm set of safflower (351 accessions) has been identified from 3115 accessions of NGB collection of safflower through SSR markers. Similarly, in Sesamum core set (1,193 acc.) has been constituted from 3360 acc. of NGB using GBS. The draft genome of *Sesamum indicum* (cv. Sweta) was assembled in 79 scaffolds to a size of 290.64 Mbp. The chromosome-level chloroplast genome has been assembled for *Oryza meyeriana* var. *indandamanica*. The whole genome sequencing of browntop millet was done to generate SSR markers. Linkage analysis in *Luffa sp.* identified an SRAP marker linked to the fruiting trait at a distance of 4.6 cM from the *Cl* locus. Transcriptome study in linseed has identified genes associated with flowering time regulation. GMO testing services were provided for 53 samples of 21 consignments of different crops.

5.1. DNA Fingerprinting of Crop Varieties

Thirty-nine (39) samples of 19 agri-horticultural crops namely bitter gourd, bottle gourd, brinjal, buckwheat, chickpea, cotton, foxtail millet, musk melon, mustard, oat, paddy, pearl millet, raya, ridge gourd, soybean, sponge gourd, tomato, watermelon and wheat were DNA profiled for various public and private sector organizations. The DNA profiling was done using mostly mapped Simple Sequence Repeats (SSRs) markers. The crop-wise details for the number of samples are provided in Table 5.1. By rendering DNA fingerprinting services, resources to the tune of Rs. 3,36,300.00 were generated.

5.2. Multi-model genome-wide association studies for Aroma, Head Rice Recovery (HRR) and Chalkiness (PGC %) in rice

Improving the quality of the appearance of rice is critical to meet market acceptance. Mining putative quality-related genes has been geared towards the development of effective breeding approaches for rice. Two SL-GWAS (CMLM and MLM) and three ML-GWAS (FASTmrEMMA, mrMLM, and FASTmrMLM) genome-wide association studies were conducted in a subset of 3K-RGP consisting of 198 rice accessions. Rice accessions consisting of a diverse set of Xian, japonica, aus/boro, intermediate type cultivars along with check varieties viz., PB-1121 and PB-1 were planted at the research field of ICAR-IARI, New Delhi in Kharif 2020 and Kharif 2021. Broad sense heritability (H_2) estimates were high for HRR (%) (0.99) and PGC (%) (0.98). A total of 594 SNP markers were identified to be associated with grain quality traits using the mixed linear model. Additionally, 70 quantitative trait nucleotides (QTNs) detected by the ML-GWAS models were strongly associated with grain aroma (AR), head rice recovery (HRR, %), and percentage of grains with chalkiness (PGC%). Among them 39 QTNs were

Table 5.1: Details of samples DNA Fingerprinted during 2023

S. No.	Crop	Scientific name	Number of samples
1	Bitter gourd	*Momordica charantia*	1
2	Bottle gourd	*Lagenaria siceraria*	1
3	Brinjal	*Solanum melongena*	1
4	Buck wheat	*Fagopyron esculentus*	1
5	Chickpea	*Cicer arietinum*	1
6	Cotton	*Gossypium hirsutum*	9
7	Foxtail millet	*Setaria italica*	1
8	Musk melon	*Cucumis melo*	1
9	Mustard	*Brassica juncea*	4
10	Oat	*Avena sativa*	1
11	Paddy	*Oryza sativa*	2
12	Pearl millet	*Pennisetum glaucum*	4
13	Raya	*Raphanus sativus*	1
14	Ridge gourd	*Luffa aegyptiaca*	1
15	Soybean	*Glycine max*	3
16	Sponge gourd	*Luffa acutangula*	1
17	Tomato	*Solanum lycopersicum*	3
18	Water melon	*Citrullus lanatus*	1
19	Wheat	*Triticum aestivum*	2
		Total	**39**

identified using single and multi-locus GWAS methods and, 20 QTNs are novel for the above-mentioned three quality-related traits. Based on annotation and previous studies, four functional candidate genes (*LOC_Os01g66110, LOC_Os01g66140, LOC_Os07g44910,* and *LOC_ Os02g14120*) were found to influence AR, HRR (%), and PGC (%), which could be utilized in rice breeding to improve grain quality traits**.** Haplotype analysis of LOC_Os07g44910 is provided in Fig. 5.1.

5.3. Genetic diversity and association analysis for flowering trait in a diverse panel of moth bean (*Vigna aconitifolia*) accessions using genotyping by sequencing (GBS)

To understand the extent and pattern of genetic diversity in moth bean germplasm conserved in the National Genebank, of India, a representative set of 428 moth bean accessions was genotyped using genotyping by sequencing approach. A total of 9078 high-quality single nucleotide polymorphisms (SNPs) were identified which were utilized for genetic diversity analysis and association of flowering trait. Model-based structure analysis and PCA grouped the moth bean accessions into two subpopulations (Fig. 5.2). Cluster analysis revealed higher variability in the accession belonging to the Northwestern region of India than accessions from the other regions. This suggests that the

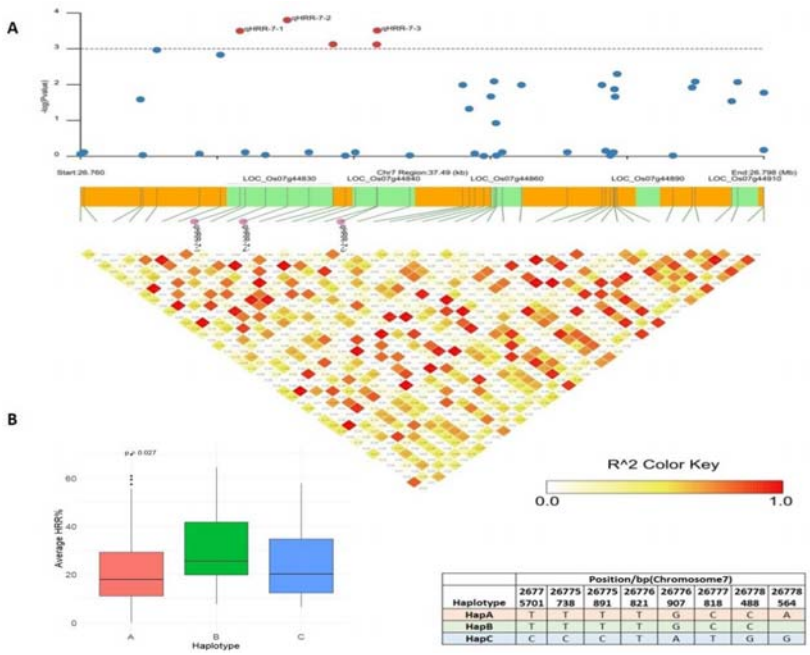


Fig. 5.1. Haplotype analysis of LOC_Os07g44910. (A) Linkage disequilibrium (LD) based heatmap for qHRR-7-2. (B) Boxplot of HRR (%) trait depicting three allelic combinations of LOC_Os07g44910. The X-axis shows three different alleles of LOC_Os07g44910 and the Y-axis shows the average HRR (%)

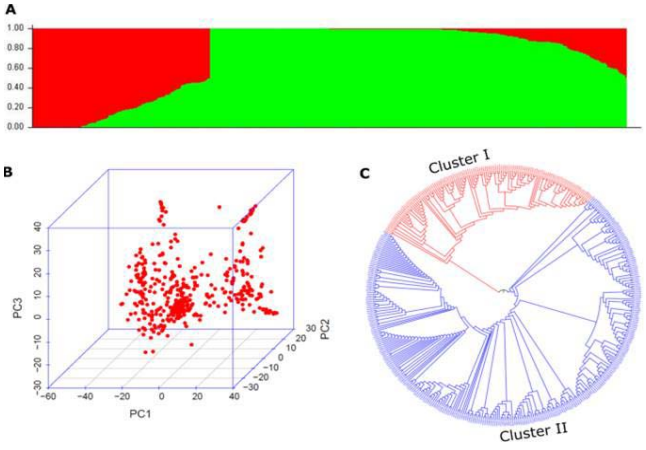


Fig. 5.2. A) Population structure of moth bean accessions showing two subpopulations, where the red color corresponds to subpopulation 1 and the green color to subpopulation 2. B) Principal component analysis plot showing 428 accessions into two subpopulations C) Phylogenetic tree of 428 accessions using NJ method, where the red color corresponds to cluster I and the blue one to cluster II

Northwestern region represents center of diversity of moth bean. AMOVA revealed more variations within individuals (74%) and among the individuals (24%) than among the populations (2%). Marker-trait association analysis for days to 50 % flowering was implemented using seven multi-locus models (mrMLM, FASTmrEMMA FASTmrEMMA and ISIS EM-BLASSO, MLMM, FarmCPU and BLINK) revealed 29 potential genomic regions for the trait, days to 50% flowering, which were consistently detected in three or more models. The Manhattan and corresponding QQ plots with three different models are presented in Fig. 5.3. Analysis of the allelic effect of the major genomic regions explaining the phenotypic variance of more than 10% and those detected in at least 2 environments showed 4 genomic regions with significant phenotypic effect on this trait. These 4 genomic regions can be further validated for their role in determining days to 50% flowering in moth bean.

5.4. Association mapping of grain size associated traits in the National Genebank wheat mini core collection

A sub-set of wheat mini core germplasm (123 accessions) of the National Genebank of India was analysed to underpin

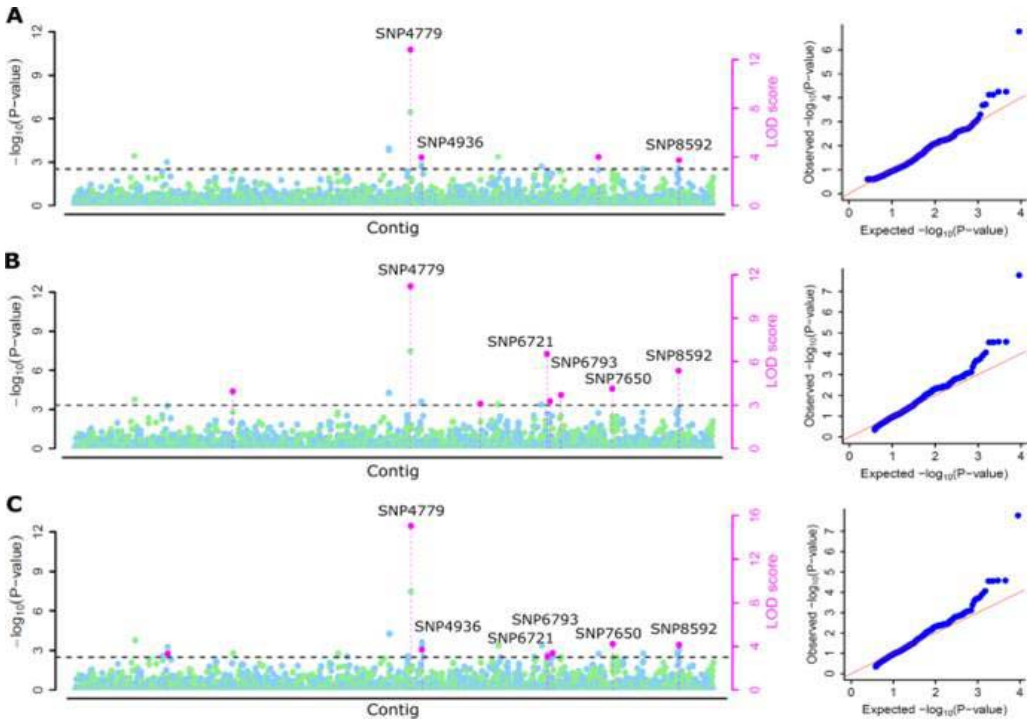


Fig. 5.3. Manhattan and corresponding QQ plots for the association study of flowering traits using multi-locus models. A) FASTmrEMMA, B) FASTmrMLM, and C) mrMLM. In Manhattan plots, the horizontal dot line shows the threshold at LOD score of 3. The dots above the threshold line represent significant SNPs. SNPs identified by more than one model are represented by their SNP id. The x-axis shows the location of SNPs on the contigs assembled using GBS data of the moth bean

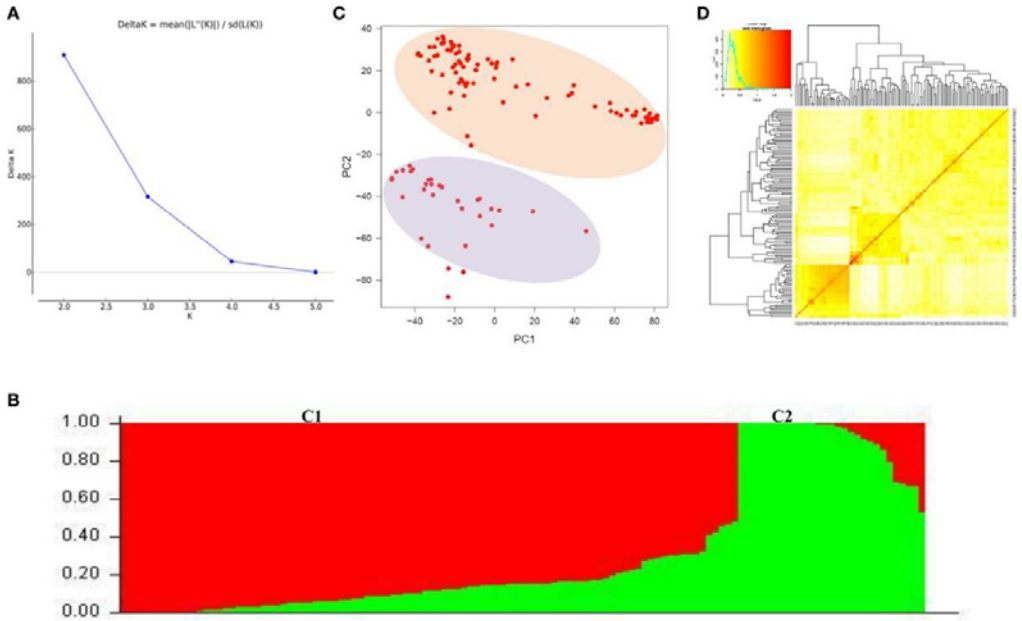


Fig. 5.4. Population structure analysis of wheat association mapping panel. (A) Magnitude of ÄK values, rate of change from 2 to 5 in association mapping panel. (B) Population structure of association panel based on SNP markers at K = 2. Different color columns represent different sub-populations. (C) Principal component analysis showing two sub-populations. (D) Heat map of kinship matrix

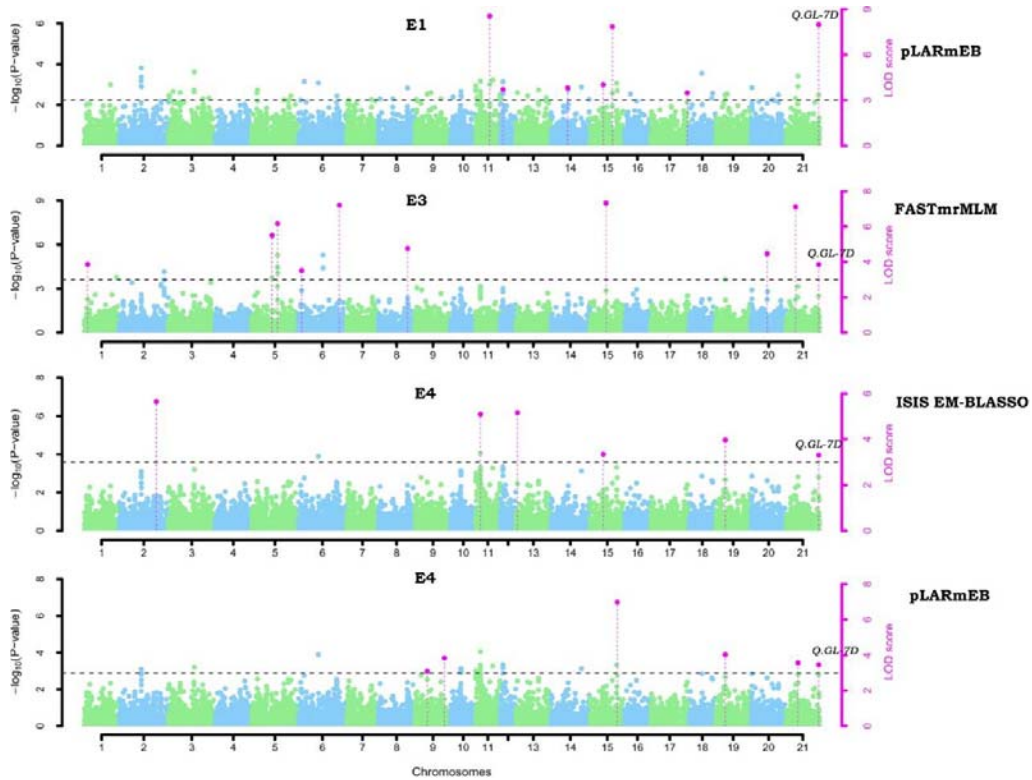


Fig. 5.5. Manhattan plots showing associated QTNs for grain length (GL) in wheat using multi-locus GWAS model. The x-axis shows the chromosome label and the y-axis displays - thresholds for significance (LOD score = 3) and log10 (p-value). The significant QTNs with LOD score >=3 is represented with purple dots

the genetic architecture for seed shape-associated traits. The wheat mini core subset was genotyped using 35K SNP array and evaluated for grain shape traits such as grain length (GL), grain width (GW), grain length, width ratio (GLWR), and thousand grain weight (TGW) across the seven different environments (E1, E2, E3, E4, E5, E5, E6, and E7). The genetic diversity and population structure analysis revealed two subpopulations in the mini core subset (Fig. 5.4) Marker-trait associations were determined using a multi-locus random-SNP-effect Mixed Linear Model (mrMLM) program. A total of 160 non-redundant quantitative trait nucleotides (QTNs) were identified for four-grain shape traits using two or more GWAS models. Among these 160 QTNs, 27, 36, 38, and 35 QTNs were associated with GL, GW, GLWR, and TGW respectively while 24 QTNs were associated with more than one trait. Of these 160 QTNs, 73 were detected in two or more environments and were considered reliable QTLs for the respective traits. Manhattan plots showing SNPs associated with grain length (GL) are presented in Fig. 5.5. A total of 135 associated QTNs were annotated and located within the genes, including ABC transporter, Cytochrome450, Thioredoxin_M-type, and hypothetical proteins. Furthermore, the expression pattern of annotated QTNs demonstrated that only 122 were differentially expressed, suggesting these could potentially be related to seed development. The genomic regions/candidate genes for grain size traits identified represent valuable genomic resources that can potentially be utilized in the markers-assisted breeding programs to develop high-yielding varieties.

5.5. Association mapping of stem rust resistance in wheat

Stem rust is one of the major diseases threatening wheat production globally. For the identification of novel resistance QTLs, a 35K Axiom Array SNP genotyping assay on a panel of 400 germplasm accessions, including Indian landraces. The SNP markers were uniformly distributed across the wheat chromosomes (Fig. 5.6a). Phenotyping for stem rust at seedling and adult plant stages was conducted in conjunction with association analyses employing three genome-wide association study (GWAS) models (CMLM, MLMM, and FarmCPU) (Fig. 5.6b). The investigation identified 20 reliable QTLs associated with seedling and adult plant resistance. Among these QTLs, five were consistently detected across three models, with four QTLs on chromosome 2AL, 2BL, 2DL, and 3BL for seedling resistance, and one on chromosome 7DS for adult plant resistance (Fig.5.6). Additionally, gene ontology analysis revealed 21 potential candidate genes linked to the identified QTLs, including notable ones the leucine-rich repeat receptor (LRR) and P-loop nucleoside triphosphate hydrolase, known for their roles in pathogen recognition and disease resistance. Validation of four QTLs (Qsr.nbpgr-3B_11, QSr.nbpgr-6AS_11, QSr.nbpgr-2AL_117-6, and QSr.nbpgr-7BS_APR) through KASP markers on chromosomes 3B, 6A, 2A, and 7B was performed. QSr.nbpgr-7BS_APR was identified as a novel QTL for stem rust resistance, demonstrated effectiveness in both seedling and adult plant stages. The novel genomic regions and validated QTLs discovered present promising opportunities for deployment in wheat improvement programs, aiding in the development of disease-resistant varieties against stem rust and contributing to the diversification of the genetic basis of resistance.

5.6. Development of Core collection from safflower (*Carthamus tinctorius* L.) germplasm through SSR marker

Evaluation of genetic diversity of 3115 safflower accessions from Indian National Gene Bank including the

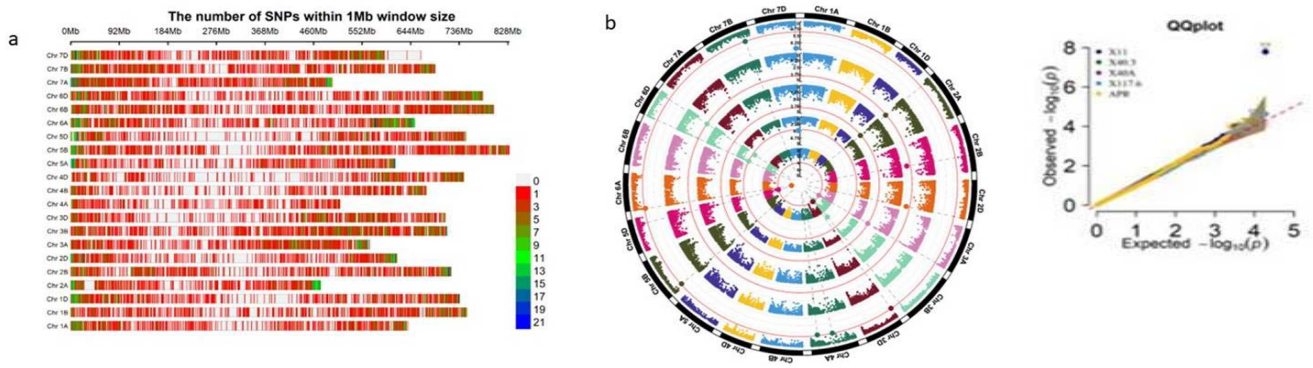


Fig. 5.6. (a) SNP density across the wheat chromosome, (b) Manhattan plots of associated genomic regions with stem rust pathotypes

Indian cultivars were carried out. A total of 18 polymorphic SSR markers were used. The genetic diversity revealed that the accessions are highly diverse and there is no correlation with the geographical collection of germplasm or sourcing of germplasm. The core set was developed using Core Hunter software with different levels of composition and found that 10% of the population showed maximum gene diversity and represented an equal number of alleles and major allele frequency with entire collection. The developed core consists of 351 accessions including Indian cultivars and they are validated with various genetic parameters to ascertain that they are true core sets for the studied accessions of safflower germplasm. The developed core set was evaluated with the different genetic parameters and found to represent similar patterns in PIC, He, and major allele frequency and significantly correlated with the entire core collection. The distribution of accession of the core set to the entire range of diversity that existed in the entire collection was enumerated in the PCA plot where the both the data sets were evenly distributed. The diversity of released varieties of safflower in India was compared with the entire collection and core collection. Despite its narrow genetic base from previous studies, the cultivars showed significant diversity between themselves and displayed enormous diversity in the PCA plot.

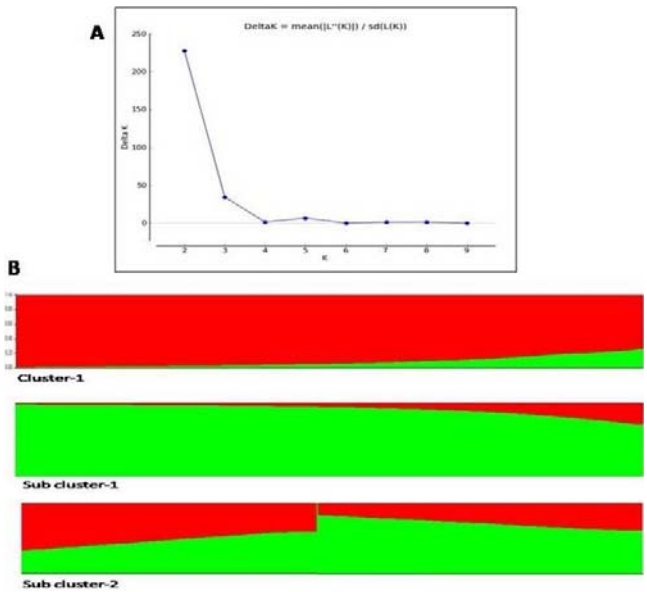


Fig. 5.7. Population structure of safflower germplasm ΔK reached maximum when K=2 following the ad-hoc method. Two population clusters with two subclusters in the second population are inferred by STRUCTURE

5.7. Chromosome-scale draft genome assembly for *Sesamum indicum* cv. Swetha

Short-read- and long-read-data for *S. indicum* cv. Swetha was generated using the Illumina and PacBio platforms, respectively. Using these datasets, a whole genome chromosome-scale draft assembly was made. The chromosome-scale draft genome assembly was made in 79 scaffolds to a size of 290.647385 Mbp. Of this, only 5.417707 Mbp were unassigned and in 66 scaffolds while the rest of the genome was assembled into 13 linkage groups (Table. 5.2). Further strategies were in progress to develop a chromosome-scale reference genome assembly.

Table 5.2: Details of the chromosome size (in bp) in linkage group-wise of the cv Swetha genome assembly

Chromosome	Cv. Swetha (bases)
LG01	22,971,715
LG02	19,978,557
LG03	27,079,882
LG04	20,938,392
LG05	18,738,983
LG06	27,063,802
LG07	17,503,372
LG08	27,170,994
LG09	24,657,878
LG10	23,333,011
LG11	18,615,220
LG12	18,786,361
LG13	18,391,511
Scaffolds (66 unassigned)	5,417,707
Total length	290,647,385

5.8. Genotyping of 5,856 sesame germplasm using high throughput genomics

Initially, a set of 2,496 sesame accessions were genotyped. In continuation with this, we have performed double digest-Restriction-site associated DNA sequencing-based genotyping for another set of 3,360 sesame accessions using the same set of enzymes that we used earlier. Using this, we have generated an iterative core set (genomics-assisted strategies) comprising of 1,193 accessions. Using this set, a composite core-set will be generated to represent the phenotype-based core-set, accessions with promising and trait-specific accessions exhibiting various abiotic or abiotic or quality traits.

5.9. Chromosome-scale draft genome assembly for *Oryza meyeriana* var. *indandamanica* (IC641181)

Using short-read (Illumina platform) and long-read (ONT, Oxford Nanopore Technology, platform) sequence data, a chromosome-scale draft genome assembly and a single contig circular chloroplast genome assembly (135,917 bp, Fig. 5.8) was made for *O. meyeriana* var. *indandamanica* (IC641181). The chromosome-scale assembly comprising twelve linkage groups was made to a size of 762,278,322 bases. Additionally, there were 717 unassigned scaffolds comprising to 24,923,137 bases. Making this to a total length of 787,201,459 bases length (Table 5.3) for this species. Further analysis is in progress at genome-scale for functional annotation and other assembly finishing steps.

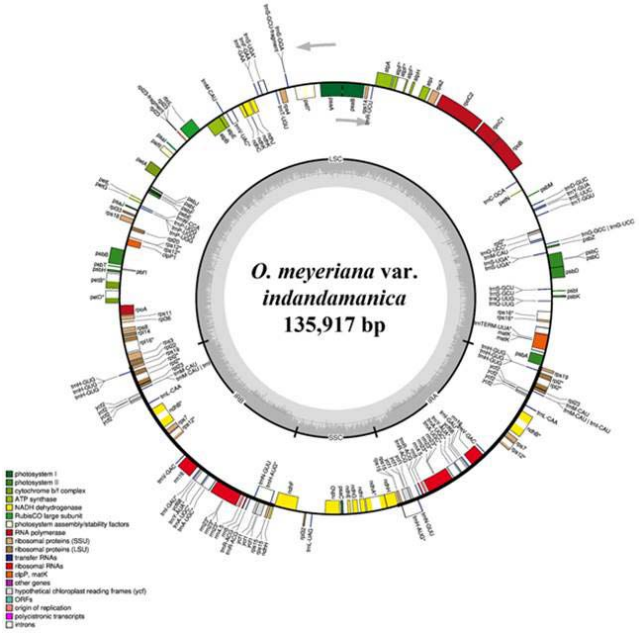


Fig. 5.8. Chloroplast genome assembly for *O. meyeriana* var. *indandamanica* (IC641181)

Table 5.3: Details of the chromosome size (in bp) in linkage group-wise of the *O. meyeriana* var. *indandamanica* genome

Chromosome	*O. meyeriana* var. *indandamanica* (bases)
LG01	76,151,503
LG02	81,567,470
LG03	81,375,216
LG04	75,508,095
LG05	67,470,539
LG06	64,200,954
LG07	65,939,849
LG08	56,797,526
LG09	60,330,445
LG10	47,505,509
LG11	44,864,443
LG12	40,566,773
Unassigned scaff (16 Nos)	602,508
Unassigned contig (701 Nos)	24,320,629
Total length	787,201,459

5.10. Whole genome sequencing for first draft genome sequence assembly and identification of SSRs in browntop millet (*Brachiaria ramosa*)

Browntop millet is rich in nutrients like other millets and in terms of changing climate scenarios, malnutrition, and lifestyle diseases, it can serve as an alternate food crop. In the dearth of genomic resources in this crop, a draft genome was assembled based on data obtained from Illumina and Nanopore sequencing of Bijapur Local variety. The total number of scaffolds generated is 1142 having a minimum scaffold length of 541 and maximum scaffold length of 9077735 and N50 of 1806821. A total of 54,367 SSRs were mixed from genome (Fig. 5.9). Phylogenetic relationship of *Brachiaria ramosa* was studied with eight other *Poaceae* species and is shown in Fig. 5.10.

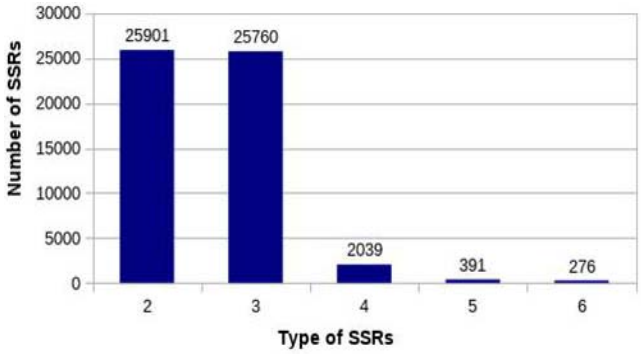


Fig. 5.9. Number and type of SSRs identified in browntop millet

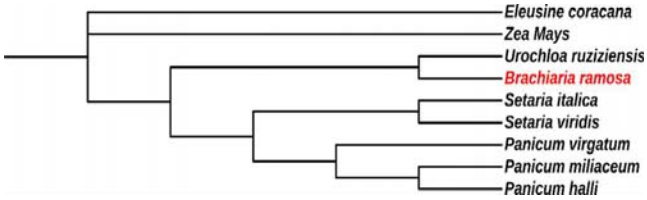


Fig. 5.10. Phylogenetic relationship of *Brachiaria ramosa* with other *Poaceae* species

5.11. Linkage analysis of SRAP marker linked to the fruiting trait in *Luffa spp*.

We have elucidated the inheritance pattern of fruiting behavior in *Luffa* using F_2 mapping population generated from a cross between Pusa Nutan (*Luffa acutangula,* monoecious, solitary fruiting) × DSat-116 (*Luffa acutangula*, hermaphrodite, cluster fruiting)(Fig.5.11a). In F_2 generation, the observed distribution of plant phenotypes fitted in the expected ratio of 3:1 (solitary vs cluster) for fruit-bearing habit. This is the first report of monogenic recessive control for cluster fruit-bearing habit in *Luffa*. F_2 plant populations (218) were genotyped using SRAP marker ME10 EM4 that was polymorphic amongst parental and bulk solitary and cluster fruiting F2 population survey of markers. Amongst several bands amplified by SRAP marker ME10 EM4, the amplicon size of 280 bp was seen only in plants that had solitary fruiting habit i.e. Pusa Nutan while absent in those plants having cluster fruiting habit i.e DSat-116. Among the 218 F_2 plants studied, a 280bp polymorphic band was present in 139 solitary-bearing plants whereas cluster fruiting plants (i.e Satputia genotype DSat-116) produced no band of the expected size (280bp), indicating the recessive nature of the gene governing the trait. The gel image depicting the segregation analysis of the F_2 population is shown in Fig. 5.11b. The recombinants were distinguished by confirming the phenotypic and genotypic status of the F_2 individuals and by repeating their marker amplification profiles. Herein, we designate for the first time the gene symbol *cl* for cluster fruit-bearing in *Luffa*. Linkage analysis revealed that SRAP marker ME10 EM4-280 was linked to the fruiting trait at a distance of 4.6 cM from the *Cl* locus (Fig. 5.11c).

In addition, the inheritance pattern of hermaphrodite sex form in *Luffa* was also studied in the F_2 population of Pusa Nutan × DSat-116 that segregated into 9:3:3:1 ratio (monoecious:andromonoecious:gynoecious:hermaphrodite), suggesting a digenic recessive control of hermaphrodite sex form in *Luffa*, which was further confirmed by the test cross. The inheritance and identification of molecular markers for cluster fruiting traits provide a basis for breeding in *Luffa* species.

5.12. Exploration of the saline-tolerant root system in Indian mustard

Germination and early seedling stages are generally considered more sensitive to salinity than the other growth stages. Root's ability to overcome or bypass stress (drought or salinity) is responded to by developing deep root systems or making metabolic adjustments; saline environments affect both the elongation and architecture of roots by reducing cell size and cell division and altering differentiation patterns.

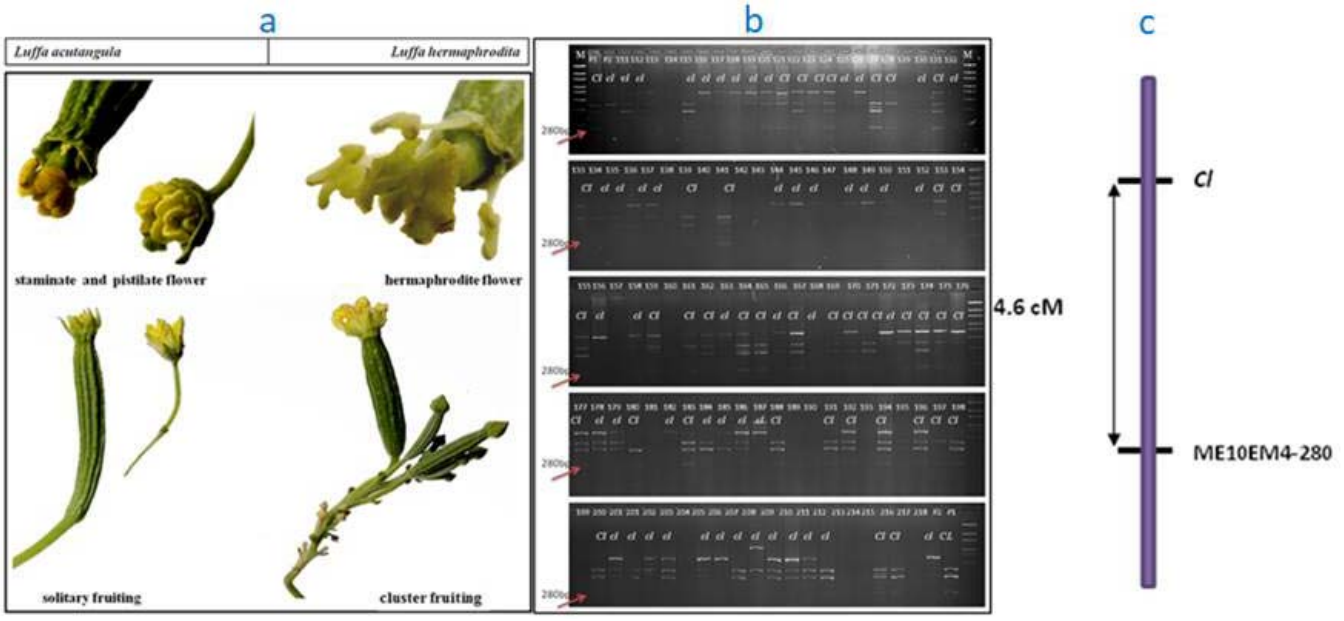


Fig. 5.11. (a) Sex form and fruiting habit in *Luffa acutangula* and *Luffa hermaphrodita* (b) Gel image of individual F_2 plants run with SRAP marker (ME10 EM4) showing segregation for solitary and cluster fruiting habits. Arrow shows the marker ME10 EM4 at 280bp. (*Cl* represents solitary fruiting and *cl* represents cluster fruiting plants) (c) Linkage map showing the linkage of *Cl* gene governing solitary fruiting habit in *Luffa* linked with SRAP marker (ME10EM4-280) at a distance of 4.6 cM

Roots being an underground organ, are the first to detect abiotic cues and accordingly modulate genetic programs for post-embryonic stage growth to survive the stress. Maintenance of optimum root architecture (tap root and lateral roots) is the result of coordinated interaction between the genetic and environmental factors; growth and development of roots is reported to be regulated by environmental stresses to optimize water and nutrient uptake. Therefore, the development of a longer tap root system is not only essential for the establishment of seedlings but also for to uptake of adequate water and nutrients in saline conditions. Forty-six hundred accessions/germplasm of Indian mustard (*Brassica juncea*) seedlings were screened under three different saline conditions (EC 9-, 10-, and 11-dS m^{-1}) to explore robust root phenotype. In the majority of accessions, the reduction in seedling's root and shoot length growth under saline stress conditions was an important observation. Identification of a limited number of accessions (0.26% of the total) demonstrating enhanced root length growth across three saline environments suggested narrow genetic diversity in the screened germplasm. Additionally, the limited biological plasticity in root growth under saline stress conditions could also be the reason for the identification of fewer accessions.

Additionally, the complementarity between phenotypic (Root length) and genotypic (SSR marker profile) data of biological replicates of ~67% identified accessions was noteworthy pointing towards the efficacy of screening strategies. Complementarity refers to the scenario where similar phenotype (root length) among replicates of accession shared similar genotype (SSR marker profile). For example, in accession G74, all four biological replicates shared similar phenotype (root length) and genotype (SSR marker profile) (Fig 5.12). On the contrary, non-complementarity was observed in ~33% of identified accessions, where despite the similarity in phenotype (root length) among biological replicates of accession their genotype (SSR marker profile) demonstrated different and distinct patterns. For example,

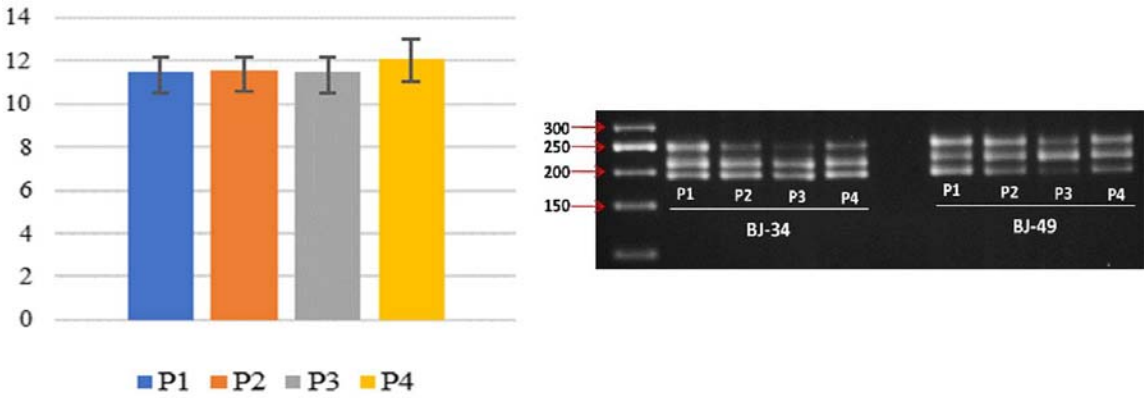


Fig. 5.12. Complementarity between phenotypic (root length) and genotypic (SSR marker) data among biological replicates (P1-4) of accession G74. The bar graph shows the root length (cm) (n=5) under saline condition (EC 10 dS m^{-1})

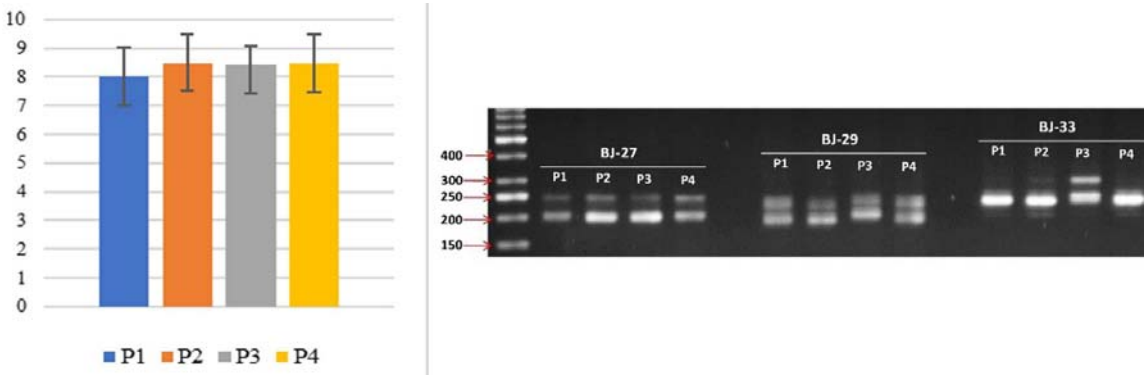


Fig. 5.13. Non-complementarity between phenotypic (root length) and genotypic (SSR marker) data among biological replicates (P1-4) of accession B77. The bar graph shows the root length (cm) (n=5) under saline conditions (EC 10 dS m^{-1})

in accession B77, though the phenotype (root length) of all four replicates were comparable to each other but genotype (SSR marker profile) data revealed that three replicates shared similar genotypes but one replicate (P3) had distinct SSR profile (Fig 5.13). The identified promising accession, after transcriptome analyses using comparative transcriptomic and gene expression associations, would unravel genetic elements associated with such trait.

5.13. Transcriptome study for identification of key genes involved in flowering time regulation in linseed (*Linum usitatissimum* L.)

To understand genes associated with floral development and flowering time regulation in linseed, transcriptome sequencing of reproductive tissues, floral bud at two developmental stages (bud 1 & bud 2), flower, and two vegetative tissues (leaf and stem) in two early flowering linseed accessions, IC0523807 (Variety Sharda), and IC0525939 was performed. A total of 47.4 GB of filtered data was obtained from 20 datasets (Bio Project ID: PRJNA773597), resulting in 43,484 transcripts. Differential expression analysis between vegetative tissues vs reproductive tissues in different combinations revealed a total of 14,244 differentially expressed genes (8159 upregulated and 6085 downregulated), with 40 GO and 161 KEGG enriched terms (Fig. 5.14). Several DEGs were involved in auxin, cytokinin, gibberellic acid, and abscisic acid signal transduction, sucrose, and starch synthesis pathways. From the 234 known genes associated with flowering in other plants, 174 genes were detected in any of the three comparisons (Bud1 vs vegetative tissue, bud 2 vs vegetative tissues, and flower vs vegetative tissues). Further, from the 79 putative candidate genes identified in earlier association studies in linseed, 56 candidate genes were among the DEGs common to bud1, bud2, and flower. Overall, based on previously identified QTLs/QTNs, candidate genes, and DEGs identified in the present study, 2 genes, flowering locus T (*LusFT, Lus10013532*) and a flowering repressor Apetalla-2 (AP2) like transcription factor SCHLAFMUTZE (SMZ) (*LusSMZ, Lus10039650*) showed to be promising candidate genes.

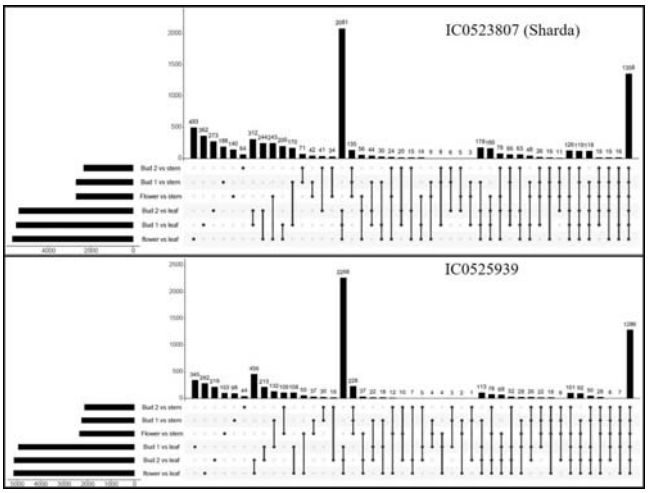


Fig. 5.14. An UpSet plot of a total number of upregulated differentially expressed genes (DEGs) (X axis) detected in six different conditions. Dots below the vertical bars indicate intersections of detected DE genes among different conditions. The horizontal bars represent the total number of DE genes for each condition

5.14. Genome size and chromosome number estimation of browntop millet

Chromosome number and genome size estimation were carried out in browntop millet genotype Bijapur Local [BrM48P1 (PLANT2)]. The chromosome spreads showed 2n=18. Genomic content of browntop millet was determined by flow cytometery using Raphanus sativus cv. Saxa (2C=1.11pg) as standard and estimated to be 1C= 710 Mb. (Table 5.4).

Table 5.4: Genome content of browntop millet as estimated through flow cytometer

Sample	Mean	CV	2C content (pg)
Raphanus sativus	17096.00	4.30	1.11
Bijapur Local	21833.09	3.18	1.417567261

5.15. Phenotypic and Molecular Characterization of CWRs of AA-Genome Species of Rice

With a view to explore genetic diversity in crop wild relatives (CWRs) of AA-genome rice (*Oryza sativa* L.) species, we analyzed 96 accessions of 10 *Oryza* species by using 37 morphological traits and 45 microsatellite markers. High extent of within and between-species phenotypic variation was observed for all the 20 morpho-qualitative traits except anther colour. Shannon-Weiner's diversity (H2 = 0.96) also confirmed the presence of high level of variability in 19 morpho-qualitative traits. The high diversity was recorded for 11 qualitative traits, namely, flag-leaf angle, basal-leaf sheath colour, culm angle, panicle type, panicle exsertion, awn colour, apiculus colour, lemma and palea colour, seed shattering, threshability and pericarp colour. Within species variability assessed in 41 accessions of *O. nivara* and 29 accessions of *O. rufipogon* revealed existence of higher variability in *O. nivara*

accessions (H2 = 0.87) as compared to *O. rufipogon* (H2 = 0.69) for most of the traits. The morpho-quantitative traits also revealed high extent of phenotypic variation within and between species. Shannon-Weiner's diversity index (H2) also confirmed the presence of high level of genetic variation. Principal component (PC) analysis explained 79.22% variance with five PCs. Genotyping based on 45 genome-wide hypervariable microsatellite markers revealed 676 alleles with mean of 15.02 alleles per locus and 0.83 mean polymorphism information content. Structure analysis revealed four subpopulations; first and second subpopulations comprised only of *O. nivara* accessions, while the third subpopulation included both *O. nivara* and *O. rufipogon* accessions (Fig. 5.15).

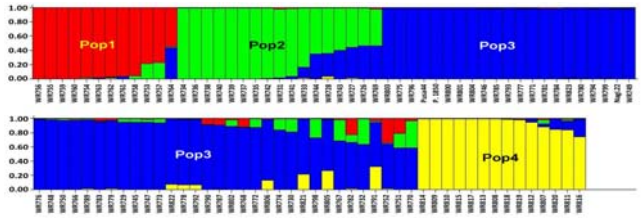


Fig. 5.15. Population structure analysis of 96 accessions of *Oryza* species revealing subpopulations designated as Pop1, Pop2, Pop3 and Pop4. Population structure showing members of the subpopulations, with sub-population-3 had the maximum accessions (53) and subpopulation-1 having the least accessions (12) of CWRs

AMOVA revealed 11% variation among the populations, whereas 70% variation was recorded among genotypes and 19% variation within genotypes (Fig. 5.16a). Principal coordinate analysis (PCoA) showed 13.10% cumulative variation from first three axes of coordinates. The pattern of variance of four populations is depicted in PCoA plot (Fig. 5.16b) with population-3 intermixed with other three populations. AMOVA of all 45 *O. nivara* accessions, analysed based on geographic locations of four states, revealed a high level of molecular variance among genotypes (64%) and PCoA plot displayed that population 2 consisted of accessions from West Bengal is genetically distant from other three populations (Fig. 5.16c, d). However, within genotype molecular variance was much higher in *O. rufipogon* (30%) (Fig. 5.16e) compared to *O. nivara* accessions (15%). PCoA plots showed admixtures between four geographically different populations of *O. rufipogon* (Fig. 5.16f). The high level of molecular and morphological variability detected in the germplasm of crop wild relatives could be utilized for the genetic improvement of cultivated rice.

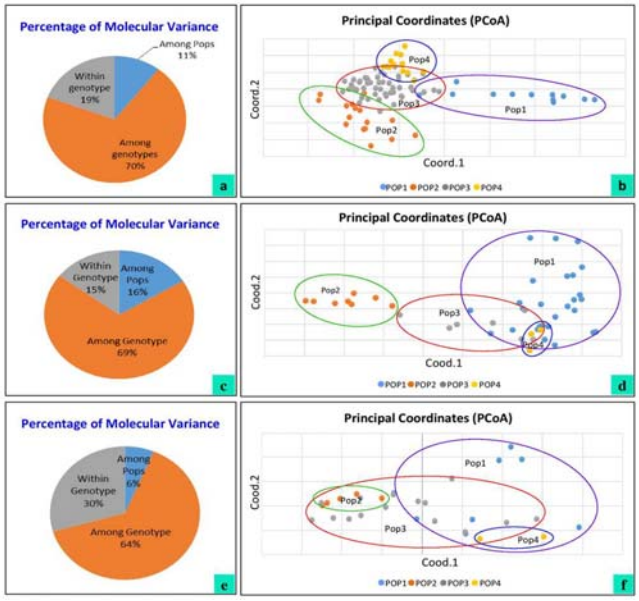


Fig. 5.16. DNA polymorphism at 45 SSR loci analysed in 10 *Oryza* species showing distribution of molecular variation (a) and PCoA plot (b) of four populations of 96 accessions of 10 species. Molecular variance and PCoA plots of 45 accessions of *O. nivara* (c, d) and 30 accessions of *O. rufipogon* (e, f)

5.16. Morphological and Molecular Analyses of Grain Traits in Aromatic Rice Landrace Accessions

Assessment of genetic variation in morphological traits of rice (*Oryza sativa* L.) grain is vital, which affects its yield and quality parameters. We analyzed 92 accessions of aromatic rice landrace germplasm from Indo-Gangetic plain region of India for grain morphometric traits as-well-as for genotypic mutation in *exon* 3 of grain size (*GS3*) gene.

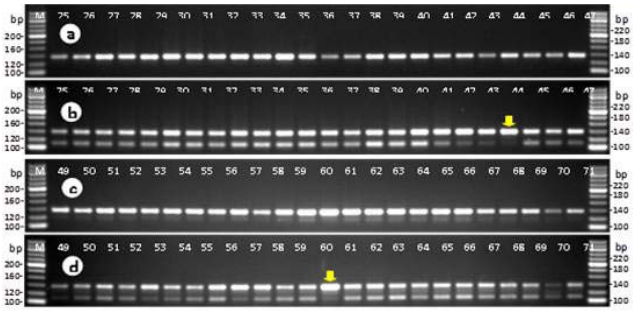


Fig. 5.17. Gel profile of *GS3* gene generated by SF28 primers in 96 aromatic rice accessions. Undigested amplicons of 136 bp present in accessions 25-48 (a) and accessions 49-72 (c). DNA fragments of 136 bp and 110 bp after digestion with *Pst*I restriction enzyme present in accessions 25-48 (b) and accessions 49-72 (d). Arrow indicates the undigested amplicon revealed in accessions 45 (Jeera Saila) and 61 (Champaran Basmati)

Significant variability was detected for grain traits namely rough rice length and breadth (RRL; RRB), rough rice length/breadth ratio (RRLB), 1000-grain weight (TGW), brown rice length and breadth (BRL; BRB) and brown rice length/breadth ratio (BRLB). Principal component (PC) analysis revealed that first two PCs explained 86.04% of phenotypic variation. The variation revealed for C/A single nucleotide polymorphism in *GS3* gene (Fig. 5.17). The superior accessions for grain traits viz., RRB (Jeera Sail/IC419047), TGW (Hansraj/IC0419006) and BRL (Kala Jira/IC0419052) identified. The genetically variable germplasm with superior grain traits could be utilized for genetic enhancement of grain size in aromatic rices.

5.17. Development of Genetic Resources for Trait Discovery and Gene Mapping in Bread Wheat for Heat-stress Tolerance

Genetically variable populations are vital for trait-discovery and fine mapping of QTLs for complex traits such as yield and heat-tolerance. The MAGIC (Multi-parent Advanced Generation Inter-Cross) populations are suitable for high-resolution QTL mapping. We created MAGIC population with enhanced resilience to heat-stress by crossing an exotic line with the well-adapted bread wheat germplasm. For the development of 5-parent MAGIC populations, we crossed five founder lines namely, Iepace Robe, NW1014, HD2864, UP2338 and DL788-2, selected based on component traits under heat-stress condition, to create three F_1 hybrids using HD2864 as reciprocal parent. Each F_{1s} were crossed in a full diallel pattern to produce six double crosses during 2016-17. The two-way crosses were further hybridized in all possible combinations in 2017-18 to reshuffle the genomes of founder lines. The MAGIC population was stabilized by natural self-pollination and 5th cycle of selfed seeds of 1920 MAGIC RILs and F_8 seeds of 1050 RILs of five biparental populations were harvested during 2022-23 (Fig.5.18). The mapping populations were exposed to 35-38°C at grain development stage during their development under late sown conditions for screening the tolerant lines against terminal heat stress and to impart adaptation to elevated temperature. The promising 510 RILs of 5-parental MAGIC population would be genotyped using SNP chip for fine-mapping of QTLs for heat-stress tolerance.

Fig. 5.18. Field view of biparental and MAGIC populations grown in Delhi during *Rabi* season of 2022-23

5.18. GMO testing services to public and private sector

GMO testing services were provided for 53 samples of 21 consignments of different crops including banana, maize, papaya, rice, soybean, tomato and ornamental plants (details enclosed in Table 5.5). Resource of Rs. 4, 37, 780 was generated.

Table 5.5: Consignments received for GMO Testing (1 January-31 December 2023)

Crop	No. of samples	Source
Banana	04	Rise N Shine Biotech Pvt. Ltd., Pune
	05	K. F. Biotech Private Limited., Bengaluru
Maize	02	East West Seeds India Pvt. Ltd., Aurangabad, Maharashtra
Papaya	06	East West Seeds India Pvt. Ltd., Aurangabad, Maharashtra
	02	Known-You Seed (India) Pvt. Ltd., Pune, Maharashtra
	04	Directorate of Plant Protection, Quarantine, and Storage (DPPQ&S), Regional Plant Quarantine Station, Rangpuri, Delhi
Rice	01	Fairlead Inspection & Testing Private Limited, Gandhidham, Gujarat
Soybean	01	Office of the Commissioner of Customs (General), Central Intelligence Unit, Raigad, Maharashtra
Tomato	01	Bio Resources, Hyderabad
Ornamental plants*	26	Institute of Biotechnology, Jayashankar Telangana State Agricultural University, Hyderabad, Telangana

**Cyperus haspan, Hymenocallis littoralis, Hydrocotyle vulgaris, Thalia dealbata, Canna indica, Alocasia macrorrhiza, Nymphaea lutea, Heliconia psittacorum, Cyperus papyrus, Cyperus alternifolius*

5.19. Validation of voucher seeds of GM events before conservation

Eleven voucher samples including stacked GM event of cotton, namely, MON15985xMON88193 (Mahyco Pvt. Ltd., Jalna), six GM brinjal events (University of Agricultural Sciences, Dharwad) and four *Arabidospis* lines overexpressing *urate oxidase* gene from *Oryza coarctata* (ICAR-National Institute for Plant Biotechnology, New Delhi) were conserved in the transgenic module after validation using PCR/ real-time PCR assays for respective transgenic elements/ GM events (Fig. 5.19).

Additionally, 58 seed samples of *Bt* cotton hybrids including parental lines [submitted by the public and private sector for deposition and conservation at National Genebank in compliance with regulatory requirements towards Release & Notification of the CVIC (Central Variety Identification Committee) identified cotton variety and hybrid] were confirmed for the presence of *cry1Ac* and *cry2Ab2* transgene (s) in respective varieties/ hybrids using PCR assays.

5.20. Checking unauthorized presence of GM ingredients in imported or indigenous food products

GM maize (corn) has been approved in many countries for commercial use, however, GM maize products have not yet been approved in India. The unauthorized presence of GM ingredients was checked in 50 maize containing samples of imported or indigenous food products purchased from the marketplace, using systematic GM detection. GM status was monitored using PCR assays targeting common screening elements: *CaMV 35S* promoter *(P-35S)*, *nos* terminator (*T-nos*), and real-time PCR assays targeting specific transgenes: *cp4-epsps* (Fig. 5.20), *cry1Ab/Ac*. Based on the tests conducted, none of these samples were found positive. Such studies will give a fair idea to ensure the absence of unauthorized GM events in the food products in markets, for regulatory compliance.

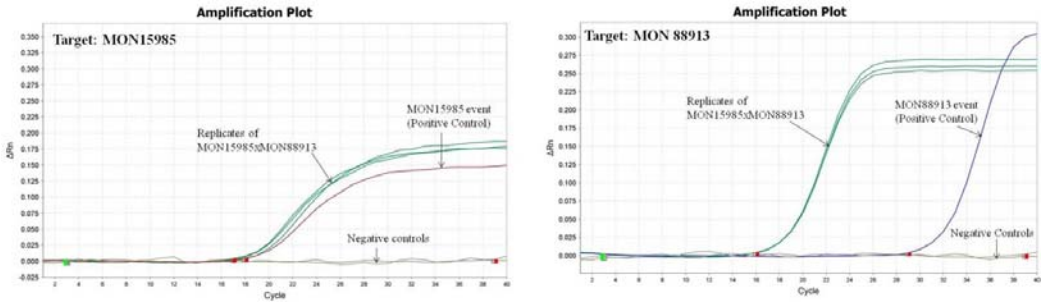


Fig. 5.19. Real-time PCR profiles for confirmation of MON15985 and MON88913 GM events in the voucher sample of MON15985xMON88913 stacked event

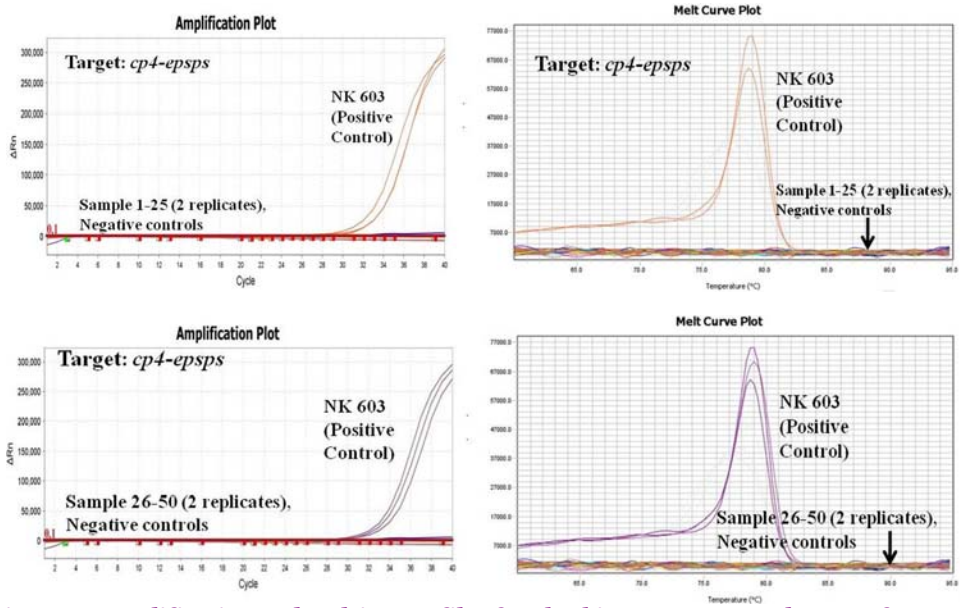


Fig. 5.20. Real-time PCR amplification and melting profiles for checking presence or absence of *cp4-epsps* gene in fifty samples of food products

5.21. Visual Loop-mediated isothermal amplification (LAMP)-based GM diagnostics targeting *cry1Ab* gene

Transgene *cry1Ab* is present in the imported GM events of maize, including MON810, Bt11xTC1507xGA21, Bt11xGA21xMIR162, Bt11xGA21xMIR162xMON89034, and in more than 25% of globally approved GM events of different crops carrying *cry* gene(s). Visual LAMP-based GM detection technology targeting *cry1Ab* gene was developed with acceptable specificity (Fig. 5.21) and limit of detection (LOD) up to 0.005%.

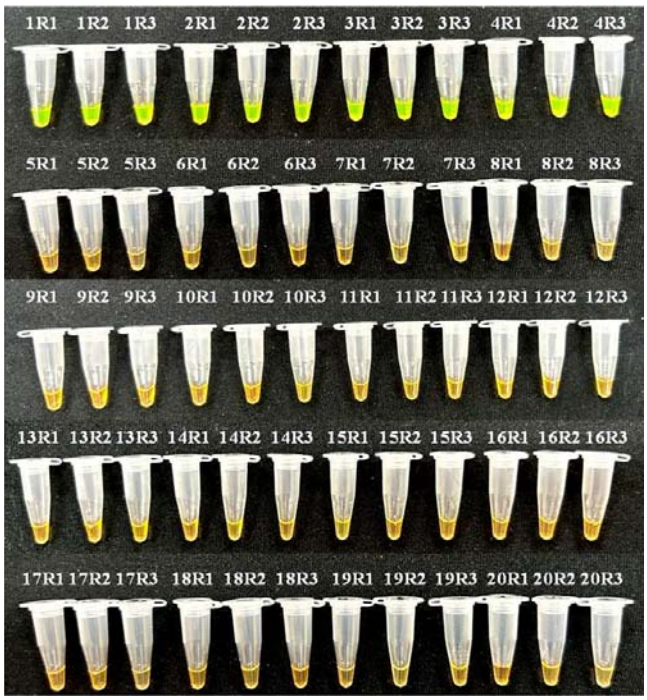


Fig. 5.21. Specificity test for LAMP assay targeting *cry1Ab* gene
1: MON 810, 2: Bt11, 3: Bt176, 4: MON863xMON810, 5: MIR604, 6: MON863, 7: NK 603, 8: TC 1507, 9: 59122, 10: 3272, 11: 98140, 12: DP356043, 13: 40-3-2, 14: 305423, 15: MON531, 16: MON15985, 17: Non-GM Maize, 18: Non-GM Soy, 19: Non-GM Cotton, 20: Non-template control

5.22. GM detection Initiated for multiplexing in Real-time loop-mediated isothermal amplification (LAMP)

Multiplexing in real-time LAMP has been initiated for the first time in GM detection using an isothermal amplification system (Genie®II). LAMP conditions were standardized for multiplexing in LAMP in duplex (*nptII, P35S-cry1Ac*) and triplex (*P-35S-cry1Ac, P-FMV, nptII*) formats. The multiple targets can be detected and differentiated based on differences in melting curve profile/ melting temperature - Tm) (Fig. 5.22). The method validation studies are in progress. Due to the portability of the Genie II system, multiplex real-time LAMP has the potential for rapid on-site GM detection.

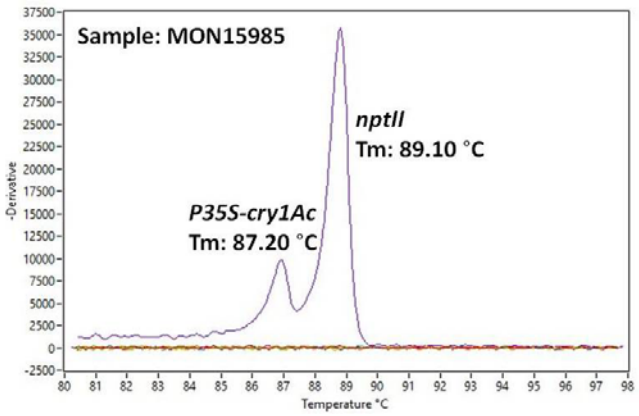


Fig. 5.22. Melting curve profile of multiplex real-time LAMP targeting *nptII* and *P35S-cry1Ac* in the sample of MON15985

Research programme (Code, Title**, Programme Leader)**
PGR/GRD- BUR-DEL- 01.00: Development of Genomic Tools for Identification, Protection and Enhanced Utilization of PGRs (Rakesh Singh)
Research Projects (Code &PI, Co-PI and Associates)
PGR/GRD- BUR-DEL- 01.01: Development of genomic tools for discovery and validation of genes of economic importance for enhancing the use of plant genetic resources of pulses, oilseeds and fiber crops (**Rajesh Kumar**, JK Yasin, DP Wankhede R Yadav, S Rajkumar, R Parimalan, AK Singh, Madhubala Priyadarshi (w.e.f. Sep 2022) and V Kaur)
PGR/GR D-BUR- DEL-01.02: Development of genomic tools for enhanced utilization of cereals (**Rakesh Singh**, MC Yadav, S Kumar, AK Singh, R Parimalan and Sheel Yadav (on study leave till Jan 2023)
PGR/GR D-BUR- DEL-01.03: Development of genomic tools for enhanced utilization of millets (**Lalit Arya,** Monika Singh, M Singh, S Gomashe and SB Choudhary)
PGR/GR D-BUR-DEL- 01.04: Development of genomic tools for enhanced utilization of horticultural crops: (**Ambika B Gaikwad**, M Verma, Vinod Kumar, K. Pradheep and D Gautam)
PGR/GR D-BUR- DEL-01.05: Development of genomic tools for species delineation and genetic erosion studies in selected crops (**Mahesh C Yadav**, S Rajkumar, DR Pani and M Latha)
PGR/GR D-BUR- DEL- 01.06: Establishment and maintenance of national genomic resources repository and bioinformatics facility (**Sundeep Kumar**, MC Yadav, L Arya, M Verma, S Rajkumar, R Kumar, AK Singh, JK Yasin, R Parimalan, DP Wankhede, M Singh, Sheel Yadav (on study leave till Jan 2023) and SK Singh) (upto 29.09.2024)
PGR/GR D-BUR- DEL-01.07: Development and utilization of GM diagnostics for detection of genetically engineered plants and derivatives (**Monika Singh,** G Randhawa (till Aug, 2022) and Amit Kumar Singh (w.e.f. 19 Dec 2022)
PGR/GR D-BUR- DEL- 01.08 (Development of unique identity system for cultivars and genetic stocks for IPR protection (**MK Rana,** AB Gaikwad, R Singh, L Arya, M Verma, S Kumar, R Kumar, S Rajkumar, R Parimalan, AK Singh, Sheel Yadav (on study leave till Jan 2023), DP Wankhede, JK Yasin and SK Singh) (upto 29.09.2024)

6 DIVISION OF GERMPLASM CONSERVATION

सारांश: विभिन्न कृषि और बागवानी फसलों के 5538 जर्मप्लाज्म परिग्रहणों के बीजों को दीर्घकालिक संरक्षण (–18^{0}C) के लिए जीनबैंक मानकों का पालन करते हुए संशोधित किया गया, जिससे राष्ट्रीय जीनबैंक में कुल जर्मप्लाज्म होल्डिंग 4,68,660 हो गई। 7477 संरक्षित परिग्रहणों के बीजों के अंकुरण की जांच और बीज की मात्रा को अद्यतन किया गया। भौतिक सत्यापन के बाद 24,773 परिग्रहणों को बारकोड किया गया। लक्षण वर्णन/मूल्यांकन/पुनर्जनन/अनुसंधान और उपयोग गतिविधियों के लिए विभिन्न फसल प्रजातियों के 47,864 परिग्रहण वितरित किए गए। पूरे देश से प्राप्त विशिष्ट गुणों और नवीन विशेषताओं वाले जर्मप्लाज्म (126) परिग्रहण को पंजीकरण प्रमाण पत्र प्रदान किया गया और परिग्रहणों को दीर्घकालिक भंडारण (एलटीएस) मे संरक्षित किया गया। राष्ट्रीय कृषि अनुसंधान प्रणाली में पहचानी गई 473 किस्मों/संकरों और उनकी मूल वंशावली के संरक्षण एवं विमोचन अधिसूचना के लिए प्राप्त बीजों के लिए विशिष्ट राष्ट्रीय आईडी के साथ प्रमाण पत्र जारी किए गए। राष्ट्रीय जीनबैंक में विभिन्न वानस्पतिक रूप से प्रसारित होने वाली फसलों को भी संरक्षित किया जाता है। इन विट्रो एक्टिव जीनबैंक (आईवीएजी) में 53 नए परिग्रहणों को जोड़ने के बाद, कुल आईवीएजी संग्रह की संख्या बढ़कर 2,015 हो गयी है जिन्हे 8–25 डिग्री सेल्सियस के भंडारण तापमान पर बनाए रखा जाता है और 1–24 महीने की अवधि में सब कल्चर किया जाता है। इसके अलावा, 2023 के दौरान इन विट्रो बेस जीनबैंक (आईवीबीजी) में 14 नए परिग्रहण जोड़े गए, जो कुल मिलाकर 333 परिग्रहणों तक पहुंच गई। इसी प्रकार, फलों, औद्योगिक फसलों, फलियां, मिल्लेट्स, चारा, सब्जियों और और जंगली प्रजातियों के बीज, भ्रूणीय अक्षों एवं परागकणो के रूप में 308 नए परिग्रहण क्रायोजीनबैंक में जोड़े गए, जिससे इसकी कुल संख्या 12,944 परिग्रहणों तक पहुंच गई। इसके अलावा क्रायोजीनबैंक में 2,194 जीनोमिक संसाधनों का भी अनुरक्षित किया जा रहा है। इन विट्रो उगाए गए हॉप्स, शहतूत और रूबिया कॉर्डिफोलिया के पौधों की आनुवंशिक अखंडता की पुष्टि की गई थी। इन विट्रो स्थापना और गुणन प्रोटोकॉल के लिए अनुसंधान किया गया एवं आर्टोकार्पस हेटरोफिलस, बनियम, रूबिया कॉर्डिफोलिया, जिंजिबर वाइटीयनम और जिंजिबर नीसानम मे सफलता प्राप्त की गई। विट्रीफिकेशन, ड्रॉपलेट–विट्रीफिकेशन तथा वी और डी–क्रायोप्लेट तकनीकों का उपयोग करके एलियम अम्पेलोप्रसम, बकोपा मोनिएरी, साईसर माइक्रोफिलम और गार्सिनिया इंडिका में क्रायोप्रिजवेशन प्रयोगों में अलग–अलग डिग्री की सफलता हासिल की गई। सॉरोपस एंड्रोगिनस और स्मॉलेंथस सोनचिफोलियस के संवर्धन के लिए धीमी वृद्धि मीडिया की स्थापना की गई। गेहूं में बीज दीर्घायु के घटक लक्षणों जैसे कि डीपीपीएच प्रतिधारण प्रतिशत, एंटीऑक्सीडेंट क्षमताय ग्लूटाथियोन आधा सेल रिडॉक्स क्षमता, अंकुरण की गति की औसत और अंकुरण समय के लिए मार्कर विशेषता एसोसिएशन विश्लेषण किया गया। जीडब्ल्यूएएस विश्लेषण से बीज दीर्घायु के लिए प्रमुख कैंडिडेट जीन के साथ दस एमटीए की पहचान हुई। छवियों से बीज के रंग के अर्ध–स्वचालित अनुमान के लिए एक आर पेकेज "सीडकलर" विकसित किया गया है।

Summary: Seeds of 5538 germplasm accessions of various agricultural and horticultural crops were processed following genebank standards for long-term conservation (-18^{0}C) thereby raising the total germplasm holding to 4,68,660 in the National Genebank. Monitoring of seed germination and updating of seed quantity was carried out in 7477 conserved accessions. 24,773 accessions were barcoded after physical verification. 47,864 accessions of different crop species were distributed for characterization/evaluation/ regeneration/research and utilization activities. Germplasm (126 accessions) with unique traits and novel features received from all over the country were provided registration certificates and the accessions were conserved in Long Term Storage (LTS). Certificates along with Unique National ID were issued for receipt of seeds for conservation of 473 varieties/hybrids and their parental lines that were identified in the National Agricultural Research System for release and notification. Vegetatively propagated crops are also conserved in National Genebank. 53 new accessions were added to the *In Vitro* Active Genebank (IVAG) thereby bringing the IVAG collection size to 2,015 accessions of various plant species maintained at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months. 333 accessions are maintained in the *In Vitro* Base Genebank (IVBG) of which 14 accessions were added during 2023. Similarly, 308 new accessions belonging to fruits, industrial crops, legumes, millets, forages, vegetables and wild species in the form of seeds, embryonic axes and pollen were added to the cryobank thereby raising the collection to 12,944 accessions. 2,194 genomic resources are also being maintained in the cyrogenebank. The genetic integrity of *in vitro* raised plants was confirmed in hops, mulberry and *Rubia cordifolia* etc. As part of supportive research, experiments were carried out for *In vitro* establishment and multiplication protocols. Success was reported for *Artocarpus heterophyllus*, *Bunium*, *Rubia cordifolia*, *Zingiber wightianum* and *Zingiber neesanum* etc. Varying degrees of success was achieved in cryopresevation experiments in *Allium ampeloprasum*, *Bacopa monnieri*, *Cicer microphyllum and Garcinia indica*, using vitrification, droplet-vitrification and V and D-cryoplate techniques. Slow growth media was established for culturing *Sauropus androgynus*, *Smallanthus sonchifolius*. Marker trait association analysis was carried out in wheat for component traits of seed longevity *viz.*, antioxidant potential measured as DPPH retention percentage; Glutathione Half Cell Redox Potential; speed of germination measured as Mean Germination Time. GWAS analysis led to the identification of ten MTAs along with major candidate genes for seed longevity. An R package *"seed colour"* for semi-automated estimation of seed colour from images has been developed.

6.1. Long Term Conservation of Orthodox Seeds in the National Genebank

6.1.1. Germplasm augmentation

13,639 germplasm accessions of various agricultural and horticultural crops were received for long-term conservation in the National Genebank. 298 accessions were rejected during quarantine examination, 220 on account of insufficient quantity were stored in MTS and will be regenerated subsequently for further long-term conservation. 13,121 accessions qualified for conservation as per the genebank standards. Of these, 8371 have been conserved at – 18 ± 2°C as base collections and rest are being processed for conservation. Of the conserved accessions, 5538 were new and 2833 accessions were received after regeneration (Table 6.1). The total germplasm holdings in the National Genebank (representing 2,164 species) has increased to 4,68,660.

6.1.2. Monitoring of germplasm

The germplasm (7477 accessions) conserved in the long-term storage condition for >10 years was monitored for seed viability and seed quantity, to ensure the status of the conserved germplasm as per the genebank standards. The accessions showing less than 85% of the initial germination will be regenerated to replace low viability seeds in genebank.

6.1.3. Distribution of germplasm

47, 864 accessions were supplied for utilization by different stakeholders. Most of the accessions were distributed for research, regeneration, characterization/ evaluation/regeneration/research and utilization activities. The details are given in (Table 6.2).

6.1.4. Physical verification and barcoding

34227 accessions of various crops were physically verified and barcoding of 24,773 was completed.

6.1.5. Large scale characterization of Sorghum

As part of celebration of International Year of Millets 2023, ICAR-NBPGR has taken up characterization programme of sorghum germplasm at Agricultural Research Station, Washim. More than 25,000 accessions of sorghum germplasm conserved in the National Genebank of ICAR-NBPGR were characterized using a set of 26 descriptors. The programme was implemented in collaboration with ICAR-Indian Institute of Millet Research, Hyderabad and Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola. This programme will help in development of core set, representing the diversity of sorghum germplasm conserved in the National Genebank and thus enhance the utilization of

Table 6.1: Status of germplasm holdings in the National Genebank (as on December 31, 2023)

Status of Base Collection in National Genebank (-18°C) (As on 31st Dec., 2023)					
Crop/Crop Group	**No. of Acc. conserved during (1st Jan., 2023 - 31st Dec, 2023)**				**Present status of total acc. conserved**
	Regenerated	**New**	**New Species Added**	**Total Species**	
Cereals (other than rice)	1325	3174	17	165	176660
Millets	561	213	2	33	60435
Forages	119	42	1	229	7519
Pseudocereals	8	118	3	60	8215
Legumes	2	387	3	120	68851
Oilseeds	6	220	2	90	63480
Fibre	358	129	3	84	17049
Vegetables	335	791	6	228	29468
Fruits & Nuts	0	2	1	73	302
Medicinal & Aromatic plants	7	382	14	721	9527
Ornamental	0	11	2	136	743
Spices, Condiments and Flavour	112	56	1	29	3695
Agroforestry	0	13	1	196	1710
Duplicate safety Samples	0	0	0	0	10235
Trial Material (Wheat, Barley)	0	0	0	0	10771
Total	**2833**	**5538**	**56**	**2164**	**468660**

Table 6.2: Distribution of germplasm of different crops for various purposes

Crop	Purpose	Total
Paddy (8131), Wheat (196), Maize (588), Finger Millet (5271), Sorghum (12100), *Borthiochloa* (57), Spear Grass (221), *Dicanthium* (340), *Cenchrus* (142), *Bromus* (57), *Festuca* (42) , *Lolium* (57), Lucerne (242), *Dactylis* (43), Babchi (19), Pearl Millet (88), Isabgol (09), Periwinkle (04) Cucumber (814), Brinjal (918), Wild Okra (155), Pigeonpea (1700)	CRP (AB)	31194
Wheat (502), Barley (286), Isabgol (72), Paddy (4544)	Evaluation	6384
Faba Bean (121), Paddy (519), Pearl Millet (998), Oilseed Brassica (1028)	Multiplication	2666
Cotton (27) Wild Sesame (1)	Species identification	28
Withania (438), Barnyard Millet (1888), Fababean (630)Taramira (377), Oilseed Brassica (113)	Characterization	3446
Wheat (68), Maize (413), Barley (40), Nigella (70), Chilli (30), Cotton (3), *Brachiaria* (5), Watermelon (6), Tomato (13), Musk Melon (50), Wild Tomato (51) Paddy (245), Little Millet (6), Brown top Millet (5), Pearl Millet (217), Finger Millet (1657), Mungbean (241), Chickpea (170), Pigeonpea (307), Horse Gram (300), Broadbean (27), Chilli (980), Lentil (150) Soybean (37), Oilseed Brassica (35)	Research	4146
	TOTAL	**47,864**

Sorghum Genetic Resources in crop improvement programme

6.2. Plant Germplasm Registration

The 50th and 51st meetings of the Plant Germplasm Registration Committee (PGRC) chaired by Dr TR Sharma, DDG, Crop Science, ICAR, New Delhi were conducted online on June 12, 2023 and November 22, 2023 respectively. 160 proposals out of the 286 proposals received, found complete in all respects and reviewed by experts were considered for registration. 125 proposals with unique/novel features belonging to 54 species were finally recommended for registration (Table 6.3, Fig 6.1 & 6.2). Some notable registered genetic stocks are:

Salient features of the germplasm registered based on the recommendation of 43rd - 45th meetings of the PGRC have been published in the 36th volume (issue 1-3) of the Indian Journal of Plant Genetic Resources. The photographs of some of the germplasm are shown in Fig. 6.3 (a-e).

Table 6.3: Crop-group and meeting wise germplasm registered and conserved in the National Genebank

Crop group	Current Status of germplasm registered for unique/novel traits	No. of acc.Jan 01, 2023 -Dec 31, 2023		
		Total accession registered during 2023	Registered during 50th PGRC	Registered during 51st PGRC
Cereals and Pesudocereals	786	55	31	24
Millets	157	15	13	2
Fibre and Forages	130	3	3	0
Grain Legumes	221	12	5	7
Vegetables	139	5	3	2
Oilseeds	261	7	4	3
Commercial Crops	121	2	0	2
M & AP & Spices	136	6	2	4
Fruits and Nuts	75	9	3	6
Tubers	57	2	1	1
Ornamentals	99	8	1	7
Narcotic/Beverages	9	1	1	0
Agro-forestry	8	0	0	0
Grand Total	2198	125	67	58

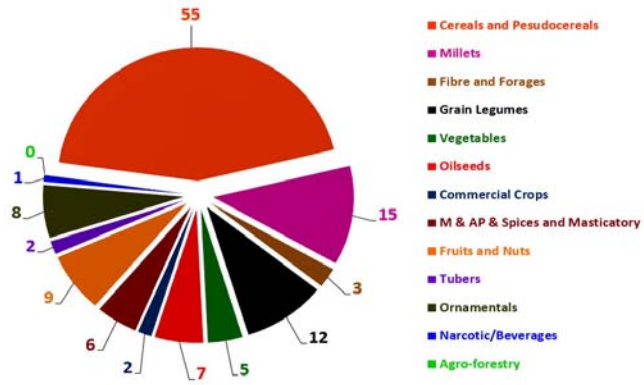


Fig. 6.1: Crop-group wise germplasm registered in between Jan 01, 2023 - Dec 31, 2023

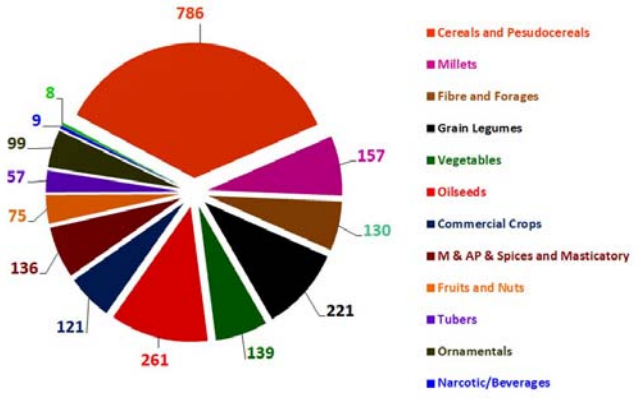


Fig. 6.2: Crop-group wise total germplasm registered with ICAR-NBPGR (1996-2023)

Fig. 6.3 (a): Hurda Sorghum (*Sorghum bicolor*; IC648614; INGR23038), with free threshability; high hundred tender grain weight (4.12g) and excellent fragrance

Fig. 6.3 (c): Sugarcane (*Saccharum officinarum*; IC650762; INGR23119), for resistance to whip smut under artificial condition

Fig. 6.3 (b): Elephant Ears (*Caladium* sp.; IC650759; INGR23116), with green/white contrast leaf color; white midrib color and white leaf spot

Fig. 6.3 (d): Apple (*Malus domestica*; IC647749; INGR23104), for solid fruit peel colour (Red group - 46 - A); early fruit peel colour (15 -20 days earlier) and early maturity (Two weeks earlier)

Fig. 6.3 (e): Areca Nut (*Areca catechu;* IC648626; INGR23064) with noticeably short internodes, dark green leaves, shorter inflorescences and highly fragrant flowers

Fig. 6.3a-e: Some notable trait specific germplasm registered during 2023

6.3. Conservation of Vegetatively Propagated Crops in National Genebank

6.3.1. Germplasm maintenance, augmentation and addition in the *In vitro* repository of NGB

In vitro cultures of 2,015 accessions of various plant species were maintained in the *In Vitro* Active Genebank (IVAG) at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months (Table 6.4 a). Of these, 53 are the *in vitro* cultures of new accessions added during the period under report. 14 accessions were cryopreserved in the form of tissue explants thereby taking the total number of accessions cryo conserved in the In Vitro Base Genebank (IVBG) to 333 (Table 6.4 b).

6.4. Cryopreservation of genetic resources in the National Genebank

6.4.1. Cryopreservation of seed, pollen, dormant bud and genomic resources in the National Genebank

Plant Genetic Resources in the form of seed, pollen, dormant bud and genomic resources are conserved in the cryotanks in the NGB (Table 6.5). 308 accessions of reclacitrant/intermediate seeds, orthodox seeds and pollen grains were cryobanked in 2023.

6.5. Genetic stability analysis of cryopreserved germplasm

Genetic stability assessment of cryopreserved plants was carried out in multiple species using ISSR markers (hops- 30 markers; one accession of mulberry cryopreserved using the encapsulated-dehydration technique- 49 markers; *R. cordifolia* regenerants - 32 markers). No variability was observed among the tested plantlets thus indicating genetic stability (Figs. 6.4- 6.6).

6.6. Germplasm supply

57 accessions belonging to seven species were supplied to different indenters. These include *Piper nigrum* (1), *Piper longum* (1) *Pichrorhiza kurroo* (3) and *Dioscorea bulbifera* (2) to Punjab University, Chandigarh; *Musa* sp. (4) to Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut and (9) to NRC Banana as *in vitro* cultures, 27 (exotic) accessions of *Rubus* spp. and 10 accessions of *Vaccinium* spp. were hardened and supplied to NBPGR, Regional Station, Srinagar for field evaluation.

Table 6.4a. Status of *in vitro* conserved germplasm in IVAG (as on 31st Dec., 2023)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)	No. of accs added during 2023	Major collections (no. of accessions)
Tropical fruits	3	20	10,000	449	-	*Musa* spp. (444), *Garcinia gummi-gutta (1)*, *Garcinia indica (4)*
Temperate and minor tropical fruits	11	42	9000	400	18	*Actinidia* spp. (19), *Aegle marmelos* (2), *Artocarpus heterophyllus* (2), *Artocarpous lakoocha* (1), *Fragaria* spp. (68), *Malus domestica* (35), *Morus* spp. (70), *Prunus* spp. (32), *Pyrus communis* (76), *Rubus* spp. (69) *Vaccinium* spp. (23) and *Vitis* (wild) (3).
Tuber crops	6	15	7000	528	01	*Ipomoea batatas* (263), *Dioscorea* spp. (154), *Colocassia esculenta* (96), *Xanthosoma sagitifolium* (10), *Alocasia indica* (4) and *Smallanthus sonchifolius* (1)
Bulbous and other crops	6	16	4,200	185	8	*Allium* spp. (168), *Dahlia* sp. (6), *Gladiolus* sp. (8), *Fritillaria cirrhosa* (1), *Lilium polyphylum (1)*, *Cicer microphyllum* (1)
Medicinal and aromatic plants	33	46	8000	221	23	*Coleus forskohlii* (14), *Plumbago zeylanica* (19), *Rauvolfia serpentina* (13), *Tylophora indica* (10), *Valeriana wallichii* (16) etc.
Spices and industrial crops	10	32	4500	232	3	*Zingiber* spp. (83), *Curcuma* spp. (109), *Piper* spp. (8), *Elettaria cardamomum* (5), *Vanilla planifolia* (4), *Simmondsia chinensis* (12), *Humulus lupulus (8)*, *Stevia rebaudiana (1)*, *Arundo donax (1)*, *Rubia cordifolia* (1)
TOTAL	**70**	**172**	**42,700**	**2,015**	**53**	

Table 6.4b. Status of germplasm cryobanked in the IVBG (as on 31st Dec., 2023)

Crop/ Species	Acc. added during 2023	Total no. of accessions	Technique (s)*	Explant (s)#
Allium sativum		135	V, DV	ST
A. albidum		1	V, DV	ST
A. chinense		8	V, DV	ST
A. hookeri		2	V, DV	ST
A. fistulosum		1	V, DV	ST
A. lineare		1	V, DV	ST
A. ramosum		1	V, DV	ST
A. scorodoprasum		1	V, DV	ST
A. tuberosum	1	5	V, DV	ST
Bacopa monnieri		8	V, DV	ST
Colocasia esculenta	3	8	DV	ST
Dioscorea bulbifera		2	V	ST
D. deltoidea	1	13	V	ST
D. floribunda		1	V	ST
Ensete glaucum		2	AD	ZE
Fragaria x ananassa		1	ED	ST
F. chiloensis		1	ED	ST
Garcinia indica		1	DV	ST
Gentiana kurroo		3	DV	ST
Morus spp.	6	6	DV	ST
M. bombycis		4	V, DV	ST
Morus indica		1	V, DV	ST
Musa spp.	1	75	DV, V, AD	SM, ECS, ZE
M. acuminata		7	DV	SM, ZE
M. balbisiana		8	AD, DV	SM, ZE
M. cheesmanii		2	AD	ZE
M. inandamanesis		2	AD	ZE
M. itirenans		2	AD	ZE
M. ornata		1	AD	ZE
M. puspanjaliae		1	AD	ZE
M. textilis		1	DV	SM
M. velutina		2	AD	ZE
Rubus hybrid		6	ED	ST
Swertia chirayta	2	2	DV	ST
Vaccinium ovatum		7	ED	ST
Total	**14**	**333**		

*AD: Air dehydration; DV: droplet vitrification; V: Vitrification; ED: Encapsulation-dehydration; EV: Encapsulation-vitrifcation
ST: shoot tip; SM: shoot meristem; ZE: Zygotic embryo; ECS: Embryogenic cell suspension

Table 6.5: Status of cryopreserved germplasm (as on 31st December 2023)

Categories	No. of accessions added in 2023	Total Accessions (no.)
Recalcitrant & Intermediate		
Fruits & Nuts	232	4461
Spices & Condiments	1	239
Plantation Crops	0	121
Agro forestry & Forestry	0	1645
Industrial crops	12	1365
Medicinal & Aromatic Plants	9	59
Total	254	7890
Orthodox		
Cereals	0	289
Millets and Forages	1	294
Pseudo-cereals	0	76
Grain Legumes	1	815
Oilseeds	1	683
Fibers	1	69
Vegetables	28	620
Medicinal & Aromatic Plants	6	1025
Narcotics & Dyes	0	35
Miscellaneous	3	83
Total	**41**	3,989
Dormant buds	0	**389**
Pollen grains	13	**655**
Total	**308**	**12,944**
Genomic resources	0	**2194**

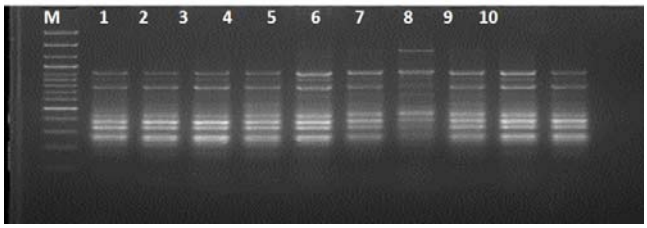


Fig. 6.4: Banding profiles obtained with ISSR primer UBC 842 of the mother plant and cryopreserved plants of hops (Ladder lane: 100 bp DNA marker, M- mother plant, 1-10: cryopreserved plants)

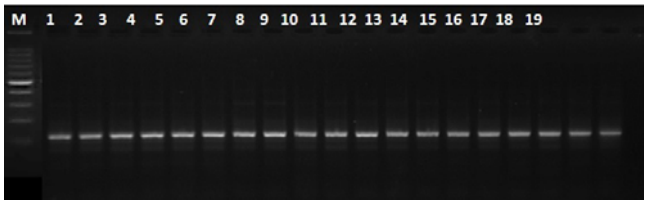


Fig. 6.5: Banding profiles obtained with ISSR primer UBC 840 of the mother plant, cryopreservation control plants and cryopreserved plants of mulberry (Ladder lane: 100 bp DNA marker, 1,2- control plant, 3-8 – cryopreservation controls, 9-19 cryopreserved plants)

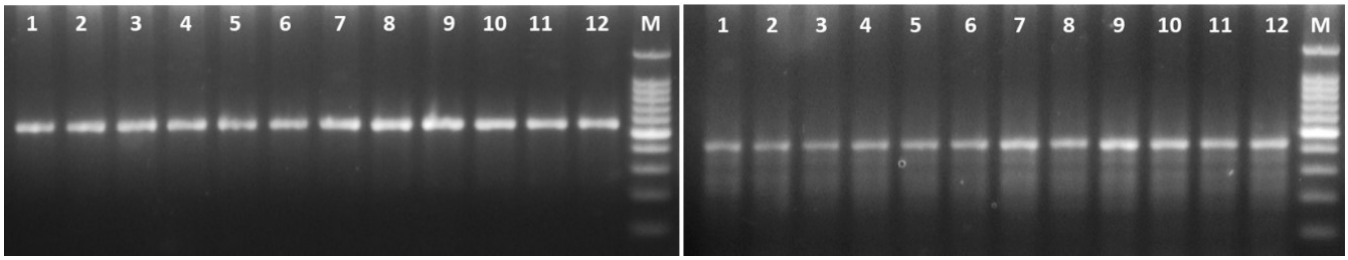


Fig. 6.6: Amplification profiles of ISSR primers a) UBC 824 and b) UBC 836, where Lane 1-3: Mother plants, Lane 4-6: plantlets regenerated using KIN, Lane 7-9: plantlets regenerated using 2-iP, Lane 10-12: plantlets regenerated using BAP and Lane M: 100 bp ladder

6.7. Supportive Research

6.7.1. *In vitro* shoot multiplication/ micro-propagation protocols

(A) *In vitro* shoot multiplication of *Artocarpus heterophyllus* Lam.: In vitro nodal segments were used to standardize shoot multiplication of *Artocarpus heterophyllus* (Jackfruit, IC013074). Highest number of shoots (3 shoots per explant) were obtained on MS media supplemented with BAP 2 mg/l. Highest shoot length (1.63 cm), higher number of nodes (2.31) and highest number of leaves (1.06) was obtained on BAP 1 mg/l (Fig. 6.7).

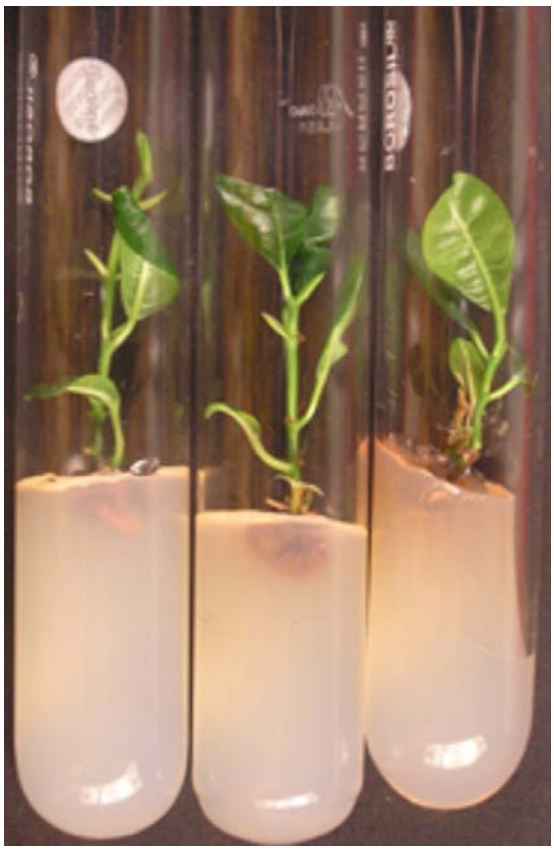


Fig. 6.7: *In vitro* shoot multiplication in *Artocarpus heterophyllus*

(B) *In Vitro* microtuberization in *Bunium*: For *in vitro* microtuberization experiments, MS medium containing BAP and NAA exhibited highest and earliest (within 28 days) *in vitro* microtuberization under standard culture room conditions. Micro-tubers exhibited germination only at 5°C and they developed into complete plantlets when inoculated on MS medium having NAA, IAA and GA_3.

(C) *In vitro* propagation and micropropagation in *Rubia cordifolia* L.: Nodal explants of *R. cordifolia* gave best shoot multiplication response on MS with 1.0 mg/L kinetin. *In vitro* rooting was optimum on half strength MS medium supplemented with 1.0 mg/L IBA. Micropropagation of *R. cordifolia* was explored using the natural cytokinin, meta-topolin (*m*T). and micro-shoots

Fig. 6.8: *In vitro* shoot multiplication and (b) acclimatization in *Rubia cordifolia*

multiplied using 2.0 mg/L meta-topolin displayed the best response, producing a substantial number of roots. (Fig. 6.8).

(D) *In vitro* multiplication protocol in *Musa indandamanensis*: The *in vitro* multiplication of *M. indandamanensis*, an endangered endemic species collected from Nicobar island was initiated using male buds. Effect of different growth regulators was tested and addition of BAP in the MS media was found to be effective in shoot initiation and multiplication with a maximum of 5 shoots per explant (Fig 6.9).

Fig. 6.9: *In vitro* plantlets showing multiplication of *M. indandamanensis*

(E) *In vitro* multiplication protocol in *Zingiber wightianum and Z. neesanum:* A micropropagation protocol was developed to produce large number of plantlets from rhizome buds of *Z. wightianum*. Surface sterilized rhizome buds were cultured onto 21 different media combinations and best response with the highest number of shoots was recorded on MS medium supplemented with 20.74 µM mT alone while optimal root induction was observed on hormone free basal MS medium. Well-developed micro-plantlets were primary hardened under mist chamber conditions and acclimatized plantlets were transferred to field (Fig. 6.10). For *Zingiber neesanum*, the highest shoot multiplication was recorded on MS medium supplemented with 2 mg/L BAP and 0.5 mg/l NAA. The multiplied shoots rooted well on this medium itself (Fig. 6.11).

Fig. 6.10: Shoot multiplication and rooting in *Z. wightianum*

Fig. 6.11: *In vitro* propagation of *Z. neesanum*

6.7.2. *In vitro* slow growth conservation

(A) Medium-term conservation of *Sauropus androgynus* (L.) Merr.: *In vitro* cultures of *S. androgynous* (IC636692) survived for only 6 months on multiplication medium. Thus to extend the subculture duration, *in vitro* shoots were grown on MS medium supplemented with different concentrations of 6-benzylaminopurine (BAP), naphthaleneacetic acid (NAA), Kinetin alone and in combination with BAP, with NAA or Kinetin or 2iP. The subculture duration was extended from 6 months to 2.5 years with 35 to 48% survival on MS+2.5 mg/l BAP, MS +2.5 mg/l Kinetin and MS + 2.0 mg/l 2iP and 100% regeneration on fresh multiplication medium and 100 % *ex vitro* survival.

(B) *In vitro* slow growth of *Smallanthus sonchifolius* (Ground apple; IC0644477): To achieve slow growth of the cultures of *S. sonchifolius* using *in vitro* micro-tuber formation, four different media were tested. The cultures inoculated in MS media containing 8% sucrose demonstrated the highest viability of plantlets, with a survival rate of ~62% after 15 months of subculture with an average of 3.5 micro-tubers per plant (Fig. 6.12).

Fig. 6.12: *In vitro* micro-tuber formation in *Smallanthus sonchifolius* (Ground apple; IC0644477) on MS media containing 8% sucrose

6.7.3. In vitro cryopreservation protocols

(A) Cryopreservation of *Allium ampeloprasum* L.: *A. ampeloprasum* has multifarious uses from food to herbal medicine. Shoot bases (1.0 mm x 1.5 mm) of *A. ampeloprasum* were grown on pregrowth media (MS + 0.1 mg/l naphthalene acetic acid + 0.02 mg/l 2-isopentenyl adenine + 0.3 M sucrose) and precultured on MS medium supplemented with 0.3 M sucrose at SCC followed by loading solution treatment for 60 min, PVS2 dehydration for 40 min were successfully cryoconserved using vitrification and droplet-vitrificaiton technique. Droplet-vitrification technique improved post- thaw regrowth by ~58.33% as compared to vitrification.

(B) Shoot tip cryoconservation protocol of *Bacopa monnieri* (L.) Wettst. : Experiments were conducted to assess the effect of shoot tip size and cryoconservation techniques, including vitrification (V) and droplet-vitrification (DV), to improve post-thaw regrowth in *B. monnieri*. Optimal results after cryopreservation were obtained when small size (SS – 0.5 x 0.5 mm) shoot tips were excised from cultures pretreated on MS basal medium supplemented with 0.3 M sucrose (SM) for 4 to 16 wk, precultured on SM medium for 2 d and dehydrated with PVS2 at 0 °C for 35 min. Post-thaw regrowth of >80% was obtained using DV technique. The results were successfully validated in four accessions and this improved protocol has potential to be implemented for cryobanking of *in vitro* germplasm of *Bacopa monnieri*.

(C) Cryopreservation of *Cicer microphyllum* Benth.: *Cicer microphyllum* is a crop wild relative of chickpea that possess useful genes for cold and drought tolerance. *In vitro* shoot tips grown on B_5 + 0.5 mg L^{-1} Kinetin + 0.1 mg L^{-1} naphthalene acetic acid + 10 mg L^{-1} silver nitrate, precultured on B5 + 6% sucrose at 10°C for 3 days, followed by PVS2 treatment for 20 min, unloading solution for 60 min and regrowth on B5 + 0.2 mg L^{-1} 6-benzylaminopurine + 20 mg L^{-1} silver nitrate resulted in highest survival (57%) and regrowth (40%) after cryoconservation. The standardized protocol was successfully used for cryobanking.

(D) Protocol for conservation using droplet vitrification technique in *Garcinia indica*: Germplasm conservation using droplet vitrification technique of cryopreservation in accession IC638183 was standardized with ~50% regeneration. This technique was successfully validated on other accessions

of *G. indica* (IC638183, IC0638185, and IC0638186) using *in vitro* derived shoot-tips.

(E) Cryopreservation experiments in *Simmondsia chinensis:* Experiments were carried out on desiccation and freezing tolerance of shoot tips of *Simmondsia chinensis* using the DV method of cryopreservation. Shoot tips isolated from one month old cultures were precultured on high sucrose medium (MS containing 0.3M sucrose) for 16 hr, followed by treatment with loading solution for 20 min. Shoot tips cryopreserved for 30, 40 and 50 min showed 30-50% survival.

(F) Cryoconservation of *Swertia chirayta* (Roxb.) H.Karst.: *Swertia chirayta* (IC594053 and IC647721) is a critically endangered medicinal plant species of India. Shoot tips (about 1 to 1.5 mm in length) were excised from 4-wk-old stock cultures pregrown on MS medium supplemented with 3 mg/l Kinetin, 2 mg/l Gibberellic acid, 0.3 M sucrose and shoot tips were precultured on MS + 0.3 M sucrose for 2 days. Thereafter, shoot tips were cryoconserved using V-Cryoplate and D-Cryoplate technique and reported high post-thaw regeneration of 80 to 90%.

6.7.4. Cryopreservation protocol for *Luffa* Pollen

The optimal medium for *in vitro* pollen germination varied in *L. acutangula*, *L. cylindrica*, *L. echinata*, and *L. graveolens* species, with Brewbaker and Kwack medium with 10% sucrose suitable for *L. acutangula, L. cylindrica*, and *L. echinata*, and BK medium with 3% sucrose ideal for *L. graveolens*. The best results for cryopreservation were achieved with desiccation periods of 20, 30, and 40 minutes, maintaining moisture content between 14.04% and 18.55%. Cryopreserved pollen at -196 °C exhibited the highest viability over a prolonged period (2 months) and was comparable to fresh pollen in terms of germination, ovule fertilization, fruit and seed set.

6.7.5. Studies on desiccation and freezing sensitivity of seeds for developing cryopreservation protocol

A total of 8 diverse species were analysed for desiccation and freezing tolerance - *Meyna spinosa* (1), *Stauntonia elliptica* (1), *Eryobotrya angustissima* (3), *Antidesma bunius* (1), *Choerospondias axillaris* (1), *Spondias pinnata* (1) and *Gymnopetalusm cochinchinense* (1). Desiccation and freezing sensitivity of the seeds revealed *Stauntonia elliptica and Antidesma bunius* as orthodox seed species while *Meyna spinosa, E. angustissima* showed recalcitrant seed storage behavior.

6.7.6. Protocol standardized for pollen collection and *in vitro* pollen germination media in *Vitis* spp.

In various Vitis species, viz., *V. vinifera* (7 accessions), *V. champini* (2 accessions) and *V. parviflora*, six media combinations were tested for maximum in vitro germination. The media consisted of 10% sucrose+100 mg/L boric acid+300 mg/L calcium nitrate and resulted in good in vitro germination (ranging from 40-90%) in all the species and could be utilized for further pollen-related studies in grapes. Additionally, five pollen collection methods were compared and cluster harvesting at 50% flowering stage and drying for 24 hours was the most effective method for grape pollen collection, with increased pollen quantity and germination percentage.

6.7.7. Marker trait association analysis for component traits of seed longevity

Marker trait association (MTA) analysis was carried out on a diverse wheat panel, for component traits of seed longevity *viz*., Antioxidant potential measured as DPPH retention percentage; Glutathione Half Cell Redox Potential; Speed of germination measured as Mean Germination Time (MGT). GWAS analysis was carried out using 35K SNP Array data. The study identified ten significant MTAs along with major candidate genes, for seed longevity (Fig 6.13). The candidate genes associated with MTAs identified on chromosomes 3A, 4A, 4B, 5A, 5B, 5D and 7D were confirmed through net mining and they could delineate network modules enriched for seed ageing traits viz., accumulation of ROS leading to cell death and co-expression clusters of biological processes pertaining to ageing, regulation of plant-type hypersensitive response and leaf senescence (Fig 6.14). The phenotypic data recorded in this study showed positive correlation with actual genebank conservation data.

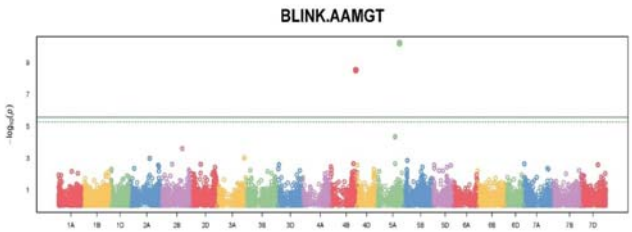


Fig 6.13: Manhattan Plot for MGT Analysis

6.7.8. Software development for estimation of seed colour

A software has been developed with functions for semi-automated thresholding of seeds (object of interest)

from an image and extraction of average RGB value. It also includes functions for colour calibration of images with a colour target or colour rendition chart (Fig 6.15).

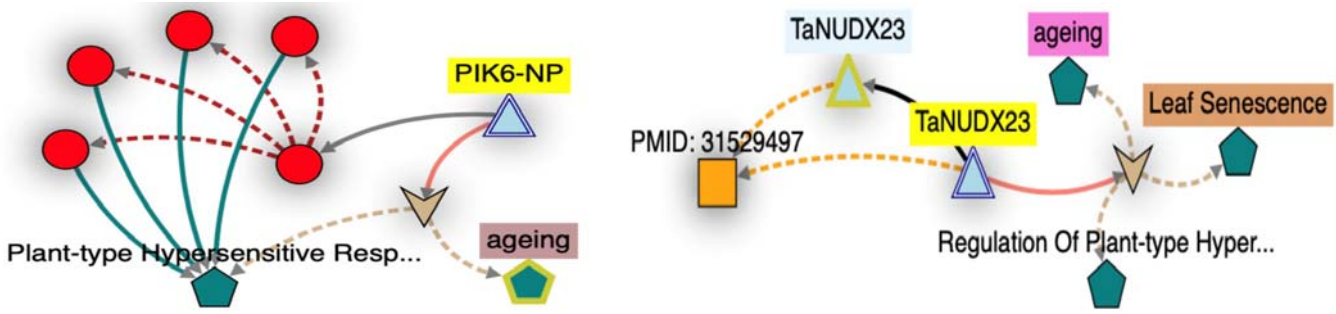


Fig 6.14: Knet Mining Analysis for MGT

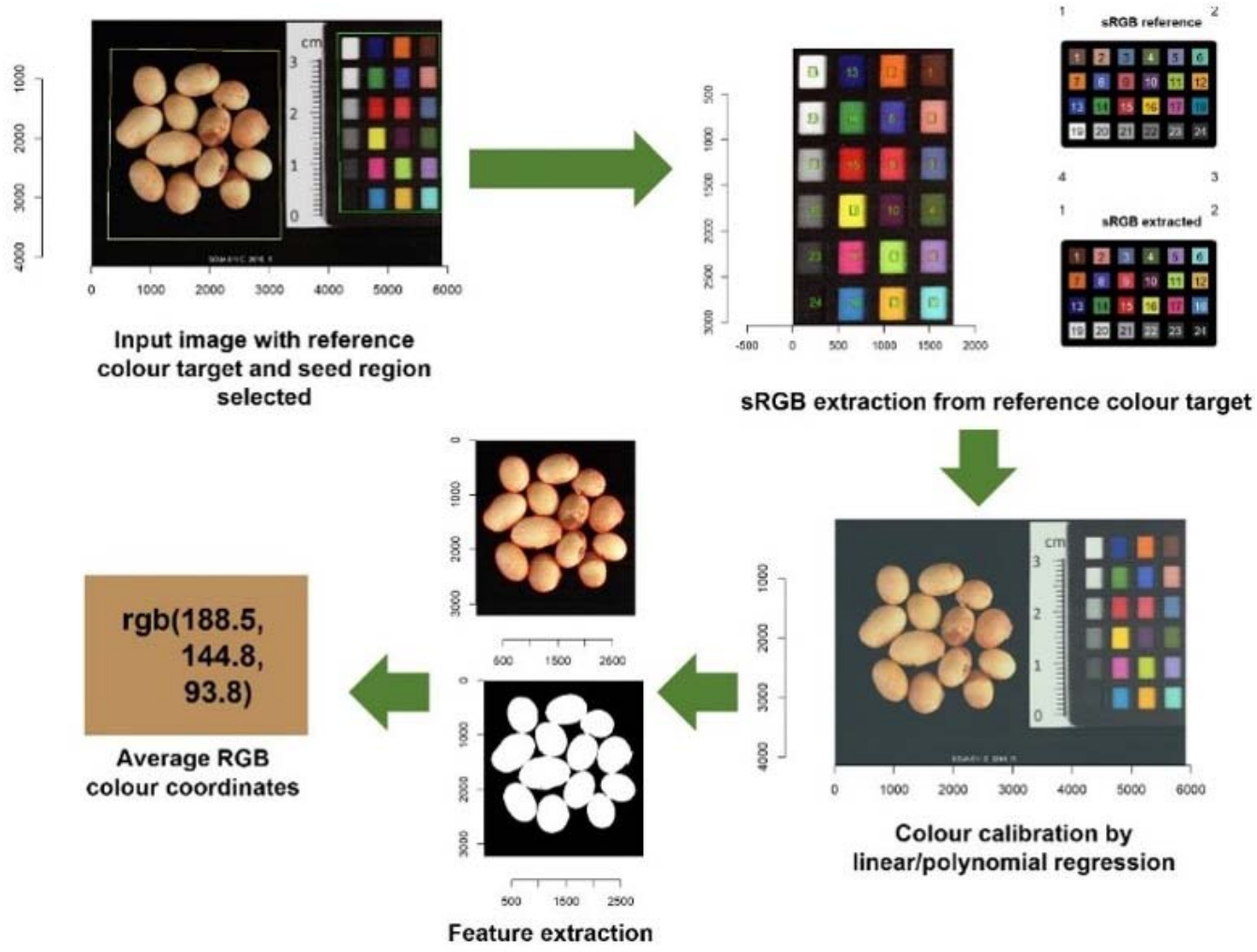


Fig 6.15: Workflow of semi-automated estimation of seed colour from images R package

Research programme (Code, Title**, Programme Leader)**
Programme I: PGR/DGC-BUR-DEL-01.00 : *Ex Situ* conservation of plant genetic resources of agricultural and horticultural crops using conventional methods (**PI: Dr Veena Gupta till 09.05.2023; Dr Anju Mahendru Singh w.e.f 10.05.2023**)
Projects under Programme I:
PGR/DGC-BUR-DEL-01.01: Management of information and national germplasm conservation network and associated research (**Anjali Kak Koul**, J Aravind, *Rajvir Singh, Smita Jain, Rajiv Gambhir, S.P Sharma* and *Nirmala Dabral*)
PGR/DGC-BUR-DEL-01-02: Conservation of grain legume germplasm using conventional seed storage methods and associated research (**Padmavati G. Gore**, Chithra Devi Pandey), Anju M Singh (w.e.f. 08.05.2023)
PGR/DGC-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods and associated research (**GD Harish** (till May 25, 2023), J Aravind, Sherry Rachel Jacob, Badal Singh and *AD Sharma*), Suman Roy (w.e.f. 26.05.2023)
PGR/DGC-BUR-DEL-01-04: Conservation of oilseed germplasm using conventional seed storage methods and associated research (**Badal Singh** (upto 25-05-2023), **J Aravind** (w.e.f 26-05-2023) , Sherry Rachel Jacob)
PGR/DGC-BUR-DEL-01-05: Conservation of cereal germplasm excluding paddy, using conventional seed storage methods and associated research (**Sherry Rachel Jacob**, Badal Singh (upto 25-05-2023) and Padmavati G. Gore)
PGR/DGC-BUR-DEL-01-06: Conservation of pseudo-cereals, medicinal and aromatic plant, narcotic and spices germplasm using conventional seed storage methods and associated research (**Veena Gupta** (upto 31-8-2023), **Anjali Kak Koul** (w.e.f 01-09-2023) and Padmavati G. Gore)
PGR/DGC-BUR-DEL-01-07: Conservation of millets germplasm using conventional seed storage methods and associated research (**Sushil Pandey**, Chithra Devi Pandey and GD Harish)
PGR/DGC-BUR-DEL-01-08: Conservation of forage and fiber germplasm using conventional seed storage methods and associated research (**Anjali Kak Koul** and Veena Gupta)
PGR/DGC-BUR-DEL-01-09: Conservation of vegetable germplasm using conventional seed storage methods and associated research (**Chithra Devi Pandey**, Neeta Singh and Sushil Pandey)
Programme II: PGR/TCCU-BUR-DEL-01.00: *Ex situ* conservation of plant genetic resources of vegetatively propagated crops using in vitro and cryopreservation techniques **(Sandhya Gupta till 09.05.2023; Anju Mahendru Singh wef 10.05.2023)**
Projects under Programme II:
PGR/TCCU-BUR-DEL-01.01: *In vitro* conservation of tuber crops with special reference to sweet potato, yams and taro (**Sangita Bansal**, Vartika Srivastava, *DPS Meena*)
PGR/ TCCU–BUR-DEL-01.02: *In vitro* conservation of spices, plantation and new industrial crops (**Era V. Malhotra**, Sangita Bansal)
PGR/ TCCU–BUR-DEL-01.03: *In vitro* conservation of bulbous and ornamental crops (**Subhash Chander,** Gowthami R.)
PGR/TCCU–BUR-DEL-01.04: *In Vitro* Conservation of Medicinal and Aromatic Plants with Special Reference to Rare and Endangered Species (**Gowthami R.**, Sandhya Gupta)
PGR/TCCU–BUR-DEL-01.05: *In Vitro* Conservation of Tropical Fruit Crops Species (**Vartika Srivastava,** Sandhya Gupta**,** *DPS Meena*)
PGR/TCCU–BUR-DEL-01.06: *In Vitro* Conservation of Temperate and Minor Tropical Fruit Crops (**Sandhya Gupta**, Subhash Chander, Narender Negi)
PGR/TCCU–BUR-DEL-01.07: Studies on genetic integrity of conserved germplasm (**Era V. Malhotra**, Sangita Bansal)
Programme III: PGR/TCCU-BUR-DEL-02.00: *Ex situ* Conservation of Plant Genetic Resources of Agricultural and Horticultural Crops using Cryopreservation of Seeds, Dormant Buds and Pollen (**Sandhya Gupta till 09.05.2023; Anju Mahendru Singh wef 10.05.2023**)
Projects under Programme III:
PGR/TCCU-BUR-DEL-02.01: Cryopreservation of Non-orthodox and Orthodox Seed Species in Various Forms using Standard Protocols (**SK Malik**, **Sangita Bansal**, Era V. Malhotra, *AP Singh*)
PGR/TCCU-BUR-DEL-02.02: Investigating Desiccation and Freezing Tolerance in Non-orthodox Seed Species, Dormant Buds and Pollen for Cryopreservation (**Vartika Srivastava,** Gowthami R, SK Malik, Subhash Chander)
Externally Funded Projects:
Cryobiotechnological approaches for Genetic Resource Conservation and Creation of a Base Germplasm Collection of Indian *Piper* Species (PI: **Era Vaidya Malhotra**, Co PI: Sangita Bansal, K. Pradheep) – Funding Agency: SERB
Implementation of legislation on Protection of Plant Varieties and Farmers' Rights (PI: **Sherry R Jacob**)-Funding agency: PPVFRA

7 AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT

सारांश: एनबीपीजीआर में कृषि ज्ञान प्रबंधन इकाई (एकेएमयू) आईसीएआर में पीजीआर सूचना विज्ञान गतिविधियों का केंद्र है। इकाई का उद्देश्य पीजीआर डेटाबेस और वेब–आधारित अनुप्रयोगों के विकास और रखरखाव के माध्यम से पीजीआर उपयोग को बढ़ाने के लिए पीजीआर जानकारी की उपभोक्ताओ तक आसान पहुंच की सुविधा प्रदान करना है। पीजीआर पोर्टल, एनबीपीजीआर का प्रमुख वेब–आधारित सूचना संसाधन हे जोकि कई देशों के शोधकर्ताओं द्वारा एक्सेस किया जेए आरएएचए हैं। नए एप्लिकेशन विकसित किए गए और कुछ को सार्वजनिक उपयोग के लिए लॉन्च किया गया। पीजीआर गतिविधियों के बारे में x द्वारा जानकारी प्रसारित करने के एकेएमयू के प्रयास ने एनबीपीजीआर द्वारा निभाई गई भूमिका को लोकप्रिय बनाते हुए कई उपयोगकर्ताओं को आकर्षित किया है।

Summary: Agricultural Knowledge Management Unit (AKMU) at NBPGR is the center of PGR Informatics activities in ICAR. Aim of the unit is to facilitate easy access to PGR information to enhance PGR utilization through development and maintenance of PGR databases and web-based applications. The PGR Portal, NBPGR's principal web-based information resource, was accessed by researchers from many countries. New applications were developed and some were launched for public use. AKMU's endeavor to disseminate information on PGR activities via 𝕏 has attracted many users popularizing the role played by NBPGR.

7.1. PGR Portal: Access to information

PGR Portal has been providing the single window to access information on the plant genetic resources conserved in the Indian genebank. A few backend functional improvements were incorporated in the past year for stability improvement. The application is running 24X7 for past nine years. PGR portal manages (creation, storage, retrieval and presentation) and analyses (discovery, exploration and extraction) diverse information (facts, figures, statistics, knowledge and news).

7.2. PGR Informatics activities

Data of 59,654 accessions were added to different databases after curation. Biological status of about 40K accessions were updated in the genebank database. Passport data details (IC and EC) of about 1500 entries were corrected.

Table 7.1: PGR Data Status (number of accessions)

Database	Additions in 2023	Status as on 31-12-2023
Indigenous collections	3,693	6,48,101
Exotic collections	38,689	11,62,740
Genebank	10,455	4,23,273
Characterization	6,153	2,34,113
Cryobase	471	10,918
Germplasm Registration	193	2,148

7.3. NBPGR on Social media

NBPGR maintain a strong presence on the social media @ Icar-Nbpgr and @NBPGR via official 𝕏 account. During 23, NBPGR tweeted 505 information bits which attracted 3,69,000 impressions; 3,67,363 profile visits, 868 mentions and an addition of 1165 new followers.

Youtube

Facebook

7.4. Virtual Platform

AKMU managed virtual meetings, webinars, interviews, events, etc. as well as NBPGR social media. During 2023, a total of 366 virtual engagements (meetings, interviews, IRC, RAC, trainings, seminars, viva, classes, etc.) were facilitated.

7.5. Launch of PGR Informatics applications

Decision support system for Trait specific germplasm identified through multilocation evaluation

Four major crops namely, rice, wheat, chickpea and pigeonpea was initiated for public use.

Under this programme, a total of 15,525 accessions (promising accessions identified under the multilocation evaluation programme for different traits) have been summarized. Information generated through integrated approach will promote effective utilization of plant genetic resources in the national system through crop improvement programmes.

Table 7.2: PGR Informatics portfolio of NBPGR (Open access)

Application	URL
NBPGR Homepage	www.nbpgr.ernet.in
PGR Portal	pgrportal.nbpgr.ernet.in
Import Permit and EC Data Search	exchange.nbpgr.ernet.in
Genebank Dashboard	genebank.nbpgr.ernet.in
Seed genebank	genebank.nbpgr.ernet.in
Cryo genebank	www.nbpgr.ernet.in:8080/cryobank
Field genebank	pgrinformatics.nbpgr.ernet.in/FGB
National Genomic Resource Repository	www.nbpgr.ernet.in:8080/ NGRR
National Herbarium of Crop Plants	pgrinformatics.nbpgr.ernet.in/nhcp
Biosystematics Portal	pgrinformatics.nbpgr.ernet.in/cwr
PGR Climate	pgrinformatics.nbpgr.ernet.in/pgrclim
Registered Crop Germplasm	www.nbpgr.ernet.in/registration/
Multi-location Evaluation Database	www.nbpgr.ernet.in/tsgi/index.htm
MTS Application	pgrinformatics.nbpgr.ernet.in/mts
Plant Quarantine Information System	www.nbpgr.ernet.in/PQIS/
PGR-IPR	pgrinformatics.nbpgr.ernet.in/ip-pgr
PGR Analytics (Gap Analysis Tool)	http://14.139.224.57/pgrtools/Default.aspx
PGR Map	nbpgr.ernet.in/PGRMap
Decision Support System for Insect and Mite Pests	www.nbpgr.ernet.in:8080/Pest
Multi-location Evaluation Database	www.nbpgr.ernet.in/tsgi/index.htm
Digital Library of Bruchids	14.139.224.57/bruchidlibrary
Network of GMO Testing Laboratories of India	gmolabs.nbpgr.ernet.in
Piper nigrum microsatellite database	www.nbpgr.ernet.in:9091/index.php
Medicinal Plants Genomic Resource Database	www.nbpgr.ernet.in/med_plant/index.html
Amaranth Genomic Resource Database	www.nbpgr.ernet.in:8080/AmaranthGRD
Mobile Apps	Genebank, PGR Map

Research Programme (Code, Title, Programme Leader)
Programme: PGR Informatics Programme Leader: Sunil Archak
IXX10707: PGR Informatics (S Archak (till 27.07.2023 ; HL Raiger (w.e.f 28.07.2023) and *Rajeev Gambhir*) [Co-PIs of this project include scientists from all divisions/units/ regional stations]
098-ICAR-AKMU-SA-014 (ICAR National Fellowship funded): Development and implementation of Novel Algorithms and Software Modules for PGR Informatics (S Archak)

8 REGIONAL STATION, AKOLA

सारांशः वर्ष 2023 के दौरान एक अन्वेषण और संग्रह कार्यक्रम से कुल 61 परिग्रहण संग्रहीत किए गए जिनमें 38 खेती योग्य फसल भू–प्रजातियां और 21 फसल वन्य सबंधी (सीडब्ल्यूआर) शामिल थे। रबी 2022–23 के दौरान 2435 और खरीफ 2023 के दौरान 1739 परिग्रहणों सहित कुल 4174 परिग्रहणों का विशेषता और मूल्यांकन किया गया। परिग्रहणों में चना (508), अनाज चौलाई (121), अलसी (1324) और कुसुम (482) और रागी (90), फॉक्सटेल मिल्लेट्स (290), तिल (154) एवं खरीफ 2023 में नाइजर (342), मूंग (400), विंज्डबीन (263) और भिंडी (200) शामिल थे। भारत मे उपयोगकर्ता एजेंसियों को अनुसंधान उद्देश्य के लिए विभिन्न फसलों की 4938 फसलें प्रदान की गईं। रिपोर्टिंग अवधि के दौरान विभिन्न फसलों के 1891 जर्मप्लाज्म परिग्रहण को संवर्धित और पुनर्जीवित किया गया। तिलहन (10452), दलहन (4687), सब्जियां (2034), संभावित फसलें (1399), श्री अन्न (1536) और फसल पौधों के वन्य संबंधी (730) सहित विभिन्न फसलों/प्रजातियों के जननद्रव्य की कुल 20,838 परिग्रहणों का रखरखाव अकोला में क्षेत्रीय केंद्र के मध्यम अवधि के भंडारण में नियंत्रित स्थितियाँ किया जा रहा है।

Summary: One exploration and collection programme was undertaken during the year and a total of 61 accessions comprised 38 cultivated crop landraces and 21 Crop Wild Relatives (CWRs) were collected. A total of 4,174 accessions comprising 2,435 accessions during *Rabi* 2022-23 and 1,739 accessions during *Kharif* 2023 were characterized and evaluated. Crop-wise accessions characterized were chickpea (508), grain amaranth (121), linseed (1324) and safflower (482) during *Rabi* 2022-23 and finger millet (90), Foxtail millet (290), Sesame (154), niger (342), mungbean (400), winged bean (263) and okra (200) in *Kharif* 2023. Supplied 4,938 accessions of various crops for research purposes to user agencies within India. Multiplied and regenerated 1,891 germplasm accessions of different crops during the reporting period. A total of 20,838 accessions of various crops/species germplasm comprising oilseeds (10,452), pulses (4,687), vegetables (2,034), potential crops (1,399), millets (1,536) and CWRs (730) are being maintained under controlled conditions in the medium term storage of the Regional Station at Akola.

8.1. Exploration and collection of germplasm

An exploration for collection of Millets, Linseed, Cajanus, Vigna sps, and other CWR was undertaken from Palghar and Thane districts (including Manjare village plateau) of Maharashtra. During exploration, a total of 61 germplasm samples included *Panicum sumatrense (10), Oryza sativa (07), Eluecine coracana (05), Vigna mungo (02), Cucumis melo (02), Cucumis hardwikii (02), Niger (03), Cajanus cajan (01), Cajanus scarabdoides (03), Cajanus platycarpus (01), Luffa acutangula (02), Macrotyloma uniflorum (01), Vigna unguiculata (02), Vigna radiata (01), Sorghum bicolor (01), Dolichos lablab (01)* and others CWRs (17) were collected. Good variability was observed in Sorghum for biomass, plant type, earliness and popping character. The tremendous potential of little millet and finger millet was also observed in these areas as being grown for their consumption and selling in local markets as an earning source (Fig. 8.1-8.3).

Fig. 8.1. Variability collected in Cucumis from Thane and Palghar districts

Fig. 8.2. Collection of little millet landraces from farmers field (Palghar)

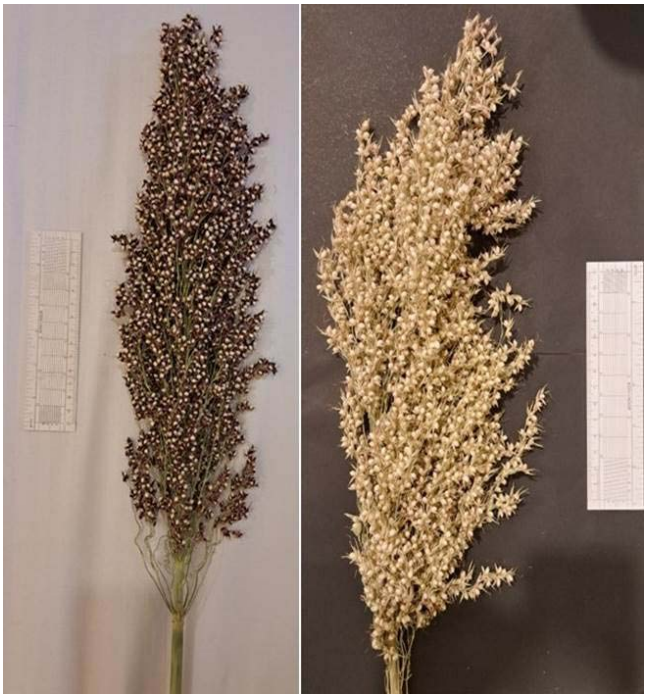


Fig. 8.3. Pop sorghum landraces collected from Palghar district

Rare germplasm (Landraces) considered *Mahodi, Kal Bhat, Wada kolum* of Paddy were also collected from these areas. Good variability in *Cucumis* sps, *Abelmoschus* sps, paddy landraces and *Vigna* sps was observed during the expedition of germplasm. *Cajanus sericius*, and *Vigna yadavii,* endemic species of Sahyadri hills also recorded for documentation.

8.2. Characterization and evaluation of germplasm

8.2.1. *Rabi* 2022-23

A total of 2,435 accessions were characterized and evaluated during *Rabi* 2022-23 and Crop-wise accessions characterized were chickpea (508), grain amaranth (121), linseed (1324) and safflower (482). The experiments were conducted in ABD and the morpho-agronomical characters were recorded as per the Minimal Descriptors (For Characterization and Evaluation) of Agri-horticultural crops (Part-I), NBPGR (2000).

Chickpea: A total of 508 accessions of chickpea along with 10 checks (Jaki-9218, PKV Kabuli-2, PKV Kabuli-4, PDKV Kanchan, Phule Vikram, Phule Vikrant, PG-12, Saki-9516, Vijay and Warangal) were evaluated in ABD during Rabi 2022-32. Promising accessions were identified for primary branches per plant: EC400552 (7.0) and IC334286 (6.0); for pods per plant: EC220052 (146), IC428088 (122) and IC428031 (102) and for 100 seed weight PKV Kabuli-4 (46.64g) and EC198718 (23.23g) and for seed yield per plant IC350842 (18.45g), IC094877 (18.20g) and EC267307 (16.41g) were promising (Fig. 8.4).

Safflower: A total of 482 accessions of safflower along with six checks (PBNS-86, SSF-12-40, SSF-13-71, SSF-15-65, SSF 1602, SSF-708 and PKV Pink) were evaluated in ABD during Rabi 2022-23. Early flowering was observed in IC0499427 (58 days), EC0210429 and EC0182230 (59 days). For the diameter of the main capitula, the accessions IC0500180 (4.00 cm), IC0500160 (3.18 cm) and EC181459 (3.16cm) were superior. The highest seed yield per plant was recorded in IC0500092 (37.43g), IC0042478 (35.48g) and EC0398114 (34.07g) and for 1000 seed weight, accessions IC0338278 (80.57g), IC0442555 (76.63g) and IC0500180 (76.55g) were found promising.

Linseed Germplasm Characterization

Under the DBT linseed project, two different core sets were developed. These two sets were evaluated during *rabi* 2022-23. A core set of 259 linseed accessions along with seven different checks (T397, Shekhar, Sheela, JLS95, LSL93, Rashmi and Tiara) were characterized and evaluated in ABD. Promising accessions identified for different characters were for days to 50% flowering accessions IC0096539 and LSL93 (38 days); EC0022648 (68.8 cm) and IC0305053 (68.4cm) recorded highest plant height. Genotype LSL93 (99 days) followed by MAU Azad-1 and IC0544570 (101 days) showed the earliest days to maturity. The highest number of capsules per plant was recorded T397 (203.8), IC0498551 (196.8)

Fig. 8.4. Variability for seed colour in chickpea

and IC0118887 (193.6). Yield per plant was recorded by IC0385377 (8.44 g), IC0499188 (8.11 g) and IC0498551 (7.85 g) and the accessions *viz.,* IC0499144 (10.26 g), IC0113105 (9.08 g) and IC0498424 (9.1 g) were found promising for 1000 seed weight.

A trait-specific core set of 342 linseed accessions were characterized and evaluated in three replicated trials and analyzed in RBD. Promising accessions identified for different characters were for days to 50% flowering LSL93 (37 days), IC0538781 and IC0096648 (38 days); for plant height IC0113109 (71.8 cm), IC0499065 (71.4cm) and EC0541213 (71.2cm); for seed yield per per plant IC0525956 (7.21 g), IC0096502 (6.02 g) and IC0499131 (5.63 g) were promising (Fig. 8.5).

Fig. 8.5. Aerial field view of linseed germplasm evaluation experiment

8.2.2. *Kharif* 2023

A total of 1,739 accessions of different crops were characterized and evaluated during the kharif 2023. Crops consisted of finger millet (90), Foxtail millet (290), Sesame (154), niger (342), mungbean (400), winged bean (263) and okra (200). The experiments were conducted in ABD/ RBD and the morpho-agronomical characters were recorded as per the Minimal Descriptors (For Characterization and Evaluation) of Agri-horticultural crops (Part-I), NBPGR (2000).

Mungbean core evaluation under DBT project

A total of 400 accessions of mungbean and seven checks (IPM02-3, IPM2-14, MH421, PDM139, SML668, Nirmal and Phule Chetak) were evaluated in ABD. Promising accessions are identified for various traits. For days to 50% flowering, EC590222 (31), EC246508 (32) and EC396394 (32); For number of branches, IC52074 (6), EC272454 (6) and EC27514 (6); For pods per plant, IC148383 (67), IC148430 (43) and IC73532 (40); For yield per plant, IC148383 (16.24g), IC76569 (16.06g), IC39448 (12.16g); For 100 seed weight, IC607183 (7.4g), and EC590222 (6.7g), EC396409 (6.7g).

Foxtail millet: A total of 290 accessions of foxtail millet and seven checks (DHFT 109-3, SIA-3156, Lepakashy, Prasad, Krishndevraya, Narsingraya, SIA-3088) were evaluated in ABD. Promising accessions are identified for various traits. For days to 50% flowering, GS-140 (50), ISE-18 and CO-4 (CO-4); For plant height, ISE-1597 (120 cm), IC 597313 (118 cm) and K-2686 (105 cm); For a number of productive tiller, GS-125 (3), MEERA (2.5) and GS-2239 (2); For panicle length, IC 597313 (19.5 cm), K-2686 (19 cm) and GS-2092 (18 cm); For yield per plant, RAP-52 (6.72g), KC/GK/OP-130 (6.34g) and GS-2092 (5.24g); For 1000 seed weight, T53/83-4 (3.56g), GS-130 (3.48g) and T50/83-5 (3.44g).

Niger: Under DBT project 342 accessions of Niger along with three checks (JNS-28, JNS-30 and IGPN-2004-1 were evaluated in ABD (Fig. 8.6). For days to 50% flowering, accessions IC0262567(48), IC33674(48) and IC262539(48); for number of capitula per plant IC0546622(120), USDA-

Fig. 8.6. Variability observed for flower colour, size and number of ray florets in niger core set

8(106), IC0262617(89); for days to maturity IC0262539(98), DNS-4(98), IC0341231(98) and for seed yield per plant IC0372572 (9.6g), IC0262617 (8.9g), NA-28 (8.6g) were found promising.

8.3. Regeneration and Multiplication of Germplasm

A total of 1891 accessions consisting of foxtail millet (290), niger (293) and chickpea (508) in *Rabi* 2022-23 and mungbean (400), winged bean (200) and okra (200) in *Kharif* 2023 were regenerated (Fig. 8.7).

Fig. 8.7. Purification and multiplication of niger core set- Aerial view

8.4. Germplasm Exchange

Supplied 4938 accessions of germplasm of various crops/species to the indenters within India for their research purpose under Material Transfer Agreements. The crops/species (accessions) supplied were of different crops *i.e.* small millets (678), linseed (2610), niger (434), okra (294), sorghum (22) and safflower (834), winged bean (66). Received 647 accessions/varieties of germplasm *i.e.* grain amaranth (49), urdbean (5), mungbean (31), pigeonpea (29), niger (341), sesame (154), winged bean (28), pearl millet (10) from different agencies.

8.5. Medium-term storage of germplasm

A total of 20,838 accessions of various crops/species comprising oilseeds (10,452), pulses (4,687), vegetables (2,034), potential crops (1,399), millets (1,536) and wild relatives of crop plants (730) are being maintained under controlled conditions in the medium term storage of the station at Akola.

8.6. Field Genebank

A total of 42 accessions consisting of *Aloe vera* (05), wild foxtail millet (08), West Indian cherry (01), *Simarouba glauca* (01), *Gymnema sylvetre* (05) and *Bael* (22) are being maintained at field genebank of Regional Station, Akola.

Research Programme (Code, Title and programme Leader) PGR/GEV-BUR-AKO-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources in the Central Indian Plains (**Sunil S. Gomashe**).
Research Projects (PI, Co-PIs and Associates)
PGR/GEV-BUR-AKO-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, and documentation of genetic resources of cereals, pulses (pigeon pea and chickpea), vegetables (okra) and Potential crops (winged bean and amaranth) (Sunil S. Gomashe)
PGR/GEV-BUR-AKO-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, and documentation of genetic resources of oil seeds (sesame, niger, castor, groundnut, safflower, soybean and linseed), millets and small millets (Sunil S. Gomashe)

9 REGIONAL STATION, BHOWALI

सारांशः आईसीएआर–एनबीपीजीआर क्षेत्रीय केंद्र भवाली के पास उत्तराखंड राज्य की पादप जैव विविधता की खोज, संरक्षण और उपयोग से संबंधित पांच अधिदेश हैं। समीक्षाधीन अवधि के दौरान केंद्र द्वारा एक अन्वेषण किया गया जिसमे 50 विभिन्न परिग्रहणों का संग्रह किया गया। केंद्र द्वारा विभिन्न अनाज, बागवानी, WEUP फसलों की कुल 1197 परिग्रहणों को एमटीएस के लिए चिह्नित, संवर्धित और पुनर्जीवित किया गया। एमटीए में संरक्षित परिग्रहणों में से देश भर के शोधकर्ताओं के साथ विभिन्न फसल जर्मप्लाज्म की कुल 326 परिग्रहणों को साझा किया गया। मध्य अवधि भण्डारण में कुल 11,826 परिग्रहण और फील्ड जीन बैंकों में 1017 परिग्रहणों का रखरखाव किया जा रहा है। केंद्र द्वारा कई अन्य गतिविधियाँ भी शुरू की गईं, जैसे कि किसान मेले और प्रशिक्षण का आयोजन। इस अवधि के दौरान केंद्र के वैज्ञानिकों ने विभिन्न बैठकों, प्रशिक्षण कार्यक्रम, सेमिनार और सम्मेलन में भी भाग लिया। रोपण सामग्री और कृषि उपज की बिक्री से केंद्र पर रूपया 5,35,870/– की राशि उत्पन्न हुई।

Summary: ICAR-NBPGR RS Bhowali has five mandates related to exploration, conservation and utilization of plant biodiversity of Uttarakhand state. During the reporting period 50 different collections were made in one exploration mission. Total 1197 accessions of various field, horticultural, WEUP crops were characterized, multiplied and regenerated for MTS. Total 326 accessions of various crop germplasm were shared with researchers across the country against MTA. A total of 11,826 accessions in MTS and 1017 accessions in field gene banks are also being maintained. Several other activities were also undertaken *viz.*, organizing farmers fair and trainings. The scientists of the station have also participated in different meetings, training programs, seminars and conferences during the period. An amount of Rs. 5,35,870/- was generated through sale of planting material and farm produce.

9.1. Exploration and Germplasm Collection

One exploration was undertaken in the month of September 2023 from the North Sikkim for the collection of wild Allium species and other wild edible temperate crops. A total of 50 accessions belonging to 35 taxa were collected from the North region of Sikkim. Some species like *Schisandra grandiflora, Rubus trutleri, Allium sikkimense, Ribes griffithii, Ribes luridum, Rubus kumaonensis* were first time collected from the north eastern Himalaya.

9.2. Germplasm Characterization and Evaluation

Total 1101 accessions of various *Kharif*-2023 and *Rabi*-2022-23 crops *viz.*, Wheat (19), Barley (30), Lentil (167), Mustard (12), Fenugreek (02), Faba bean (54), Coriander (06), Paddy (15), Amaranth (13), Soybean (24), Maize (09), Finger millet (394), Barnyard millet (198), Proso millet (21), Foxtail millet (34), Sorghum (02), Buckwheat (25), Sesame (03), Horsegram (38), Blackgram (05), Frenchbean (25) and vegetables (05) were characterized, evaluated and multiplied during the reporting period.

The new collections were sown for characterization for onward submission to the LTS and IC number allocation. Seed multiplication was done for accessions with less quantity of seeds. The station is also involved in providing seeds of traditional landraces to the local farming community of Uttarakhand hills, hence, quality seed is multiplied for assured supply to the beneficiaries.

Fig. 9.1. Wild edibles collected from North region of Sikkim

9.2.1. Evaluation of ICARDA Nurseries of Fababean

Total 58 entries of fababean from ICARDA including checks were received from ICAR-NBPGR New Delhi for evaluation for yield and chocolate spot disease and were sown according to the guidelines and evaluated.

Trial-1: Selection of high yielding Faba Bean genotypes (Seed Type): Total 30 entries along with 5 checks (Hashbenge, Rebya-40, SLL, HFB-1 and Vikrant) were evaluated for various yield traits in 3 replications (RBD) during *Rabi* 2022-23. The individual plants in R1 were also covered with selfing bags to maintain genetic purity.

The range of variation as well as promising entries are mentioned in Table 9.1. The maximum variation was found for seed yield/plot (27.23%) followed by 100-seed weight (19.29%) whereas least variation was found for days to 80% maturity. Few promising varieties have outperformed the best check.

Trial 2: Evaluation of Chocolate Spot Nursery: Total 23 entries and 3 checks (Rebya-40, HFB-1, Vikarant) were evaluated in RBD with 3 replications during *Rabi* 2022-23 for chocolate spot disease. None of the entry showed resistance to the disease, few entries have shown some tolerance on the basis of yield *viz.*, ET-226468, ET-226481, ET-226474 and ET-226469 (Table 9.2).

9.2.2. Evaluation of Lentil core set for cold tolerance (location-Bhowali)

One hundred sixty-six accessions of lentil core set were received from ICAR-NBPGR New Delhi under multi-location evaluation for cold tolerance with 4 checks (IPL-220, L-4727, L-4729 and RVL-31). The mean and range of variation for the traits studied is shown in Table 9.3.

9.2.3. Germplasm characterization, evaluation, regeneration and seed multiplication of horticultural and M&AP crops

Temperate horticultural crops *viz.*, peach (34), plum (11), apricot (14), kiwi (05), Nectarine (09), *Rubus* spp. (08) persimmon (03) and Malta (12) were characterized for different qualitative and quantitative characters. In wild *Allium* species, 14 species viz., *Allium perzewaskianum, A. negianum, A. stracheyi, A. tuberosum, A. wallichii, A. hookerii, A. chinense* etc. were characterized for the morphological traits like vegetative growth, flowering character and seed setting behavior under Bhowali condition.

A total of 14 accessions of Ridge gourd were multiplied/ regenerated at Bhowali station for initial LTS or regeneration of MTS seed material.

Table 9.1: Range of Variation for the Characters

Character (s)	Mean	Range	CV (%)	Promising entries
Plant Height (cm)	42.74	34.65- 53.15	12.34	ET-272853, ET-272854, ET-272840, ET-273797, ET-272844, ET-273796
Days to 50% Flowering	94.38	89-103	3.63	ET-272840, ET-272839, ET-252775, ET-272838, ET-252780, ET-252792
Days to 80% Maturity	180.52	176.67-184.33	0.93	ET-272840, ET-252793, ET-272839
Pod Length (mm)	52.54	43.83-76.36	10.28	ET-272840, ET-272845, ET-273796
Pod Width (mm)	11.82	9.86-13.61	9.24	ET-272851, ET-273797, ET-252780, ET-273789, ET-252785, ET-272838, ET-272840, ET-273796
Seed Yield/Plot (g)	197.21	98.10-346.68	27.23	ET-272852, ET-272845, ET-252788, ET-272853
100-Seed Weight (g)	64.54	33.45-101.47	19.29	ET-252785, ET-252790

Table 9.2: Range of Variation for the Characters

Character (s)	Mean	Range	CV (%)	Promising entries
Plant Height (cm)	46.13	35.87-63.27	17.46	ET-226475, ET-226468, ET-226481
Days to 50% Flowering	98.63	93.33-101.33	2.45	ET-226464, ET-226472,ET-226474, ET-226477
Days to 80% Maturity	178.79	172-183.67	1.75	ET-226459, ET-226479, ET-226463
Pod Length (mm)	59.67	45.77-77.35	12.27	ET-226482, ET-226481, ET-226468
Pod Width (mm)	12.13	9.03-14.85	11.58	ET-226460, ET-226482, ET-226479
Seed Yield/Plot (g)	149.87	94.45-269.62	24.31	ET-226468, ET-226481, ET-226474, ET-226469
100-Seed Weight (g)	86.23	41.63-116.64	18.91	ET-226470, ET-226466,ET-226477

Fig. 9.2 (a & b). Chocolate Spot disease in fababean nursery

Table 9.3: Range of Variation for the Characters

Character (s)	Mean	Range	CV (%)
Days to 50% flowering	104.53	93-131	6.70
Days to first pod initiation	113.34	104-141	4.96
Days to 80% maturity	173.15	117-185	4.65
100 Seed weight (g)	2.36	1.33-5.33	30.97
Plant height (cm)	26.90	15.08-36.64	13.88
Pods per plant	43.04	6.2-178.2	58.90
Number of secondary branches	6.17	1.8-12.8	28.80
Seeds per pod	1.51	1-1.8	16.57
Yield per plant	1.22	0.08-6.33	79.29
Seed Diameter (mm)	3.94	1.96-5.68	12.88
Seed Thickness (mm)	2.30	1.32-2.98	8.72

9.3. Germplasm conservation

9.3.1. Germplasm conservation in MTS

A total of 11,826 accessions including cereals (3509), pseudocereals (582), millets (592), pulses and legumes (3820), oilseeds (543), vegetables (1599), spices and condiments (695), medicinal and aromatic plants (180), WEUP (284) and ornamentals (23) have been maintained in MTS module of the station.

9.3.2. Germplasm conservation in FGB

A total of 1,017 accessions of different crops comprising Horticultural crops (536), WEUP (227), Wild Allium spp. (174) and MAP (80) were maintained in the FGB. Some of the RET species viz., *A. stracheyi, A. negianum, Citrus medica, Prunus cornuta, P. jacquemontii, P. mira, Rubus nepalensis, Ribes alpastre, R. himalense, Thymes lineris* etc are being maintained in the field genebank for future research purposes.

9.4. Germplasm exchange

A total of 326 accessions of various crops/species (Horticultural & MAP) were supplied under material transfer agreements to the different indenters for their research purposes. The crops/species supplied were of different crops i.e. Chilli (153), Ridge gourd (37), Pomegranate (84), Allium (45), strawberry (04), wild Malus (02) and MAP (04) to the different indenters within India.

Germplasm Supplied to Local farmer/indentors: Live rooted / grafted/cutting plant material (9737) viz. Kiwi (2455), Kiwi scion wood (3050), stone fruit (1226), strawberry (1537) Citrus (476), other fruit crops (62), MAP (131) and cuttings of MAP (800) were supplied to different farmers as per the rate list fixed at station.

Research Programme (Code, Title, **Programme Leader,** *Associates***)**
PGR/PGC-BHO-01.00- Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation and Documentation of Genetic Resources of the Northern Himalayas and Adjoining Plains. **Mamta Arya.**
PGR/PGC-BHO-01.01: Management of genetic resources of field crops with emphasis on ethno botanical aspects **(Mamta Arya,** *Girish Chandra***)**
PGR/PGC-BHO-01.02: Management of genetic resources of temperate horticultural crops **(K.M. Rai,** *Anuj Kumar Sharma***)**
PGR/PGC-BHO-01.03: Management of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species **(K.M. Rai, (since 29.6.2017),** A. Raina, Mamta Arya, *Anuj Kumar Sharma***)**.
Externally Funded Projects
"Mainstreaming Agricultural Biodiversity Conservation and Utilisation in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability" under UNEP-GEF and Bioversity International. **CCPI: Mamta Arya, KM Rai**

10 BASE CENTRE, CUTTACK

सारांशः *अबल्मोश्चस ओडिशा* आर.सी. मिश्रा स्पीसीज नोवो, एक जंगली भिंडी, ओडिशा से खोजी गई थी और इसे भारत में पादप विज्ञान के लिए एक नई प्रजाति के रिकॉर्ड के रूप में रिपोर्ट किया गया था। मालवा सिल्वेस्ट्रिस एल. और ओसीमम बेसिलिकम वार पाइलोसम (विल्ड) बेन्थ, ओडिशा से खोजे गए जो कि पूर्वी और मध्य भारत के लिए नए वितरण रिकॉर्ड के रूप में पाया गया। धान (190), जंगली धान (82), *ओसीमम* स्पीसीज (51), *हिबिस्कस सबदरिफा* (22), *एबेलमोस्कस* स्पीसीज (36), *डायोस्कोरिया* स्पीसीज (18), *कोस्टस* स्पीसीज (9), *लूफ्फा* स्पीसीज (5) और *जिंजिबर जेरुम्बेट* (1) सहित 414 परिग्रहणों को लक्षित फसलों के बीच परिवर्तनशीलता/विविधता की जांच करने के लिए विभिन्न गुणात्मक और मात्रात्मक लक्षणों के लिए चित्रित किया गया। प्रत्येक फसल के लिए कृषि–रूपात्मक और आर्थिक लक्षणों के लिए बेहतर जीनोटाइप की पहचान की गई। जंगली भिंडी की पहचान का सत्यापन, मीठी तुलसी में अंतर–विशिष्ट मूल्यांकन और आनुवंशिक परिवर्तनशीलता और *ओसीमम* स्पीसीज में जैव रासायनिक परिवर्तनशीलता का अध्ययन किया गया। 1431 परिग्रहणों का एक सेट जिसमें चावल, जंगली चावल, *ओसीमम* स्पीसीज, *एबेलमोस्कस* स्पीसीज, *हिबिस्कस सबदरिफा*, *लुफ्फा* स्पीसीज, *सोलनम* स्पीसीज, *थेस्पेसिया लैंपस*, *डायोस्कोरिया* स्पीसीज, *कोस्टस स्पेशियोसस*, *हेडिचियम* स्पीसीज, *जिंजिबर जेरुम्बेट*, *कैनावलिया ग्लैडियेट* और *आर्गीरिया नर्वोसा* को संवर्धित एवं पुनर्जीवित किया गया। 83 परिग्रहणों जिसमें वन्य धान की प्रजातियां, तुरई, करेला, ओसीमम का सुगंधित तेल, हिबिस्कस सबदरिफा की पत्ती और कैलीक्स पाउडर, *कोस्टस* स्पेशियोसस के प्रकंद के नमूने, *कोस्टस पिक्टस*, *जिंजिबर जेरुम्बेट* और *एबेलमोस्कस मोस्कैटस* की आपूर्ति की गई और धान और जंगली धान प्रजाति के 523 परिग्रहणों को पुनर्जनन और संरक्षण के लिए आईसीएआर संस्थानों से प्राप्त किया गया। धान (682), जंगली धान (9) कुकुरबिट्स, ओषधिये एवं सुगंधित और फसल के वन्य संबंधियों (120) को एलटीएस के लिए जमा किया गया था और विभिन्न फसलों के 25 परिग्रहण एफजीबी में जोड़े गए। जंगली धान प्रजाति, ओषधिये एवं सुगंधित और फसल के वन्य संबंधि एवं कंद फसलों और बागवानी फसलों के कुल 598 परिग्रहणों को एफजीबी/प्रायोगिक प्लॉट में रखरखाव किया जा रहा है। बेस सेंटर, कटक में कुल 1450 पादप वानस्पतिक नमूने संरक्षित किए जा रहे हैं, दो प्रकार के नमूने (आइसोटाइप) सेंट्रल नेशनल हर्बेरियम (सीएएल), बी.एस.आई., हावड़ा में जमा किए गए हैं और एक होलोटाइप सहित चार नमूने एनएचसीपी, नई दिल्ली में जमा किए गए हैं। 200 अनुसूचित जाती के किसानों को शामिल करते हुए दो पीजीआर जागरूकता कार्यक्रमों का सह–आयोजन किया गया, पीजीआर प्रबंधन पर दो ओरिएंटेशन प्रशिक्षण और यूजी छात्रों के लिए हर्बेरियम तकनीकी में आमंत्रित वक्ता के रूप में भाग लिया और संगोष्ठी/कार्यशाला/बैठक (ऑनलाइन) में व्याख्यान दिया। 200 अनुसूचित जाति कृषक समुदाय के बीच छोटे कृषि उपकरण, रोपण सामग्री और बीज वितरित किए गए। एमजीएमजी गांवों के किसानों को नियमित फसल सलाहकार सेवाएं प्रदान की गईं। शोध पत्र (6) और सम्मेलन सार/सारांश (1) प्रकाशित किए और भारतीय चावल कांग्रेस में एक पोस्टर पेपर प्रस्तुत किया।

Summary: *Abelmoschus odishae* R.C. Misra sp. nov., a wild okra, was discovered from Odisha and reported as a new species record to plant science from India. *Malva sylvestris* L. and *Ocimum basilicum* var. *pilosum* (Willd.) Benth., explored from Odisha were found as new distributional record for Eastern and Central India. A set of 414 accessions comprising cultivated rice (190), wild rice (82), *Ocimum* spp. (51), *Hibiscus sabdariffa* (22), *Abelmoschus* spp. (36), *Dioscorea* spp. (18), *Costus* spp. (9), *Luffa* spp. (5) and *Zingiber zerumbet* (1) was characterized for different qualitative and quantitative traits to investigate the variability/ diversity among targeted crops. Superior genotypes for multiple agro-morphological and economic traits for each crop were identified. Validation of identity of wild okra, inter-specific evaluation and genetic variability in sweet basil and biochemical variability in *Ocimum* spp. were undertaken. A set of 1431 accessions comprising rice, wild rice, *Ocimum* spp., *Abelmoschus* spp., *Hibiscus sabdariffa*, *Luffa* spp., *Solanum* spp, *Thespesia lampas*, *Dioscorea* spp., *Costus speciosus*, *Hedychium* spp., *Zingiber zerumbet*, *Canavalia gladiata* and *Argyreia nervosa* multiplied/regenerated; 83 accessions comprising wild *Oryza* species, ridge gourd, bitter gourd, essential oil of *Ocimum*, leaf and calyx powder of *Hibiscus sabdariffa*, rhizome samples of *Costus speciosus*, *Costus pictus*, *Zingiber zerumbet* and seeds of *Abelmoschus moschatus* were supplied and 523 accessions comprising cultivated rice and wild *Oryza* species was received from ICAR institutes for regeneration and conservation. Cultivated rice (682), wild rice (9) cucurbits, M&AP and crop wild relatives (120) were deposited for LTS and 25 accessions of various crops were added to FGB.A total of 598 acc comprising wild *Oryza* species M&AP, CWR, tuber crops and horticultural crops are being maintained in the FGB/ experimental plot. A total 1450 herbarium specimens are being preserved at Base Centre, Cuttack, two type specimens (isotypes) deposited at Central National Herbarium (CAL), B.S.I., Howrah and four specimens including one holotype are deposited at NHCP, New Delhi. Co-organised two PGR awareness programme involving 200 SC farmers, two orientation training on PGR management and herbarium technique to UG students. Attended as invited speaker and delivered lectures in Symposiums/ workshop/Meetings (online). Small farm implements, planting materials and seeds were distributed among 200 SC farming community. Regular crop advisory services were provided to farmers of MGMG villages. Published research papers (6) and conference abstracts/ summary (1) and presented one poster paper in Indian rice congress.

10.1. New species of wild okra discovered

Abelmoschus odishae R.C.Misra *sp. nov.* (Malvaceae), a rare wild okra, discovered from a moist deciduous forest in Keonjhar district of Odisha in tropical Eastern India, is reported as a new species. It shares morphological similarities with *A. palianus*, however, differs in significant characters exhibiting perennial large shrub; densely hispid prickly stem with long retrorse hairs; spinescent pedicel; 8 (7–9)

segmented, lanceolate epicalyx; campanulate corolla; ovoid to oblong bristly capsules; sub-reniform seeds with stout porrect trichomes. In addition, the seed micro-morphology was examined using scanning electron microscope in order to distinguish the taxonomic disposition of the new species from known taxa. The seed germplasm were conserved in the National Genebank and the holotypes and the isotypes were deposited at the NHCP, New Delhi and Central National Herbarium (CAL), Calcutta respectively. The diagnostic characters were compared with all entities of *Abelmoschus* and allied syntypes of *Hibiscus* described from India and abroad along with the authentic digital images available in Kew Herbarium, London to confirm the identity of the plant. However, none of them matched with this specimen and it was quite different from all known species. After careful morphological comparison of collected material with congeneric taxa in *Abelmoschus*, it is concluded as an undescribed taxon. Therefore, it establishes a new entity warranting a species status *Abelmoshus odishae* and the present collection forms a new species record to plant science from India.

Fig. 10.1. *Abelmoschus odishae* R.C.Misra *sp. nov.*, a new species of wild okra discovered from Odisha

10.2. New distributional record of plant genetic resources

During the course of plant exploration in parts of Odisha, the occurrence of an interesting plant species on a fallow field, used as a leafy vegetable, was recorded from Bargarh district of Odisha. The seed germplasm was conserved in National Genebank and the herbarium specimens were deposited at NHCP, ICAR-NBPGR, New Delhi. After thorough examination of morphological characters of live plants and herbarium specimens, the species was identified as *Malva sylvestris*. On verification of major published Indian literature, it was found that it has not been reported till date from Eastern India. Therefore, the present collection counts an addition of genus *Malva* to the flora of Odisha and forms a new distributional plant record for Eastern India.

Fig. 10.2. *Malva sylvestris* Linn., a leafy vegetable explored from Odisha, forms a new distributional record for Eastern India

During the plant exploration for germplasm collection in Odisha, the occurrence of one wild species of *Ocimum* was noticed at different locations in Sundargarh and Dhenkanal districts of Odisha. Nine germplasm accessions were collected and conserved in National Genebank, NBPGR, New Delhi. After thorough examination of morphological characters, the species was identified as *Ocimum basilicum var. pilosum* (Willd.) Benth., a species reported in wild state so far only from Kerala, Tamil Nadu and Andhra Pradesh. On verification of Indian literature, it was found that it has not been reported till date in wild condition from Central and Eastern India. Therefore, the present collection counts an addition of species to the flora of Odisha and forms a new distributional record for Eastern and central India.

Fig. 10.3. *O. basilicum* var. *pilosum*, an aromatic herb collected from Odisha, a new distributional record for Eastern and Central India

10.3. Germplasm Characterization

A set of 414 accessions comprising cultivated rice (190), wild rice (82), *Ocimum* spp. (51), *Hibiscus sabdariffa* (22), *Abelmoschus* spp. (36), *Dioscorea* spp. (18), *Costus* spp. (9), *Luffa* spp. (5) and *Zingiber zerumbet*(1) was characterized for different qualitative and quantitative traits to investigate the variability/ diversity among targeted crops. Superior genotypes for multiple agro-morphological and economic traits were identified.

10.3.1. Cultivated rice germplasm

A set of 190 accessions of rice germplasm comprising small grained scented rice (120) and coloured rice (70) augmented during exploration missions are characterized and genetic diversity was assessed based on 10 quantitative traits.

10.3.2. Scented rice germplasm

120 accessions of scented rice were grown in augmented design with five blocks and six checks(Naveen, Geetanjali, Ketakijoha, Kalajeera, Panidhan, CR Dhan-202) during *Kharif*, 2023. Each entry was transplanted in a spacing of 15X20 cm between plants and rows. Observations on 14 qualitative and 10 quantitative traits were recorded and promising accessions were identified (Table 10.1).

Coloured rice germplasm: A set of 70 acc of coloured rice germplasm augmented from National Genebank, ICAR-NBPGR, New Delhi was selected and grown in augmented design in five blocks and six checks (IR-64, CR Dhan-202, Swarna, Panidhan, Ketakijoha and Geetanjali) with a spacing of 15X 20 cm between plants and rows. Observation on 10 different quantitative traits were recorded and promising types over best check values are identified (Table 10.2).

10.3.4. Wild rice germplasm

A set of acc comprising *Oryza rufipogon* (47) and *Oryza nivara* (35) was characterized for different agro-morphological traits. Each acc was maintained in two rows in a plot size of 4.5m^2/entry following a spacing of 50x50cm between rows and plants. Observation on 14 qualitative and 10 quantitative traits were recorded and genetic variability for quantitative traits was calculated (Table 10.3).

10.3.5. *Ocimum* spp.

Fifty one accessions of *Ocimum* spp. comprising *O. africanum* (7), *O. americanum* (4), *O. tenuiflorum* (10), *O. basilicum* (10), *O. gratissimum* (18) and O. *kilimandscharicum* (2) were characterized for 35 agro-morphological and economic traits in RBD with two replications. The superior genotypes (10) identified for highest herbage yield and essential oil yield/ plant in respect of each species are

Table 10.1: Variability among quantitative traits in scented rice germplasm(120 acc)

Traits	Range		Best check	Promising lines
	Min.	Max.		
Plant height (cm)	85.8 (IC-203530)	188.7(IC-203536)	Naveen (119.3)	DP/DPS/BCM-2464
Panicle length(cm)	17.8 (IC-203530)	35.0 (IC-203370)	Kalajeera (29.6)	IC-203391, 203454
EBT/Plant	5.4 (IC-568918)	10.2 (IC-568839)	Panidhan (6.5)	IC-203373, 203482
Grains/panicle	91.3 (IC-257218)	264.4 IC-596897	Geetanjali (216.0)	IC-596897,258781
Sterility %	5.2 (IC-203500)	40.6 (IC-257505)	CR Dhan-202(4.2)	IC-257505,137599
Panicle wt. (g)	1.44 (IC-203500)	7.1(IC-257505)	Geetanjali (5.60)	IC-283042,203370
Leaf length (cm)	37.4 (AC-35401)	70.9 (IC-203536)	Kalajeera (66.2)	IC-203536,257256
Leaf width(cm)	0.58 (IC-568008)	1.78 (IC-280579)	Ketakijoha (1.5)	IC-280579,256676
Ligule length (cm)	1.02 (IC-203530)	2.3 (IC-203142)	Geetanjali (2.2)	IC-203142, 256837
100 seed wt. (g)	0.7 (IC-203142)	3.3 (IC-259929)	CRDhan-202(3.08)	IC-259929

BASE CENTRE, CUTTACK

Table 10.2: Variability among quantitative traits in coloured rice germplasm (70 acc)

Traits	Range		Best check	Promising lines
	Min.	Max.		
Plant height (cm)	86.18	177.78	IR-64 (131.4)	EC-934566, 934621
Panicle length (cm)	23.48	31.58	Swarna (28.5)	(EC-934566, 934650)
EBT	5.6	9.8	Geetanjali (8.5)	DP/DPS/BCM-2528, EC-934837
Grains/panicle	68.2	242.0	Geetanjali (222.2)	DP/DPS/BCM-2535, EC-934894
Sterility %	4.2	44.4	IR-64 (3.5)	DP/BCM-2462, EC-934924
Panicle wt. (g)	1.77	5.82	Panidhan (5.2)	EC-934908, 934900
Leaf length (cm)	37.98	75.12	IR-64 (46.5)	EC-934561
Leaf width(cm)	0.64	1.52	Ketakijoha (1.28)	EC-934831
Ligule length (cm)	1.26	2.76	Panidhan (2.4)	EC-934561
100 seed wt. (g)	1.4	3.22	CRDhan-202 (3.1)	EC-934566

Table 10.3: Range of variability among quantitative traits in wild *Oryza* species

Traits	*Oryza rufipogon* (47acc)			*Oryza nivara* (35acc)		
	Range	Mean	SEM(+)	Range	Mean	SEM (+)
Days to 50% flowering	131.2-143.5	135.4	0.68	95.3-122.7	121.5	0.56
Days to maturity	152.0-166.0	152.4	0.56	119.3-147.1	129.5	0.61
Plant height (cm)	144.2-190.8	168.7	5.4	62.8-153.7	102.0	1.98
Leaf length (cm)	36.8-43.2	40.24	1.04	24.0-49.4	39.8	1.8
Leaf width (cm)	1.02-1.6	1.21	0.04	0.7-1.0	0.8	0.36
EBT/Plant	7.2-14.0	12.2	0.90	5.4-16.2	9.6	0.85
Panicle length (cm)	22.4-33.9	25.4	1.35	15.4-26.3	21.4	0.80
Spikelets/panicle	72.0-127.3	98.2	2.42	66.0-162.2	106.6	3.8
Spikelet sterility(%)	26.4-46.6	40.2	1.4	34.8-89.1	66.1	1.12
100 grain weight (g)	1.2-2.8	1.5	0.24	1.7-2.8	2.2	0.30

O.africanum (IC-624514, 626384), *O. americanum* (IC-641714), *O. basilicum* (IC-641781,645595), *Ocimum tenuiflorum* (IC-641734, 599304), *O. kilimandscharicum* (IC-627244) and *O. gratissimum*((IC-645594, 627242).

10.3.6. *Hibiscus sabdariffa*

Twenty-two acc of *Hibiscus sabdariffa* (roselle), used as leafy vegetable by rural/ tribes,were characterized for 35 agro-morphological and economic traits in RBD with two replications and promising genotypes such as IC-630723, 630724, 614084 and 617967 and were identified for multiple traits viz. plant height, fresh leaf yield/ plant, calyx yield/ plant and number of fruits/plant and 100 seed weight.

10.3.7. *Abelmoschus* spp.

A total of 36 acc belonging to 12 taxa collected from Odisha were grown and detailed taxonomic enumeration for each taxon was recorded and herbarium specimens were preserved for identification. Developed an identification key for 12 taxa of *Abelmoschus* spp. (36 acc) including new species *A.odishae* based on taxonomic characters.

10.4. Germplasm Evaluation

10.4.1. Evaluation of wild rice germplasm for submergence tolerance

A set of 29 wild rice accessions comprising *Oryza nivara*(9), *Oryza rufipogon*(3) and *O. sativa* var *spontanea* (15) including two check varieties (Resistant-Swarna *sub*-1; Susceptible-Swarna) was evaluated in two replications in artificial screening method for identification of donors for submergence tolerance. The accessions viz. DP/BCM -2859, 2873, 2875 and 2884 were found tolerant to submergence for 14 days under preliminary evaluation.

10.4.2. Validation of identity of wild okra

Seed micro-morphology of four wild taxa of *Abelmoschus* was validated through scanning electron microscope (SEM).

BASE CENTRE, CUTTACK

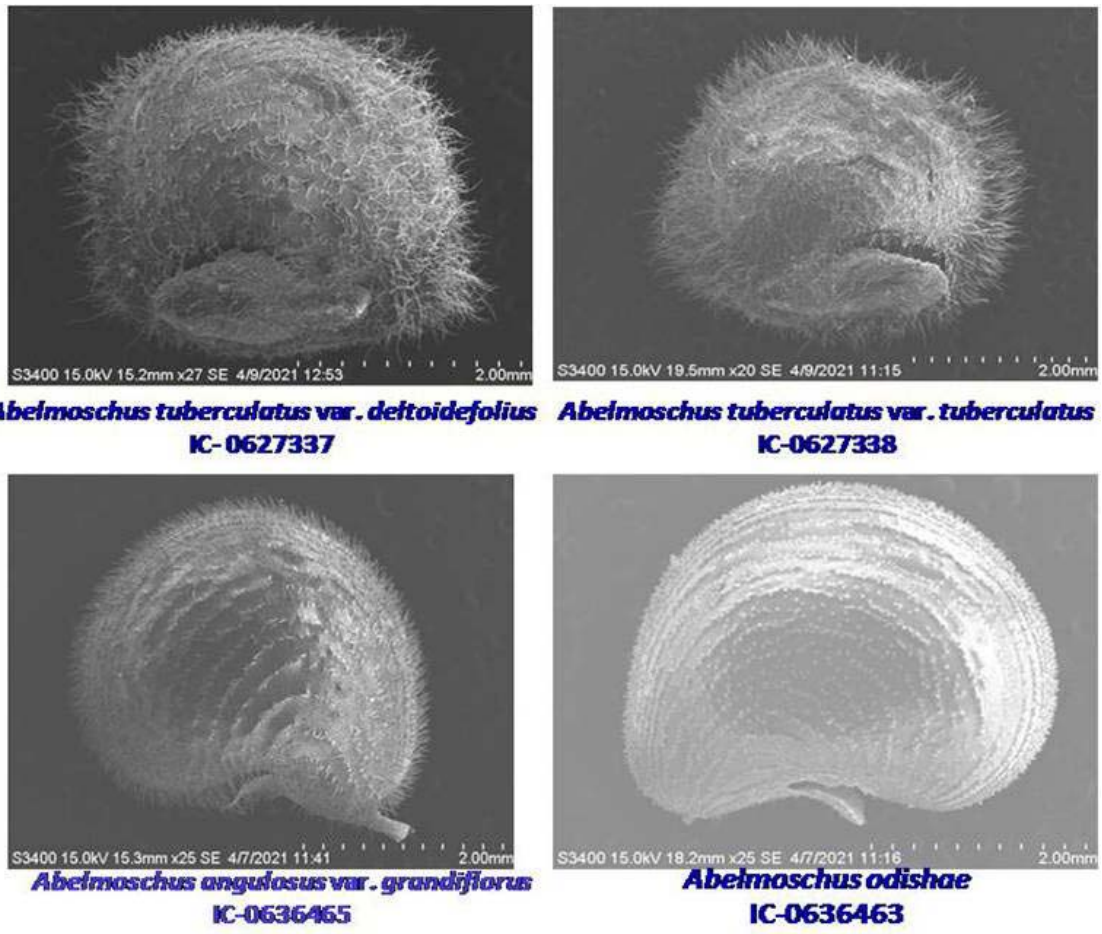


Fig. 10.4. SEM micrographs of whole seeds of four taxa of *Abelmoschus* showing variability in seed structure

The micro-morphology of *A. angulosus* var. *grandiflorus* was compared with a new species *A. odishae* and two taxonomic varieties of *A. tuberculatus* which exhibited clear distinction of seed structure including hilum, trichomes and spermoderm cells.

10.4.3. Inter-specific evaluation and genetic variability in sweet basil

Studies on morphology of Bio-systematic studies of *Ocimum basilicum* (29 acc) collected during previous explorations from Eastern India exhibited a high genetic variability in indumentum of stem, leaves and verticillaster and flower colour. Based on critical analysis of taxonomic and agro-morphological characters, six taxonomic varieties viz. *Ocimum basilicum* var. *pilosum, O. basilicum* var. *thyrsiflora, O. basilicum* var. *basilicum,O. basilicum* var. *glabratum* , *O. basilicum* var. *difforme, O. basilicum* var. *purpurascense* were identified.

10.4.4. Biochemical variability in *Ocimum* spp.

Biochemical variability of essential oil of six species (36 accessions) of *Ocimum* exhibited species-specific chemotypes such as camphor-rich *O. americanum*, methyl cinnamate rich *O. basilicum*, geranial/ neral rich *O. africanum*, eugenol and methyl eugenol rich *O. tenuiflorum*, methyl-chavicol rich *O. kilimandscharicum* and eugenol rich *O. gratissimum*. These chemical variations between the species can not only facilitate selection of better economic traits for further improvement of the genotypes but also for utilization as a source of industrially important aromatic compounds those rely on products of food, aroma and medicines.

10.4.5. Medicinal & aromatic plants

Essential oil extracted from leaves/ aerial parts of 20 acc of *Ocimum* spp., *Hedychium* spp. (3) and rhizome shred samples of *Costusspeciosus* (11), *Zingiber zerumbet* (1) and seeds of *Abelmoschus moschatus* (2) were supplied to the Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi for evaluation of biochemical constituents.

10.4.6. Leafy vegetables

Leaf and calyx powder of twenty acc of *Hibiscus sabdariffa* (roselle), used as leafy vegetable by rural/ tribal inhabitants

of Odisha were supplied to ICAR-NBPGR, for nutritional analysis.

10.5. Germplasm multiplication

A set of 1431 accessions comprising cultivated rice (711), wild rice (558),*Ocimum* spp. (59), *Abelmoschus* spp. (36), *Hibiscus sabdariffa* (22), *Luffa* spp.(5), *Solanum* spp (2), *Thespesia lampas* (1), *Dioscorea* spp. (19), *Costusspeciosus* (11), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Canavalia gladiata* (2), *Argyreia nervosa* (1) were multiplied/ regenerated for seed enhancement, characterization, herbage and oil yield and further biochemical evaluation.

10.6. Germplasm exchange

A total of 83 accessions comprising wild *Oryza* species(13), ridge gourd (14), bitter gourd (1), essential oil of *Ocimum* (20), leaf and calyx powder of *Hibiscus sabdariffa* (20), rhizome samples of *Costusspeciosus* (11), *Costus pictus* (1), *Zingiber zerumbet* (1) and seeds of *Abelmoschus moschatus* (2) were supplied to ICAR institutes for research purpose. A set of 523 accessions comprising cultivated rice (68) and wild *Oryza* species (455) was received from ICAR-NBPGR for regeneration and conservation.

10.7. Germplasm conservation

A total of 688 accessions comprising of rice (682) and *Cajanus scarabaeoides* (6) multiplied during *Kharif,* 2022 was deposited in the NGB. Similarly, 123 accessions comprising wild rice germplasm collected from Maharastra (9 acc), cucurbits, M&AP and CWR collected from Odisha (114 acc) were deposited for LTS in NGB, NBPGR, New Delhi. In addition, 25 acc comprising *Oryza nivara (8 acc) Oryza rufipogon (5 acc), Abelmoschus odishae* (1), *Abelmoschus crinitus* (4), *Ocimum basilicum* var. *pilosum* (1), *Ocimum gratissimum* (2), *Luffa aegyptiaca* (1), *Hibiscus sabdariffa* (1), *Costus pictus* (1), *Thespesia lampas* (1) were added to the FGB of the centre.

10.8. Germplasm maintenance

A total of 598 acc comprising wild *Oryza* spp. (227), M&AP (205),*Ocimum*spp. (59), *Abelmoschus* (36), *H. sabdariffa* (22), *Dioscorea* spp. (19), horticultural crops (6), *Costus speciosus* (11), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Luffa aegyptiaca* (5), *Canavalia gladiata* (2), *Scleicheraoleosa* (1), *Thespesia lampas* (1), were maintained in the FGB/ experimental plots of the centre

10.9. Herbarium preservation/ deposit

Deposited two isotypes at Central National Herbarium (CAL), B.S.I., Howrah and four specimens including one holotype at NHCP, New Delhi. Identified and augmented herbarium materials (36) and curated (270). The important specimens such as *Abelmoschus odishae, Abelmoschus pungens, A. tuberculatus,Malva sylvestris*, *Thespesia lampas*, *Zingiber zerumbet, Luffa aegyptiaca, O. basilicum var. pilosum* etc were augmented to the herbarium.

10.10. Documentation

The passport data pertaining to one exploration and germplasm collections and information on traditional uses of wild *Abelmoschus, Cajanus, Corchorus,* cucurbits, *Solanum, Dioscorea* including wild leafy vegetables and other medicinal and aromatic plants were collected and documented.

Research Programme (Code, Title, **Programme Leader)**
PGR/EXP- BUR-CUT-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation documentation and distribution of plant genetic resources of Odisha and adjoining regions **(Dr D R Pani)**
Research Project (PI, *CoPIs* **&** *Associates***)**
PGR/EXP-BUR-CUT- 01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural and horticultural crops in Odisha and adjoining regions. **(D.R. Pani,** R.C. Misra)
PGR/EXP-BUR-CUT- 01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of medicinal & aromatic plants, wild economically useful and rare and endangered plants of Odisha and adjoining regions. (**R. C. Misra,**D.R.Pani)

11 REGIONAL STATION, HYDERABAD

सारांशः वर्ष 2023 के दौरान, संगरोध निकासी के लिए कुल 73,641 फसल जननद्रव्य नमूने (19,399 आयातय 54,242 निर्यात) संसाधित किए गए। 31 फैटोसैनिटरी प्रमाण पत्र जारी किये गए। उल्लेखनीय रूप से, आयात फसल जननद्रव्य के नमूने (6,590) कीटों/रोगजनकों से पर्यक्रांत/संक्रमित थे, उनको बचाए गए। मक्के पर ड्रेक्सलेरा मेडीस, स्टीनोकार्पेल्ला मेडीस, ग्रेन वीविल (सिटोफिलस एसपी.), चेनोपोडियम लेंटिक्युलेर और चेनोपोडियम सिम्प्लेक्स का संक्रमण, तिल पर अल्टरनेरिया सेसमी, सोयाबीन पर पेरोनोस्पोरा मैनशूरिका, कोलेटोट्राइकम ग्लियोस्पोरियोइड्स और सी. डिमेटियम, मिर्च पर आल्टरनेरिया सोलानी, पेस्टालोषिया एसपी। राइजोक्टोनिया सोलानीय टमाटर पर बोट्रीओडिप्लोडिया थियोब्रोमई, फ्यूसेरियम सोलानी, फियोइसारियोप्सिस ग्रिसेओला, पेस्टालोषिया एसपीय करेले पर बोट्रीओस्फेरिया एसपी, फोमा एसपी कुछ महत्वपूर्ण अवरोधन हैं। पी. मैनशूरिका से संक्रमित सोयाबीन की दस प्रविष्टियों को अस्वीकार कर दिया गया। निजी उद्योग, आईसीआरआईएसएटी, विश्व सब्जी केंद्र, सार्वजनिक संगठन और एनबीपीजीआर आरएस हैदराबाद में उगाई गई विभिन्न फसलों की 8590 पहुंच के लिए संगरोध निरीक्षण आयोजित किया गया था। दक्षिण भारत में संगरोध सेवाओं को 39 संगठनों तक विस्तारित किया गया और रुपये के संसाधन आयातित खोपों के संगरोध प्रसंस्करण के माध्यम से रु. 41,41,423/– उत्पन्न किये गए। समानांतर में, तमिलनाडु में एक अन्वेषण पहल का नेतृत्व किया गया और तिरुचिरापल्ली, पेरम्बलुर, अरियालुर और कुड्डालोर जैसे जिलों से 50 विविध मोरिंगा जर्मप्लाज्म नमूनों का संग्रह किया गया। इसके अतिरिक्त, 625 कृषि–बागवानी फसल परिग्रहण की विशेषता बताई गई, जिनमें से 150 को राष्ट्रीय जीन बैंक को संरक्षण के लिए भेजा गया। इसके अलावा, स्टेशन पर एमटीएस में 183 स्वदेशी जर्मप्लाज्म परिग्रहण शामिल किए गए, और 677 जर्मप्लाज्म परिग्रहण 34 एसएयू/आईसीएआर संस्थानों में प्रसारित किए गए। इसके अलावा, पीजीआर प्रबंधन में स्टेशन के योगदान को प्रदर्शित करते हुए,142 लोबिया प्रवेशों की जांच की गई, और मेलोइडोगाइन इन्कॉग्निटा के विरुद्ध चार प्रतिरोधी जर्मप्लाज्म परिग्रहणों का खुलासा किया गया।

Summary: During the reporting period, crop germplasm consisting of 73,641 samples (19,399 imports; 54,242 exports) was processed for quarantine clearance. 31 Phytosanitary certificates were issued. Notably, 6,590 infected/ infested import crop germplasm samples were salvaged. *Drechslera maydis*, *Stenocarpella maydis*, grain weevil (*Sitophilus* sp.), *Chenopodium lenticulare* and *C. simplex* infestation on maize, *Alternaria sesami* on sesamum, *Peronospora manshurica*, *Colletotrichum gloeosporioides* and *C. dematium* on soybean, *Alternaria solani*, *Pestalotia* sp. and *Rhizoctonia solani* on chilli, *Botryodiplodia theobromae*, *Fusarium solani*, *Phaeoisariopsis griseola*, *Pestalotia* sp., on tomato, *Botryosphaeria* sp., *Phoma* sp. on bittergourd are some of the significant interceptions. Ten accessions of soybean infected with *P. manshurica* were rejected. Post-entry quarantine inspection was conducted for 8590 accessions of different crops grown at private industry, ICRISAT, World Vegetable Center, public organizations and NBPGR RS Hyderabad. Quarantine services were extended to 39 organizations in South India and resources worth Rs. 41, 41, 423/- were generated. In parallel, an exploration initiative in Tamil Nadu led to the collection of 50 diverse *Moringa* germplasm from districts Tiruchirapalli, Perambalur, Ariyalur, and Cuddalore. Additionally, 625 agri-horticultural crop accessions were characterized, with 150 sent to the National Genebank for conservation. Furthermore, 183 indigenous germplasm accessions were incorporated into the MTS at the station, and 677 germplasm accessions were disseminated to 34 SAUs/ICAR Institutes. Moreover, 142 cowpea accessions were screened, revealing four resistant germplasm accessions against *Meloidogyne incognita*, showcasing the station's contribution to PGR management.

11.1. Germplasm Quarantine Overview

Quarantine processing of 55,489 samples comprising of 19,399 import samples and 54,242 export samples was conducted as detailed below. In all, 4 international, 10 public (ICAR institutes, universities/state govt. organizations) and 25 private organizations received the quarantine services. Resources worth Rs. 41,41,423/- were generated through quarantine processing of imported consignments.

11.2. Import Quarantine Details

A total of 19,399 samples including paddy-8450, wheat-3061, barley-135, maize-4408, sorghum-141, pearlmillet-5, fingermillet-5, pigeon pea-4, bambaranut-20, soybean-32, safflower-10, sesame-111, castor-53, chilli-1332, tomato-986, bitter gourd-163, cucumber-112, radish-24, ash gourd-14, beans-44, okra-54, cauliflower-100, onion-75, hairy vetch-54, *Arabidopsis* sp-4 and tobacco-2, were imported from different countries.

11.3. Import Releases and Interceptions

Imports released: Seed samples (19455) consisting of paddy-8444, wheat-3061, barley-135, maize-4352, sorghum-76, pearlmillet-5, finger millet-5, pigeonpea-65, mungbean-44, soybean-25, sesame-111, chilli-2079, tomato-618, radish-24, ashgourd-14, bittergourd-136, okra-1, cucumber-112, onion-75, hairy vetch-51, tobacco-18, and *Arabidopsis*-4 were released after necessary mandatory treatments.

During quarantine processing, the following major pests were intercepted.

Paddy: *Aphelenchoides besseyii* from Philippines **Maize:** *Drechslera maydis* from Mexico, South Africa, Thailand and USA; *Drechslera rostrata, Fusarium* sp from Indonesia; *D. setariae, Fusarium* spp., *Pestalotiopsis* sp., *Phoma* sp., *Stenocarpella maydis* from South Africa; *D. rostrata* and *F. verticilloides* from Thailand; Grain weevil (*Sitophilus* sp.) from

Mexico; Weed (*Chenopodium lenticulare* and *C. simplex*) infestation from France; **Sorghum:** *Acremonium* sp from Austria; **Pearlmillet:** *Acremonium* sp; and *Fusarium* spp from Kenya; **Sesamum:** *Alternaria sesami* from USA; **Soybean:** *Colletotrichum gloeosporioides* and *C. dematium* from USA; *Peronospora manshurica* from Taiwan; **Chilli:** *Alternaria solani, Drechslera rostrata*, *Phoma* sp. *Pestalotia* sp. and *Rhizoctonia solani* from Taiwan; **Tomato:** *F. solani, F. semitectum* from France; *D. rostrata, Phoma* sp., *F. solani, Rhizoctonia solani*, *Botryodiplodia theobromae, Phaeoisariopsis griseola* from Taiwan; *D. rostrata, Phoma* sp., *Fusarium semitectum, F. solani, Pestalotia* sp., *Rhizoctonia solani* from Thailand; **Bittergourd:** *Alternaria longissima, Botryosphaeria* sp., *D. rostrata, Phoma* sp. from Thailand; **Ash gourd:** *Phoma* sp. and *D. rostrata* from Taiwan

TSOP Treatment for Germplasm: The mandatory trisodium orthophosphate treatment (10% sol) was given to 2697 imported germplasm consisting of tomato (618) and chilli (2079) before release to ensure compliance with regulatory standards.

Import Germplasm Salvaged: Out of 6,600 samples found infected or infested, 6,590 were successfully salvaged, while 10 samples were rejected due to *Peronospora manshurica* on soybean from Taiwan. The details of infection/infestation are fungi (Pathogenic- 1907; saprophytes- 4797), bacteria-204, nematodes- 56, insects- 12, and weeds- 01.

11.4. Export Quarantine Operations

Crop germplasm samples (54,242) consisting of maize (243) received from CIMMYT and sorghum-12526, pearl millet-11381, foxtail millet-124, finger millet-875, little millet-11, barnyard millet-64, proso millet-96, kodo millet-11, chickpea-11281, and pigeon pea-2206 received from ICRISAT, bittergourd-24 received from World Vegetable Centre were processed for export purpose. In all, 71 samples were detained or withdrawn. Thirty-one (31) Phytosanitary certificates were issued.

Of the 54,242 exported samples, a total of 4320 accessions of ICRISAT crop germplasm (sorghum-1952, pearlmillet-305, pigeonpea-105, chickpea-845, groundnut-430, fingermillet-325 and foxtailmillet-38), along with 320 duplicate samples meant for export to Norway for secondary level of conservation in the Svalbard Global Seed Vault was examined from seed health aspects. Among the exported samples, 48,300 accessions were sent for primary level of conservation as safety duplicates. They were groundnut (14650), pigeonpea (2050) and assorted millets (600) to USDA ARS Genebank; chickpea (10000) to WVC, Taiwan; sorghum (10500) and pearlmillet (10500) to ICARDA, Morocco.

11.5. Post entry quarantine (PEQ) inspections

Post-entry quarantine inspection was conducted for 8590 accessions of different crops grown at private industry (4804), ICRISAT (3406), World Vegetable Center (136), public organizations (14) and NBPGR RS Hyderabad (230).

NBPGR RS Hyderabad: Crop germplasm (230) comprising of maize-106, soybean-65, bambarnut-59 were grown and found healthy.

ICRISAT: Crop germplasm (3406) comprising of pearl millet-899, groundnut-294, pigeon pea-204, chickpea-5, sorghum-170, wheat-1654 and maize-378, was inspected. *Sterility mosaic virus* infection in pigeon pea, leaf spot/blight disease in sorghum recorded. Virus suspected plants in wheat and maize were uprooted and incinerated.

World Vegetable Centre (WVC) and Public organization: Chilli (99) and mungbean (37) grown by WVC at ICRISAT field and maize (14) grown at Winter Nursery Centre, ICAR-IIMR, Hyderabad were inspected. Virus suspected plants in chilli and maize were uprooted and incinerated. Downy mildew and *Fusarium* stalk rot incidence were observed in maize.

Private industry: PEQ inspection of crop germplasm (4804 accessions) consisting of barley-142; bittergourd-2 ; chilli-

Fig. 11.1. Facilitation of germplasm conservation in Svalbard global seed vault

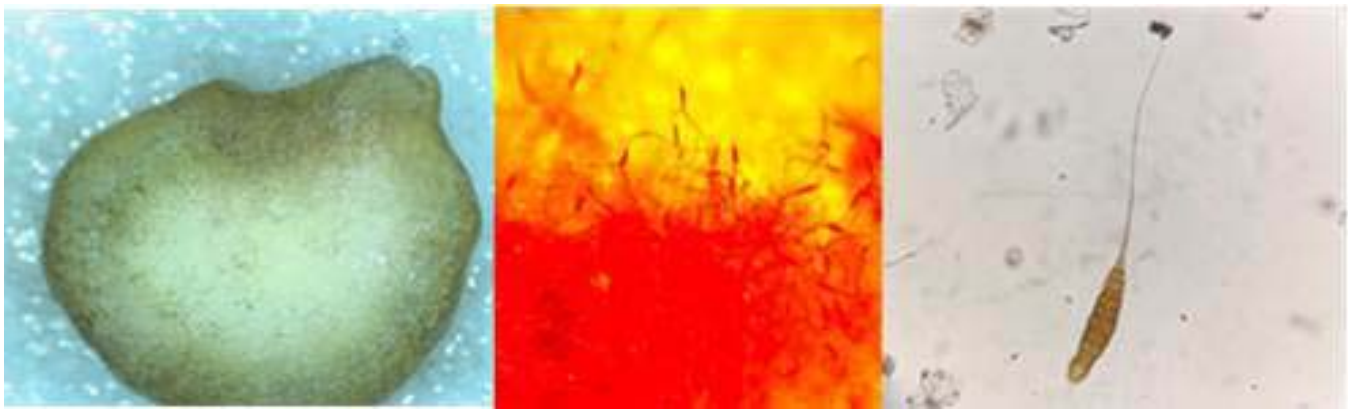


Fig. 11.2. *Alternaria solani* on tomato seed from Taiwan

Fig. 11.3. Weed seed infestation in maize *Chenopodium lenticulare (a)* and *Chenopodium simplex (b)* seeds intercepted in maize from France

944; cucumber-33; maize-2619; muskmelon (36); mustard-226; okra-504; pearl millet (71); pumpkin (29); sorghum (8); squash (1); sunflower (96); tobacco-8; tomato-66; *Vinca* spp.-10; watermelon-3 from USA was conducted at indentors' site.

Major observations were: Maize: *Puccinia polysori* from Brazil; Downy mildew from USA; Pokkah boeing disease from Thailand; wilt incidence from Brazil; **Chilli:** *Tobacco mosaic virus*, tospovirus, chilli leaf curl complex, wilt incidence and black thrips from Taiwan; **Okra:** *Okra yellow vein mosaic virus* from Thailand; **Tobacco:** Leaf curl incidence on all accessions from Brazil and consignment was rejected as the regulations of isolation distance were not followed.

11.6. Germplasm exploration and collection

In September 2023, the Indian Council of Agricultural Research-National Bureau of Plant Genetic Resources (ICAR-NBPGR) and the Indian Council of Agricultural Research-Indian Institute of Horticultural Research (ICAR-IIHR) jointly conducted a germplasm collection expedition focused on *Moringa* species in the districts of Tiruchirapalli, Perambalur, Ariyalur, and Cuddalore in Tamil Nadu, India. This expedition aimed to collect and document genetic diversity within *Moringa oleifera,* a valuable plant species known for their nutritional and medicinal properties. A total of 50 samples from various landraces were collected, including *Naatu murungai, Sem murungai, Kodikal murungai, Pona murungai,* and *Pei murungai*. The survey also resulted in the collection of wild species of *Moringa* known as *Moringa concanensis*.

11.7. Germplasm Evaluation

A total of 625 acc. of different agri-horticultural crops including chilli (32),dolichos bean(30), field bean (23) maize (128), bambara groundnut (59) sorghum (25), black gram (1), green gram (82), browntop millet (22),rice bean (14), foxtail millet (18),finger millet (10), pillipesara (4), brinjal (60) dolichos bean (17) and tomato (100) was grown for characterisation, evaluation, screening and multiplication along with appropriate check varieties during *Kharif* 2023

Fig. 11.4. *Moringa* germplasm collections from Tamil Nadu (A) *Moringa concanensis* From Thuraiyur (B) High yielding elite line (C) Vegetative stem cuttings of Moringa collected from parts of Tamil Nadu

11.8. Germplasm Conservation

11.8.1. Germplasm sent to NGB/GHU

Germplasm of cucurbits and pulses (150 acc.) were sent to GHU for long term conservation in NGB. Germination and seedling vigour were tested in 1,500 accessions comprising of green gram, brinjal, tomato and chillies in the MTS for over 10 years.

12.8.2. Medium Term Storage

Germplasm of different agri-horticultural crops (183 acc.), which were augmented, evaluated and multiplied consisting of black gram (1), green gram (82), tomato (100) were added to the MTS at the station.

11.9. Germplasm Distribution

A total of 677 acc. germplasm acc. of different agri-horticultural crops was distributed to 34 indentor's *viz.*, SAUs/ NGO/ICAR and other institutes.

11.10. Supportive Research

11.10.1. Screening cowpea germplasm for resistance to root-knot nematode

Total 142 cowpea accessions were screened against *Meloidogyne incognita*. Nematode resistance was confirmed in four accession of cowpea (IC381584, IC397455, EC724441 and EC472264) as root galling in these four accessions were 10 galls/egg masses per root system. While, root galling in susceptible check (EC372714, EC244073, EC101981) was >100 galls/egg masses per root system.

Research Programmes (Code, Title, **Programme Leader,** *Associates***)**
Programme I: PGR/PQR-BUR-HYD-01.00: Quarantine processing of plant germplasm under exchange and supportive research (**K Anitha upto 31.05.2023**)
Research Projects (**Code:** Title, **PI,** Co-PI and *Associates***)**
PGR/PQR-BUR-HYD-01.01: Detection, identification and control of pests associated with import and export of seed/plant material (**K Anitha**; Prasanna Holajjer; Bhaskar Bajaru; B Parameswari; L Saravanan)
PGR/PQR-BUR-HYD-01.02: Post-entry quarantine processing of imported germplasm (**Prasanna Holajjer**; K Anitha; Bhaskar Bajaru; B Parameswari; L Saravanan)
Programme II: PGR/PQR-BUR-HYD-02.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of south east coastal zone (**K Anitha upto 31.05.2023**)
Research Projects (**Code:** Title, **PI,** Co-PI and *Associates*)
PGR/PQR-BUR-HYD-02.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of agricultural crops (cereals, millets, pulses, oilseeds etc.) and their wild relatives (S R Pandravada (up to 28.02. 2023); N Sivaraj; P Pranusha; Bhaskar Bajaru; L Saravanan
PGR/PQR-BUR-HYD-02.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of horticultural crops (vegetables, fruits, spices, medicinal and aromatic plants etc.) and their wild relatives (**SR Pandravada** (up to 28.02. 2023); N Sivaraj; P Pranusha; Prasanna Holajjer; B Parameswari; L Saravanan)
Externally Funded Projects
"Documentation and sustainable management of Agro-Biodiversity (Crop Genetic Resources) in Andhra Pradesh through developing diversity databases, crop atlas, GIS mapping and modelling (Project No. 1012783), Funded by Andhra Pradesh State Biodiversity Board, Guntur, Andhra Pradesh (PI: N Sivaraj)
"Network Project on Genetic Enhancement of Minor Pulses, the Regional Station is part of a New Project 'Characterization, Evaluation, Genetic Enhancement and Generation of Genomic Resources for Accelerated Utilization and Improvement of Minor Pulses (Scheme Code: 40003; Project Code: 1010668)", Cooperating Centre, Hyderabad, funded by DBT (PI: Dr K Anitha)
"Pathological and morphological investigations of *Hylocereus undatus*" (Consultancy project) (Scheme Code: 40395-565; Project Code:161141002) funded by Deccan Exotics (FPO) (PI: Anitha Kodaru)
"Development of Recombinase Polymerase Amplification Combined Lateral Flow Dipstick Kits for Rapid Detection of Major Viruses Infecting Sugarcane" (Scheme Code: 40346-564; Project Code: 1611320003) funded by DST-SERB(PI: Dr. B. Parameswari)

12 REGIONAL STATION, JODHPUR

सारांशः जोधपुर स्टेशन पर विभिन्न कृषि फसलों के कुल 1892 जर्मप्लाज्म का रूपात्मक, जैव रासायनिक और जैविक तनाव लक्षणों के लिए लक्षण वर्णन और मूल्यांकन किया गया, जिसमें रबी 2022–23 के दौरान 1042 परिग्रहण और खरीफ 2023 के दौरान 850 परिग्रहण शामिल हैं। विभिन्न बागवानी फसलों के कुल 260 जर्मप्लाज्म का विभिन्न मात्रात्मक और गुणवत्ता मापदंडों के लिए लक्षण वर्णन और मूल्यांकन किया गया। रबी 2022–23 के दौरान मेथी (400), धनिया (200), जीरा (212) और सरसों (230) से संबंधित कुल 1042 अभिगमों का संवर्धित ब्लॉक डिजाइन या दृच्छिक पूर्ण ब्लॉक डिजाइन में लक्षण वर्णन और मूल्यांकन किया गया और आईसीएआर–एनबीपीजीआर द्वारा प्रकाशित न्यूनतम विवरणकों के अनुसार कृषि–आकृति विज्ञान संबंधी चरित्र दर्ज किए गए।

Summary: Total 1892 germplasm accessions of various agricultural crop comprising 1042 accessions during *Rabi* 2022-23 and 850 accessions during *Kharif* 2023 were characterized and evaluated at Jodhpur station for agro-morphological, biochemical and biotic stress traits. Total 260 accessions of different horticultural crops were characterized and evaluated for various quantitative and quality parameters. During *Rabi* 2022-23, total 1042 accessions belonging to fenugreek (400), coriander (200), cumin (212) and mustard (230) were characterized and evaluated in Augmented Block Design/ Randomized complete Block Design and the agro-morphological characters were recorded as per the Minimal Descriptors published by ICAR-NBPGR.

12.1. Characterization and Evaluation of Germplasm

12.1.1. Characterization and Evaluation of horticultural germplasm

During the reporting period, total of 260 accessions of horticultural germplasm comprising of ber (26), karonda (18), aonla (41), phalsa (19), ker (15), bael (19), pomegranate (26), date palm (05), fig (05) and jojoba (86) conserved in FGB, Jodhpur were characterized and evaluated for morphological as well as for biochemical traits. Among ber germplasm wide range of variation was observed in agro morphological and biochemical traits. It was found that IC625863 was superior in term of TSS richness (Fig. 12.1). IC644655 of Karonda was found superior for higher fruit bearing (8 to11 fruits per cluster) and IC 103393 of Ker for higher fruit weight (14 gm).

Fig. 12.1. IC625863 High TSS (24) & Cu (0.16)

Table 12.1 : Promising accessions identified during the year 2023

Crop	Acc.	Characters	Promising accessions
Ber	26	Maturity	IC 625854 (Jan) IC625449 (April)
		Moisture (%)	IC625848 (68.10)
		TSS (>20 ^{0} B)	62586 3(24.0)
		Phenol (>200)	IC 625864 (250)
		Vitamin C (mg/ 100 g)	IC625848 (130)

Characterization of fig germplasm

Total five accessions of fig (*Ficus carica*) were characterized for quantative traits. IC648517 was identified promising in terms of white pulp colour at time of maturity, IC648521 had dark red pulp colour. Variability of leaf characteristics was also studied and it has been observed that diversity was found in term of leaf shape, leaf margin dentation and leaf dimensions (Fig. 12.2).

The results revealed that there was wide variation in fruit length (35.12 to 56.94 mm), fruit width (32.94 to 40.92mm) and no. of fruit per plant (10 to 38).

Characterization of date palm germplasm

Total five accessions of date palm (*Phoenix dactylifera*) were characterized for quantative traits. IC 524156 was identified promising due to its seedless character at time of maturity (Fig. 12.3).

IC 648517 IC 648521

Fig. 12.2. Promising fig accessions identified during 2023

Fig. 12.3. IC 524156 identified promising seedlessness during 2022-23

12.1.2. Characterization and Evaluation of Agricultural Crops

During the *Kharif* season, total 850 accession belonging to moth bean (150), cluster bean (400) cowpea (285) and Kallingda (15) were multiplied and evaluated for agro-morphological traits. The experiments were conducted in Augmented Block Design. During *Rabi* 2022-23, total of 1042 accessions were characterized and evaluated. Crop wise accessions characterized and evaluated in ABD/RBD design were fenugreek (400), coriander (200), cumin (212) and mustard (230) respectively.

Evaluation of fenugreek germplasm for agronomic and biochemical trait

Total 400 accessions of fenugreek were evaluated for agro-biochemical traits. Accession EC510664 was validated for higher number of pods per plant and early days to 50 % flowering; EC510658 was identified for dense foliage; EC 510685 was validated for green- copper colour leaf with high antioxidants value; EC510559 was validated for high protein content in seed (30.0 %) and EC 510705 for high oil content in seed (5.10 %). The fully mature leaves of fenugreek germplasm were also subjected for bio-chemical analysis and EC510559 was found to have higher Ca content (330mg/ 100 gm) (Fig. 12.4).

Screening of fenugreek germplasm against powdery mildew disease

A set of 211 accessions of fenugreek along with four local checks (Rmt-1, Afg-1, Afg-2 and Afg-3) were screened under natural condition for identifying resistance against powdery mildew disease caused by *Erysiphe polygoni*. During the season per cent disease incidence of powdery mildew disease ranged from 2 to 88 % in all the accession. Out of 211 accessions, three accessions (EC 510741, EC 510559, EC 510588) were found resistant and nine accessions (IC-272892, EC-510584, EC-510590, EC-510604, EC-510662, EC-510561, EC-0624520, EC-510576, EC-570708) gave resistant reaction against powdery mildew disease under natural conditions. Thus, these accessions can be used in resistance breeding against powdery mildew disease. All the

Fig. 12.4. EC510559 having higher protein content (30.0 %) & Ca (330mg/100 gm) in seed

Table 12.2: List of promising accession identified during evaluation of germplasm in the year 2023

S. No.	Crops	Characters	Promising accessions
1	Fenugreek	Green purple leaf color No of pod / plant Protein (%) in seed Oil content (%) in seed	EC510685 EC-510664 (88) EC510559 (30.59), EC510722 (29.80) EC510705 (5.10) EC510608 (4.63)
2	Cow pea	No. of branches No. of pod/plant Pod length (cm) No. of seed/pod Pod colour Long peduncle 100 seeds weight (g)	EC-390239 (11.2) IC-349857 (29), EC-101292 (28.8) EC-714298 (24.56), EC-724300 EC-724298 (17.2), EC-724300 (17) IC-333208 (Purple) EC-724380, EC724306 IC 40133 (3.94)
3	Moth bean	Early 50 % flowering Early maturity (Days) No. of pods per plant Number of seeds per pod	IC28156 (30 days), IC14148 (28 days) and IC28155 (27 Days) IC28156 (66) and IC28155 (66) IC28156 (176) and IC28792 (165) IC28792 (9)
4.	Mustard	Flower color Dwarf & early in maturity (< 65 cm & <85 days)	IC426381P5 (White) IC392314 (63 cm, 77days), IC363656 (62cm, 81 days)
5.	Sesame	Flowering (Day) Capsule per plant (>150)	IC 500816 (26 days) IC208657 (75 days) IC023271 (194.00)
6	Cluster bean	Plant height (cm) Days to 80% maturity 100 seed weight (g) Higher no of pod / plant No. of seed/pod	IC421833 (186.48), IC102800 (186.4) IC421839(Branched)IC113295(Unbranched) IC 113224(3.8), IC 113295 (3.63) IC113295 (363), IC140773 (378) IC113305 (11), IC10520 (11)
7.	Cumin	Flower color Early flowering & maturity (Days) Umbel/plant	IC632089 (White) IC640192 (60&107 days) IC574097 (112)
8.	Coriander	Flower color Dwarf & early Dual purpose (Leaf & seed) Stem color Umbel / plant	IC394742 (White) IC589329,IC280063,IC589344 IC406536,IC588579,IC424455 IC 588907 IC033728 (45.4), IC143610 (44.8)
9.	Ber	TSS(°B) (>23) Total phenol (>200)	IC625863 IC 625864

REGIONAL STATION, JODHPUR

S. No.	Crops	Characters	Promising accessions
10.	Ker	Flower colour Fruit weight (>12gm)	IC103395 (Saffron) IC103393
11.	Bael	Shell thickness	IC644661 (< 0.70mm)
12	Karonda	Fruit /cluster (>6)	IC 644655

Fig. 12.5. Fenugreek germplasm accessions EC 510576 showing resistance reaction against powdery mildew disease

other accessions showed various degree of susceptibility to powdery mildew disease (Fig. 12.5).

Screening of mustard germplasm against powdery mildew disease

A total of 102 accessions of mustard including its crop wild relative (CWR) along with susceptible checks were screened under natural conditions for identifying resistance against powdery mildew disease caused by *Erysiphe cruciferarum*. There was heavy incidence of the disease during the crop. Out of 102 germplasm accessions, 15 accessions gave complete resistance reaction and 08 accessions gave resistance reaction against powdery mildew disease. These accessions will be further evaluated under natural as well as artificial conditions of high disease inoculum pressure (Fig. 12.6).

Fig. 12.6. Mustard germplasm accession (IC 399855) showing resistance reaction against powdery mildew disease compared to IC 278023 (Susceptible)

Research Programme (Code, Title, **Programme Leader,** *Associates***)**
PGR/DGC-BUR-JOD-01.00- Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in arid and semi arid regions (**Programme leader: Vijay Singh Meena**).
Research Project: (Code, Title, **PI,** *Co-PI***)**
PGR/DGC-BUR-JOD-01.01-Management of genetic resources of agri-horticultural crops in arid and semi arid regions (**Vijay Singh Meena**; Kartar Singh, Neelam Shekhawat and Kirti Rani)
PGR/DGC-BUR-JOD-01.02 -Evaluation of Agri-horticultural crops germplasm against abiotic stress tolerance in arid and semi arid regions (**Neelam Shekhawat**; Vijay Singh Meena, Kartar Singh and Kirti Rani)
PGR/DGC-BUR-JOD-01.03-Evaluation of Agri-horticultural crops germplasm against biotic stress tolerance in arid and semi arid regions (**Kartar Singh**; Vijay Singh Meena, Neelam Shekhawat, Kirti Rani and Bharat Raj Meena)

13 BASE CENTRE, RANCHI

सारांशः गोड्डा, झारखंड से कृषि जैव विविधता एकत्र करने के लिए एक पादप अन्वेषण किया गया। झारखंड से एकत्र की गई कुल 50 धान (*ओराइजा सेटाइवा*) की भू–प्रजातियों को मूल्यांकित किया गया और गुच्छेदार स्पाइकलेट के साथ एक अद्वितीय जीनोटाइप की पहचान की गई। इसके अलावा, फील्ड जीन बैंक में संरक्षित किए जा रहे कटहल के 90 फलों को परिपक्वता के समय में जैव रासायनिक गुणों के लिए मूल्यांकन किया गया और बेहतर पाये जाने वाले फलो के परिग्रहणों की पहचान की गई। झारखंड के सिमडेगा जिले के कोलेबिरा ब्लॉक में जैव विविधता पर दो प्रशिक्षण और एक दिवसीय किसान जागरूकता कार्यक्रम आयोजित किया गए।

Summary: One exploration was undertaken to collect agro biodiversity from Godda, Jharkhand. A total of 50 paddy (*Oryza sativa*) landraces collected from Jharkhand characterized and a unique genotype with bunched spikelet identified. Besides, 90 accessions of Jackfruit being conserved in Field Genebank evaluated for biochemical traits at ripen fruit stage and accessions with superior performance identified. Two training and one farmers awareness programme on biodiversity organized in Kolebira block of Simdega district, Jharkhand.

13.1. Exploration and Germplasm Collection

13.1.1. Germplasm exploration

Godda district of Jharkhand were explored from 19/03/2023 to 27/03/2023 for agro-biodiversity. A total of 74 accessions representing *Annona reticulata, Amaranthus* spp., *Momordica charantia, Vigna mungo, Lagenaria siceraria, Solanum melongena, Capsicum frutescens, Coriandrum sativum, Vigna unguiculata, Cucumis sativus, Eleusine coracana, Phaseolus vulgaris, Allium sativum, Panicum sumatrense* and *Macrotyloma uniflorum* collected from the region.

13.2. Germplasm Evaluation, Characterization and Multiplication

Characterisation of 50 paddy (*Oryza sativa*) landraces collected from Jharkhand and identified a unique genotype with bunched spikelet were carried out. The genotype (IC0646595) collected from Purulia district of west Bengal,

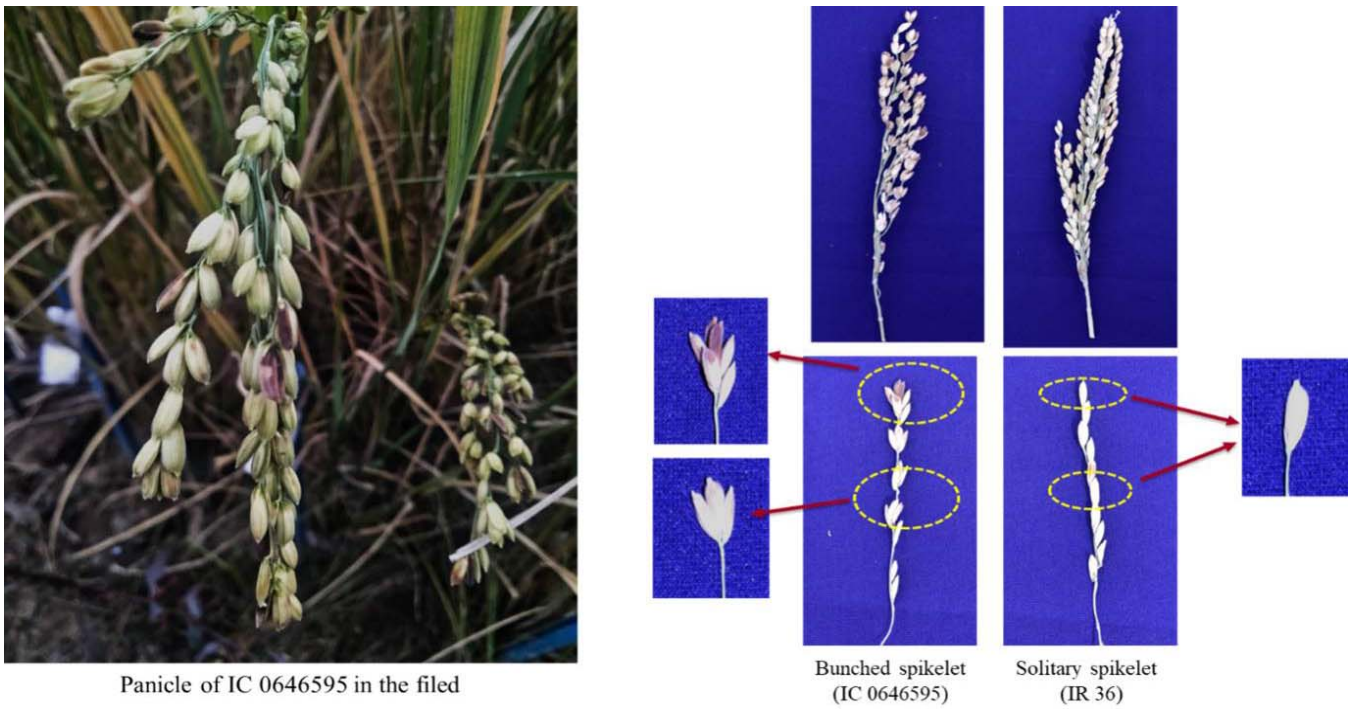


Fig. 13. 1. *Khejurphooli*: A paddy accession with bunched spikelet

Table 13.1: Biochemical performance of 90 Jackfruit (*Artocarpus heterophyllus*) accessions

Sl. No.	Biochemical attribute	H^2	Max	Min	Mean	CV
1	Total Soluble Sugar (°Brix)	0.86	25.1	10	16.95±0.76	15.97
2	Acidity (%)	0.9	0.67	0.17	0.33±0.02	36.97
3	TSS: Acid ratio	0.89	132.5	17.69	59.82±5.39	37.03
4	Total Sugar (%)	0.77	12.2	4.5	6.96±0.49	18.76
5	Reducing Sugar (%)	0.81	7.69	2.24	4.31±0.31	21.86
6	Non Reducing Sugar (%)	0.72	7.23	0.07	2.51±0.43	38.37
7	Phenol (mg GA eq/100 g)	0.9	152.51	29.81	75.15±6.13	34.11
8	Antioxidant activity on the basis of FRAP (mg AEAC/100g)	0.96	167.88	30.93	89.21±4.30	32.93

Note: *H2*: Broad Sense Heritability; *Max:* Maximum; *Min*: Minimum; *Mean*: Grand Mean value; *CV*: Coefficient of variation (%)

India. locally known as "Khejurphooli" attributed to the unique trait and bearing bunched spiklet (Fig. 13.1). Bunching of the spikelet attributed to clustering of florets on tertiary branch of the panicle as revealed during comparative study with the check IR 36. Grain size of the accession is bold.

A total of 90 Jackfruit (*Artocarpus heterophyllus*) accessions evaluated for biochemical traits at fruit ripen stage. Details are mentioned in Table 14.1 Accession number IC 24369 (167.73), IC 24361 (149.06), IC 376161 (143.77) found superior for its antioxidant activity on the basis of FRAP (mg AEAC/100g) assay. While accessions IC 542362 (31.12), IC 24325 (36.53), IC 438850 (37.32) found superior for phenol (mg GA eq/100 g)content.

13.3. Germplasm Multiplication and Maintenance

A total of 617 accessions of fruit/ vegetable/ natural dye yielding plants are being conserved in field genebank of the station (Table 13.2).

About 300 plant species of medicinal and aromatic plants (Annual/Perennial) were multiplied and maintained in Herbal Garden I, II, III and in perennial Field Genebank block. Besides, a total of 254 accessions of *Macrotyloma uniflorum* L. multiplied at the station for LTS.

Table 13.2: Details of accessions conserved in field genebank

S. No.	Crop		No. of accession
	Common name	Botanical name	
1	Jamun	*Syzygium cumini*	52
2	Bael	*Aegle marmelos*	162
3	Jackfruit	*Artocarpus heterophyllus*	238
4	Aonla	*Phyllanthus emblica*	19
5	Banana	*Musa* species	34
6	Lakoocha	*Artocarpus lacucha*	14
7	Mehandi	*Lawsonia inermis*	25
8	Drumstick	*Moringa oleifera*	14
9	Tamarind	*Tamarindus indica*	51
	Total		**609**

Research Programme (Code: Title, **Programme Leader)**
(PGR/PGC-BUR-RAN-01.00): Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in Bihar, Jharkhand and adjoining areas. (PI: **S.B.Choudhary**)
Research Projects (Project Code: Title, **PI, CoPIs and Associates)**
Project-1 (PGR/PGC-BUR-RAN-01.01): Management of PGR of agriculture crops, their wild relatives and economic species including medicinal plants [PI: Dr. S. B. Choudhary; Co-PI: Dr. Shephalika Amrapali]
Project-2 (PGR/PGC-BUR-RAN-01.02): Management of PGR of horticultural crops and perennial medicine [PI : Dr. Shephalika Amrapali; Co-PI: Dr. S.B. Choudhary]
Externally funded project (1014194):*In-situ* Management of Indigenous Crop Diversity for Climate Resilience, Value Addition and Improved Market Access in Jharkhand [Consortium Leader: ICAR-NBPGR PI: Dr. S. B. Choudhary; Co-PI: Dr. Shephalika Amrapali

14 REGIONAL STATION, SHILLONG

सारांश: क्षेत्रीय केंद्र शिलांग ने मेघालय और त्रिपुरा के चार जिलों से दो पादप अन्वेषणों के माध्यम से 12 जेनेरा और 13 प्रजातियों के 81 विभिन्न बहु–फसल जननद्रव्य के संग्रह एकत्र किए। क्षेत्रीय केंद्र में मक्का (404), हल्दी (164), अदरक (63), कोइक्स (128), सोहफ्लांग (28) और राइसबीन (130) जनन द्रव्यों की विशेषता का मूल्यांकन किया गया। फील्ड जीन बैंक में साइट्रस की नौ प्रजातियाँ यानी साइट्रस इंडिका, सी. मैक्रोप्टेरा, सी. लिमोन, सी. लैटिप्स, सी. स्यूडोलिमोन, सी. जम्भिरी, सी. साइनेंसिस, सी. ऑरेंटियम और सी. रेटिकुलाटा स्थापित की गईं। एमटीए के तहत विभिन्न मांगकर्ताओं को तराई धान (*ओराइजा सेटाइवा*) और राइसबीन (*विग्ना अम्बेलटा*) की 96 नमूनो की आपूर्ति की गई।

Summary: ICAR-NBPGR, Shillong station conducted two explorations in Meghalaya and Tripura collecting 81 accessions of various multi-crops germplasm from four districts covering twelve genera and thirteen species. The station has characterized maize (404), turmeric (164), ginger (63), Coix (128), Sohphlang (28) and rice bean (130) germplasm. Established nine species of Citrus i.e. *Citrus indica, C. macroptera, C. limon, C. latipes, C. pseudolimon, C. jambhiri, C. sinensis, C. aurantium* and *C. reticulata* in the field genebank. Supplied 96 accessions of lowland Rice (*Oryza sativa*) and rice bean (*Vigna umbellata*) to various indenters under MTA.

14.1. Germplasm exploration

Two multi-crop explorations were conducted, one in Tripura (Khowai, Dhalai and Gomati districts) and the second in Meghalaya (Ri-Bhoi district). Thirty-five accessions comprising of cereals- upland rice (20) and lowland rice (01); pseudo cereals- fox tail millet (04), Job's tears (01), Sorghum (03); Sesamum (03); yam bean (*Pachyrhizus erosus*, 01) and wild relatives of brinjal i.e. *Solanum indicum* (01) and *S. aethiopicum* (01) were collected from three districts of Tripura. Important collections include two rice landraces Maimi-Nokha and Releng known for medicinal properties and high panicle numbers, respectively. Foxtail millet landrace Maisoi with long panicles and Sorghum landrace Kurumim with black seed colour were collected.

Forty six germplasm accessions of different crops including *Gymnopetalum cochinchinense* (33), *Eriobotrya angustissima* (02), *Solanum* spp. (03), one accession each of *Nicandra physalodes*, *Zanthoxylum armatum*, Chilli, *Sesamum indicum*, *Perilla frutescens*, *Antidesma bunius*, *Spondias pinnata* and *Choerospondias axillaris* were collected. Among the accessions of *G. cochinchinense* collected, variations in morphological characters viz. fruit length, fruit width, fruit weight and ridges/fruit were observed. *Eriobotrya angustissima* (Family - Rosaceae) a wild relative of *E. japonica* (loquat) was collected from two different localities. TSS values were observed to vary between the two accessions where SH/RSR/KCB-2023-1 collected from Umphrew was higher.

14.2. Germplasm Characterization

Maize: A total of 404 accessions of maize were characterized for 16 descriptors along with four checks in augmented block design (ABD). Wide range of variability was observed for characters like plant height (147 cm to 320 cm), ear height (69 cm to 226 cm), tassel length (16 cm to 45 cm), kernel length (6 mm to 10 mm) and kernel width (3 mm to 10 mm). Superior accessions were identified for yield attributing traits like high tassel length in IC624056 (45cm), kernel length (10 mm) in three accession IC526628, IC-623950 and IC62398, kernel width (3.3 mm) in IC411757.

Fig. 14.1. Rice landrace *Maimi Nokha*

Fig. 14.2. Rice landrace *Releng*

Fig. 14.3. Foxtail millet landrace *Masoi*

Fig. 14.4. *Gymnopetalum cochinchinense*

Fig. 14.5. *Eriobotrya angustissima*

Fig. 14.6. *Antidesma bunius*

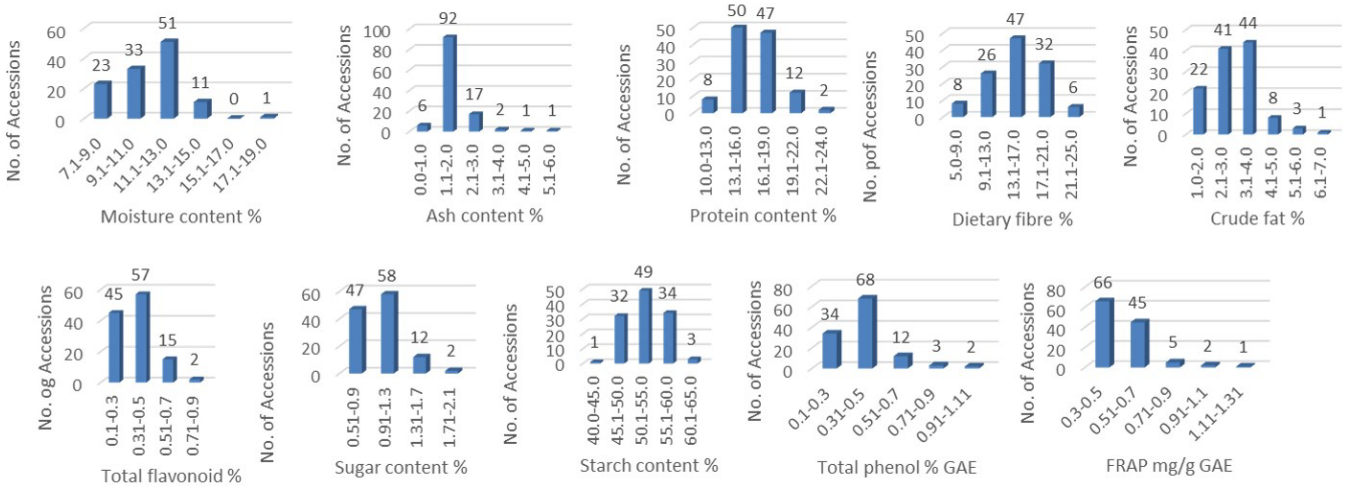


Fig. 14.7. Frequency distribution of Coix accessions based on proximate composition, sugar content, total starch, total phenol content and total anti-oxidant capacity assay

Ginger and Turmeric: The station characterized 164 accessions of turmeric along with two checks in augmented block design (ABD). Superior accessions were identified for number of rhizomes (7.7) in IC280945 & IC22578, single rhizome weight (40g) in IC319396 & IC586756 and high total rhizome weight of 871.7 g in IC330394. In the case of ginger, 63 germplasm were characterized with one check. Accessions with high rhizome length in IC584339 (12 cm), total rhizome weight in IC420560 (7.4 kg) and daughter rhizome weight in IC540381(1.1 kg) were recorded.

Job's tear (*Coix lacryma-jobi*): Twenty agro-morphological traits were studied in 128 accessions and 03 checks of *Coix lacryma-jobi*. Superior genotypes were identified for various traits *viz*. IC416868 for days to 50% flowering (99 days), IC417053 and SH-2021-16 for number of seeds/plant (662, 665), IC618548 for 100 seed weight (17.30g), SH-TM-2020-28 for seed weight/plant (143.33 g) and seed weight/plot (1170 g), IC625388 for seed length (1.2 cm), SH-2021-6 for seed width (1.1 cm), SH-2021-9 for kernel length (0.63 cm), SH-2021-6 and SH-2022-67 for kernel width (0.67 cm).

Biochemical profiling of *C. lacryma-jobi*: Seeds of 119 accessions of Coix were evaluated for proximate composition, total sugar, total starch, total phenols and anti-oxidant potential at Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi. Superior genotypes were identified for various traits viz., IC334314 for high moisture content (14.5%), IC89381 for high ash content (5.64%), IC521339 for high protein content (23.31%), IC521339 for high content of dietary fibre (22.8%), IC591727 for high crude fat content (6.41%), IC486143 for high flavonoid content (0.82%), SH-2022-72 for high sugar content (1.93%), IC540256 for high content of starch (63.7%) and IC374506 for high total phenol content (0.96%). Whereas, IC416824 was identified as a superior genotype for high content of antioxidant capacity based on FRAP assay (1.15 mg/g).

Sohphlang: Twenty-eight accessions of sohphlang were characterised for 17 agro-morphological traits. Superior accessions were identified for various traits IC0627420 for number of tubers/plant (31), IC0627416, IC0627420 for tuber weight/plant (281.67g, 273.33g), IC0627407, IC0627416, IC0627420 for tuber weight/plot (1020 g, 1045 g, 1032 g) and HI/plant (0.91, 0.90, 0.90).

Rice bean: Eleven agro-morphological traits were studied in 130 accessions and 04 checks of rice bean. In addition, preliminary study was also carried out on some important physiological parameters viz. SPAD chlorophyll meter reading (SCMR), leaf temperature, root exudation and root morphology in 34 selected accessions. Root attributes like root morphology and root exudation are reported to be important adaptive traits for acid soils of Meghalaya. In this connection root exudation qualitative assessment were performed using agar plate techniques having pH sensitive dye – bromocresol purple. This dye turns yellow upon acidification in agar media. IC394201 and SH-2020-21 can be identified as superior genotypes for increased root exudation (Fig. 14.8) as these accessions showed more yellowness around rhizospheric root zone, thereby indicating their ability to adapt better to acidic soil by increasing solubilization of fixed phosphorus in acid soil (80-85% of total P). Similarly, IC524464, IC524081, IC140795,

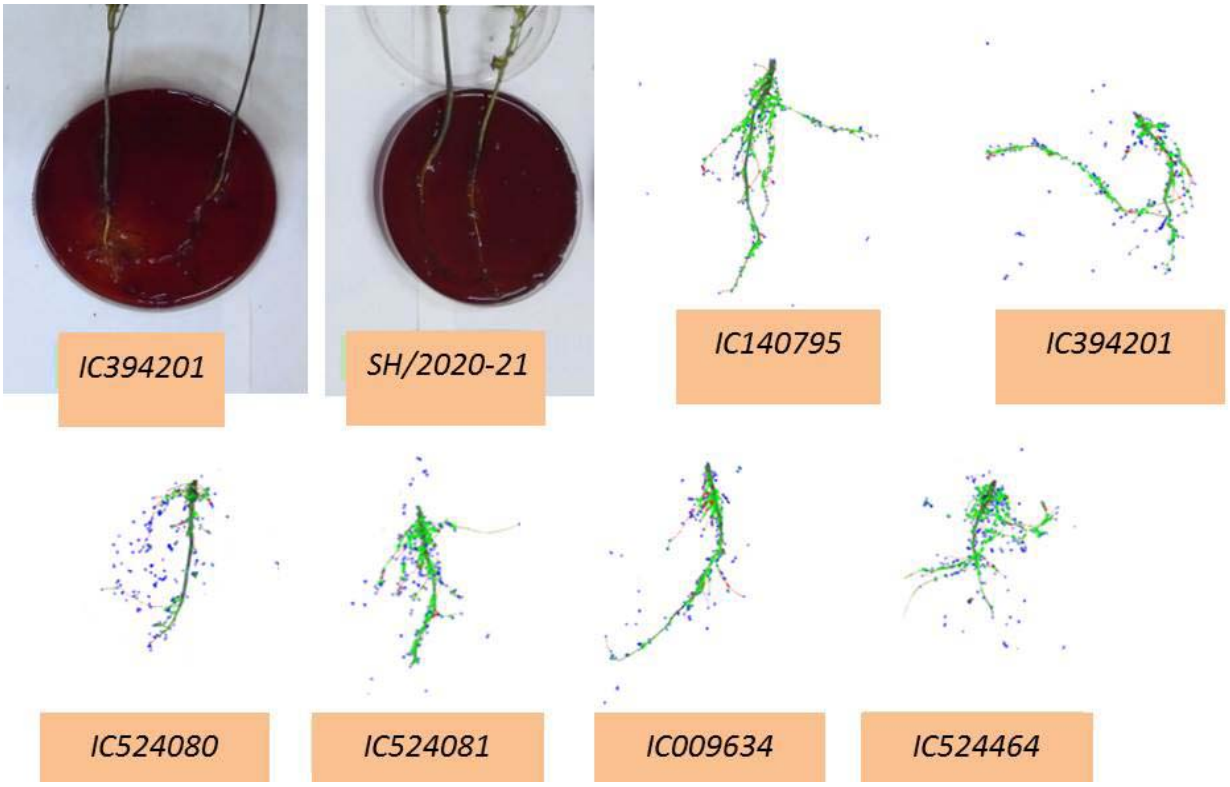


Fig. 14.8. Root exudation and root architecture in some of the selected accessions of rice bean

Fig. 14.9. Regeneration and multiplication of various germplasm collected during PGR awareness programs

IC524080, IC009634 and IC394201 are identified as superior genotypes for root architecture (Fig. 14.8). IC140795, IC394201, IC524080, IC524464 and IC009634 were identified as better performing accessions for the traits- SCMR (30-34) and leaf temperature (25.8-26.8).

14.3. Germplasm regeneration and multiplication

French bean, broad bean, rice bean, chilli and pumpkin germplasm collected during PGR awareness programme were multiplied.

Field Genebank: The station established nine species of Citrus i.e. *C. indica, C. macroptera, C. limon, C. latipes, C. pseudolimon, C. jambhiri, C. sinensis, C. aurantium* and *C. reticulata* in the field genebank.

Supply of seeds: Station supplied 49 accessions of lowland rice (*Oryza sativa*) and 47 accession of rice bean (*Vigna umbellata*) to various indenters under MTA.

Institute Research Projects (Code: Title, **PI,** *CoPIs***)**
PGR/PGC-BUR-SHL-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural crops (paddy–low land/upland, maize and mustard) and their wild relatives. (**PI: Julius Uchoi,** *Co-PI: S Hajong*).
PGR/PGC-BUR-SHL-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of horticultural crops (chilli, ginger, turmeric, yams, taros, citrus, banana and passion fruit) and their wild relatives. (**PI: Julius Uchoi,** *Co-PI: S Hajong*).
PGR/PGC-BUR-SHL-01.03: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of underutilized (UU) crops and their wild relatives. (**PI: S Hajong,** *Co-PI: Julius Uchoi*).
Externally funded project:
(Project no: 1012951, Project code: 16113210009, Scheme code: 40003) Collection, conservation and morpho-phenological characterization of citrus germplasm of NE region. (**PI: Julius Uchoi,** *Co-PI: Harish GD*).
(**Project No. 1011967, Project code: 16113200014, Scheme code: 40004**). Genetic diversity and biochemical profiling of Job's tears (*Coix lacryma-jobi* L.) accession from North East India". (**PI: Subarna Hajong**).

15 REGIONAL STATION, SHIMLA

सारांशः विभिन्न फसलों के कुल 35 विविध जननद्रव्य संग्रह जैसे कि ऊपरी भूमि धान (20), तराई चावल (1), श्री अन्न (7) जॉब्स टियर (1), रतालू (1) तिल (3) और बैंगन के दो महत्वपूर्ण वन्य संबंधि यानी *सोलनम इंडिकम* और *सोलनम एथियोपिकम* भी त्रिपुरा के खोवाई, धलाई और गोमती जिलों से एकत्र किए गए। अनाज ऐमारैंथ (173), बकव्हीट (108), चेनोपॉड (33), फ्रेंच बीन (297) और मटर (159) के कुल 770 परिग्रहणों को कृषि–रूपात्मक लक्षणों के लिए जननद्रव्य लक्षण वर्णन और मूल्यांकन हेतु चित्रित किया गया। डेटा के परिणामस्वरूप अनाज ऐमरैंथ IC38160 (जल्दी पकने वाली फसल), IC338464 (पुष्पक्रम लंबाई), बकव्हीट EC9772203 (जल्दी परिपक्वता), चेनोपॉड IC109249, IC341715, EC359445 (बीज उपजध्यौधा) और EC507733 (जल्दी पकने वाली फसल) में आशाजनक परिग्रहणों की पहचान हुई। इसी तरह फ्रेंच बीन में, प्रमुख जैविक तनावों (एन्थ्रेक्नोज, बीन कॉमन मोजेक वायरस, एंगुलर लीफ स्पॉट, डाउनी फफूंदी, पाउडरी फफूंदी) के खिलाफ 297 जर्मप्लाज्म परिग्रहणों की स्क्रीनिंग के परिणामस्वरूप एन्थ्रेक्नोज (EC24950, EC25504, IC24255, IC361584, IC326623) बीन कॉमन मोजेक वायरस (EC24950, EC24956, EC121013, IC24255, IC41665), कोणीय पत्ती धब्बा (EC18608, EC127645, EC397825, IC37137, IC43557), डाउनी फफूंदी (EC44624, EC129372, EC286091, IC18119, IC37154) पावडरी फफूंदी (EC113166, EC284251, IC18154, IC39067, IC326623) कुछ प्रतिरोधी परिग्रहणों की पहचान हुई, इसके अलावा, बागवानी आनुवंशिक संसाधनों में तीन परिग्रहण अर्थात् EC977548, EC977549 और EC977550 पीले गूदे वाले पाए गए। विभिन्न कृषि–बागवानी फसल प्रजातियों के कुल 533 नमूने सामग्री हस्तांतरण अनुबंध के माध्यम से उनके बुनियादी और साथ ही रणनीतिक अनुसंधान के लिए देश भर में विभिन्न मांगकर्ताओं को आपूर्ति किए गए। समझौते. कृषि क्षेत्र में आनुवंशिक संसाधनों की भूमिका के बारे में कृषक समुदाय को शिक्षित करने के लिए एससीएसपी और टीएसपी कार्यक्रमों के तहत दो पादप आनुवंशिक संसाधन जागरूकता कार्यक्रम भी आयोजित किए गए।

Summary: Total 35 diverse germplasm collections of different crops namely upland rice (20),lowland rice (1), millets (7) job tears (1), yam bean (1) sesamum (3) and two important wild relatives of brinjal *i.e. Solanum indicum* and *Solanum aethiopicum* were also collected from Khowai, Dhalai and Gomati districts of Tripura. As far as germplasm characterization and evaluation is concerned, total 770 accessions of grain amaranth (173), buckwheat (108), chenopod (33), french bean (297) and pea (159) were characterized against agro-morphological characters. The data resulted inthe identification of promising accessions in grain amaranth IC38160 (earliness), IC338464 (inflorescence length), buckwheat EC9772203 (early maturity), chenopod IC109249, IC341715, EC359445 (seed yield/plant) and EC507733 (earliness). Likewise in french bean, screening of 297 germplasm accessions against major biotic stresses (anthracnose, bean common mosaic virus, angular leaf spot, downy mildew, powdery mildew) resulted into identification of some resistant accessions against anthracnose (EC24950, EC25504, IC24255, IC361584, IC326623), bean common mosaic virus (EC24950, EC24956, EC121013, IC24255, IC41665), angular leaf spot (EC18608, EC127645, EC397825, IC37137, IC43557), downy mildew (EC44624, EC129372, EC286091, IC18119, IC37154) powdery mildew (EC113166, EC284251, IC18154, IC39067, IC326623). Further, in horticulture genetic resources three accessions namely EC977548, EC977549, and EC977550 were reported yellow fleshed. Total 533 seed samples of various agri-horticulture crop species were supplied to different indentors across the country for their basic as well as strategic research through material transfer agreements. Two plant genetic resources awareness programmes were also organized under SCSP and TSP heads to educate the farming community about the role of genetic resources in the agricultural sector.

15.1. Germplasm augmentation

Total 35 diverse collections of different crops namely upland rice (20), lowland rice (1), millets (7), jobs tears (1), yam bean (1), sesamum (3) and two important wild relatives of brinjal *i.e. Solanum indicum* and *Solanum aethiopicum* were also collected from Khowai, Dhalai and Gomati districts of Tripura.

15.2. Germplasm characterization and evaluation of agricultural crops

During the reporting period, total 770 germplasm accessions of grain amaranth (173), buckwheat (108), chenopod (33), and french bean (297) were characterized against agro-morphological traits during kharif of 2023 and 159 accessions of pea in the winter season of 2022-23 in the experimental field of ICAR-NBPGR Shimla under Augmented Block Design (ABD) along with standard checks. The characterization data resulted into identification of promising accessions against important traits using the range, mean and coefficient of variation (Table 15.1). In grain amaranth, the mean seed yield/plant was recorded 39.86 g and it ranged from 13.00-129.62 g, which resulted into identification of promising accessions IC383578, IC384400, IC444162. Likewise, inflorescence length ranged from 26.30-78.40 cm and it averaged 49.57 cm. The promising accessions against the character were IC338464, IC35732 and IC274464. The other characters *viz*; days to flowering, maturity and plant height also revealed significant variation in the germplasm and accessions IC38160 and IC38758 were reported promising for earliness (Fig. 15.1).

Table 15.1: Promising accessions identified for important agro-morphological traits

Character	Range	Mean ± SE	CV%	Promising accessions
Grain Amaranth				
Days to flowering	47.00-138.00	97.54±1.37	18.41	IC-38758, IC-38149, IC-38160
Days to maturity	115.00-197.00	175.23±1.22	9.16	IC-38149, IC-38758, IC-38160
Plant height (cm)	88.10-274.40	197.10±2.50	16.7	IC-38397, IC-340823, IC-338464
Infl. length (cm)	26.30-78.40	49.57±0.84	22.24	IC-338464, IC-35732, IC-274464
Seed yield/plant(g)	13.00-129.62	39.86±1.36	44.73	IC-383578, IC-38440, IC-444162
1000-seed wt. (g)	0.30-0.90	0.67±0.01	13.55	IC-38440, IC-274449, IC-274463
Buckwheat				
Days to flowering	26.00-62.00	38.75±0.81	21.76	IC-354481, IC-353948, EC-977202
Days to maturity	86.00-127.00	105.22±1.02	10.03	EC-977203, EC-977202, EC-977208
Plant height (cm)	39.20-132.90	86.20±2.42	29.22	IC-521290, EC-977249, EC-977207
No. of infl./plant	4.33-28.00	11.17±0.48	44.59	EC-977209, EC-977249, EC-977234
Seed yield/plant(g)	0.12-3.60	0.81±0.06	79.29	EC-977203, EC-977202, EC-977250
1000- seed wt. (g)	11.30-36.04	20.22±0.49	25.03	EC-977203, EC-977226, EC-977219
Chenopod				
Days to flowering	55.00-155.00	81.82±2.89	23.59	IC-258254, IC-381106, IC-540842
Days to maturity	117.00-211.00	150.15±3.43	13.88	EC-507733, EC-359451, IC-381078
Plant height (cm)	136.10-276.30	203.47±6.66	19.2	EC-507737, EC-507734, KP/SC-1553
Infl. length (cm)	30.10-62.10	39.50±0.01	16.18	KP/SC-1553, IC-109235, IC-109739
Seed yield/plant(g)	3.03-41.38	18.78±1.69	61.39	IC-109249, IC-341715, EC-359445
1000-Seed wt. (g)	0.11-1.30	0.74±0.04	34.76	IC-540842, EC-507733, IC-341705
Pea				
Days to flowering	62-106	92.05±0.57	7.83	EC-598621, EC-598700, EC-598733
Days to maturity	137-179	160.25±0.64	5.02	EC-598608, EC-598700, EC-598621
Plant height (cm)	43.86-141.73	80.45±1.38	21.68	EC-598720, EC-598667, EC-598646
No. of pods/plant	4.33-20.33	10.33±0.23	28.03	EC-598656, EC-598657, EC-838189
Seed yield/plant(g)	1.61-15.86	6.33±0.20	39.18	EC-598657, EC-838189, EC-598656
100- seed wt. (g)	7.18-27.52	12.05±0.18	18.79	EC-598582, EC-598511, EC-598540

In buckwheat, seed yield/plant showed a wide range of variation from 0.12-3.60g and the average yield was recorded 0.81g. However, significant variability has also been reported in other characters and accession EC977203 was selected promising against early maturity. Likewise in chenopod, variability has been reported in seed yield/plant ranging from 3.03-41.38 g with an average yield of 18.78 g, which also resulted into identification of promising accessions IC109249, IC341715, IC359445. Accession EC507733 has been recorded promising for early maturity (Fig. 15.2).

In pea, seed yield/plant showed wide range of variability ranging from 1.61-15.86g and averaged 6.33g. The genotype EC598657, EC838189, EC598656 exhibited significance for seed yield. The other promising characteristics like days to maturity, plant height, number of pods/plant and 100-seed weight also exhibited remarkable variation that resulted into identification of certain promising accessions against the trait of interest. The germplasm characterization results concluded that selected promising accessions against the target traits (seed yield, seed weight, pod number, earliness, inflorescence length and number of clusters) could be a useful resource for their utilization in crop improvement programmes.

15.3. Screening of French bean germplasm against major biotic stresses

Total 297 germplasm accessions belonging to different countries of their origin including India (61), USA (39), Cali-

Fig. 15.1. IC38160 and IC338464 of grain amaranth identified promising for earliness and inflorescence length respectively

Fig. 15.2. Accession EC507733 of *Chenopodium quinoa* recorded promising for early maturity

Columbia (35), Columbia (31), USSR (26), Brazil (15), Mexico (14), Israel (11), Hungary (09), Nepal (09), Germany (08), Australia (06), Bulgaria (06), Czechoslovakia (05), Turkey (03), Slovakia (03), Holland (03), Belgium (02), Sweden (02), China (02), Liberia (01), W. Germany (01), Canada (01), Romania (01), UK (01) has been screened against various prevailing diseases viz; anthracnose, bean common mosaic virus, angular leaf spot, powdery mildew and downy mildew. The

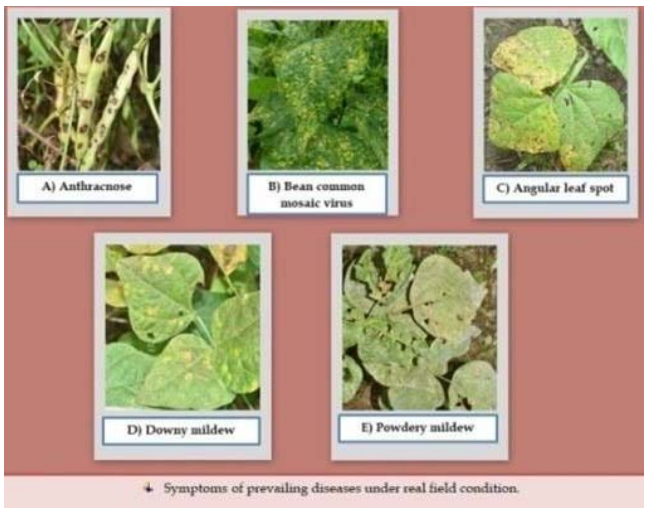


Fig. 15.3. Disease symptoms of major biotic stresses of french bean

REGIONAL STATION, SHIMLA

results revealed some complete resistant accessions against anthracnose resistance (EC24950, EC25504, IC24255, IC361584,IC326623), bean common mosaic virus (EC24950, EC24956, EC121013, IC24255, IC41665), angular leaf spot (EC18608, EC127645, EC397825, IC37137, IC43557), downy mildew (EC44624, EC129372, EC286091, IC18119, IC37154) powdery mildew (EC113166, EC284251, IC18154, IC39067, IC326623). Interestingly, accessionEC24950 has been recorded resistant against anthracnose and bean common mosaic virus and IC326623 against anthracnose and powdery mildew. Reaction of different biotic stresses in germplasm accessions is depicted in Fig. 15.3.

15.4. Characterization of horticultural genetic resources

The kiwifruit germplasm was characterized for various pomological traits. Total 17 germplasm accessions were started giving flowers and five accessions were reported as staminate and EC977572 bears large number of male flowers. The remaining twelve accessions produced pistillate flowers and started bearing fruits. The average fruit length, width, fruit weight, pedicel length and TSS of the fruits are 62.03 mm, 43.63 mm, 69.08 g, 35.96 mm and 14.36°B respectively. The highest fruit weight was recorded in accession EC977549 (107.80 g) and TSS in accession EC977550 (16.2 °B). Three accessions namely EC977548, EC977549 and EC977550 reported yellow coloured flesh and EC977557 with light yellow flesh (Fig. 15.4).

Fig. 15.4. Variability in kiwi flesh colours

15.5. Germplasm conservation

Medium Term Storage: A total of 12,425 accessions of various seed propagating crops are conserved in MTS.

Crop	No of acc.
French bean	4,533
Amaranth	2,956
Buckwheat	994
Pea	705
Wheat	642
Finger millet	410
Ricebean	332
Foxtail millet	278
Chickpea	258
Cowpea	228
Chenopod	199
Adzuki bean	169
Proso millet	160
Horsegram	150
Soybean	144
Paddy	108
Barnyard millet	71
Meethakarela	42
Urdbean	30
Cuphea	16
Total	**12,425**

Field Genebank: A total of 1,023 germplasm accessions of various horticultural crops such as fruits, medicinal and aromatic plants including other economic plants conserved in the field genebank at ICAR-NBPGR Regional Station Shimla.

Crops	Accessions
Apple	241
Peach	52
Pear	87
Plum	49
Apricot	38
Cherry	4
Walnut	115
Hazelnut	20
Pecan nut	50
Almond	11
Kiwi	8
Persimmon	9
Pistacia	1
Chinese ber	7
Hops	2

Crops	Accessions
Citrus	4
Pineapple guava	2
Fig	7
Olive	6
Crataeagus	3
Chest nut	2
Viburnum	3
Rubus spp.	20
Quince	10
Grape	41
Mespilus spp.	2
Mulberry	4
Rose	35
Pomegranate	90
M&AP	27
Ornamentals	51
Other economic plants	22
Total	**1,023**

16.6. Germplasm supply

Germplasm comprising of 500 seed samples of agricultural crops and 33 accessions of pomegranate in the form of scion woods were supplied to researchers/indenters across the country.

- **Seed Crops:** Buckwheat (154), Amaranth (200), Chenopodium (45), French bean (63), Adzuki bean (20), Ricebean (18).
- **Bud sticks/ scion woods:** Pomegranate (33).

Research Programme (Code, Title, **Programme Leader,** *Associates***)**
PGR/GEV/BUR/SHM-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of pseudo cereals, pulses, and other lesser-known hill crops **(Mohar Singh, Rahul Chandora and Narender Negi)**
PGR/GEV/BUR/SHM-01.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation, and distribution of genetic resources of temperate fruits, vegetables and medicinal and aromatic plants. **(Narender Negi and Rahul Chandora)**

16 REGIONAL STATION, SRINAGAR

सारांश: क्षेत्रीय केंद्र श्रीनगर को वर्ष 2023–24 के तहत सौंपे गए तीन अन्वेषण और जननद्रव्य संग्रह कार्यक्रम सफलतापूर्वक कार्यान्वित किये गये। पहला जम्मू के किश्तवाड़ जिले के सुदूर मारवाह–वारवान क्षेत्र से,दूसरा बांदीपुर जिले की गुरेज घाटी और कुपवाड़ा जिले के आसपास के इलाकों से और तीसरा जम्मू के रामबन और रियासी जिलों से। मारवाह–वारवान क्षेत्रों का पहली बार भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो द्वारा अन्वेषण किया गया। अन्य जिलों जिनका उल्लेख यहां किया गया है में भी कई स्थानों का पहली बार अन्वेषण किया गया है। इन अन्वेषणों के दौरान कुल 229 विविध जननद्रव्य परिग्रहण एकत्र किए गए, जिनमें 156 खेती योग्य और 73 वन्य संबंधी शामिल है, जिनमें पहली बार एकत्र किए गए कई दिलचस्प जननद्रव्य परिग्रहण शामिल है। रबी 2022–23 के दौरान न्यूनतम विवरणकों के अनुसार बाकला (41), जौ (47) और गेहूं (39) के एक सौ सत्ताईस (127) जननद्रव्य परिग्रहण को विभिन्न लक्षणों के लिए मूल्यांकन किया गया। सक्षम/संभवित फसलों के प्रति अखिल भारतीय नेटवर्क परियोजना के एक सहयोगी केंद्र के रूप में, रबी 2022–23 के दौरान बाकला की 25 जर्मप्लाज्म और 13 IVT/AVT परिग्रहण का मूल्यांकन किया गया। वर्ष 2021 और 2023 के दौरान TCCU Unit भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो नई दिल्ली से प्राप्त in vitro संरक्षित ब्लैकबेरी जननद्रव्य की पैंतालीस (45) परिग्रहण फील्ड जीनबैंक में स्थापित की गई है। 25 मार्च 2023 को KVK, SKUAST (J) के सहयोग से काजी मोरा,पुंछ जम्मू–कश्मीर में एक ''पादप आनुवंशिक संसाधन जागरूकता शिविर/जैव विविधता मेला'' आयोजित किया गया है, जिसमें महिला किसानों सहित 150 किसानों ने भाग लिया।

Summary: Three exploration and germplasm collection programmes assigned to the station under NEP 2023-24 were undertaken during the year 2023; one from remote Marwah-Warwan region of Kishtwar district of Jammu, second from Gurez valley of Bandipur district and adjoining areas of Kupwara district of Kashmir and third from Ramban and Reasi districts of Jammu. Marwah-Warwan regions have been first time explored by ICAR-NBPGR. Several places in other districts have also been explored for the first time. A total of 229 diverse germplasm accessions were collected during these explorations comprising of 156 cultivated and 73 wild including several interesting germplasm accessions collected for the first time. One hundred and twenty seven (127) germplasm accessions comprising of faba beans (41), barley (47) and wheat (39) were characterized for various traits as per the minimal descriptors during *rabi* 2022-23. As a cooperating centre of AICRN on potential crops, 25 germplam lines and 13 IVT/AVT entries of faba beans (*Vicia faba*) were also characterized during *rabi* 2022-23. Forty five (45) accessions of *in vitro* conserved blackberry germplasm received from TCCU Unit, ICAR-NBPGR New Delhi during the year 2021 and 2023 have been established in the field. One "PGR Awareness camp/ Biodiversity Fair" has been organized under TSP at Qazi Morah, Poonch (J&K) on March 25th, 2023 in collaboration with KVK SKUST-Poonch, in which 150 farmers including women farmers participated.

16.1. Germplasm exploration and collection

Three germplasm exploration and collection programmes assigned to the station under National Exploration Plan (NEP) for the year 2023-24 were carried out successfully and a total of 229 diverse germplasm accessions were collected including 156 cultivated and 73 wild.

Exploration and germplasm collection of potential crops (buckwheat, chenopod, amaranth), minor fruits (*Rosa*, *Rubus*, *Prunus*, *Viburnum*) and MAPs (*Angelica*, *Podophyllum*, *Picrorhiza*, *Rheum* etc.) from Warwan and Marwah regions of Kishtwar district of UT of Jammu & Kashmir: The exploration was carried out with the help of SKUAST-Kashmir during the month of September and a total of 82 germplasm accessions belonging to 27 (15 cultivated & 12 wild) genera and 30 (15 cultivated & 15 wild) species were collected. Warwan and Marwah regions are among the remotest areas and last wildernesses in inner Himalayas of Jammu and Kashmir and have been explored for the first time by ICAR-NBPGR. The maximum number of accessions *i.e.* 11 have been collected in common bean followed by buckwheat (9), maize (7), wheat (6), barley (4) and foxtail millet (4). The region is famous for tasty common beans known as *Madeaw-Wardwan rajma,* mostly with reddish colored medium sized seeds. One short duration ("tripache") common bean accession (SHEIKH-1309) with yellow elongated grains has been collected. Interestingly only bitter buckwheat, *Fagopyrum tataricum* is cultivated in the entire belt. It is locally called as "Trumba" or "Dhrauv". Other notable collections include sea buckthorn (SHEIKH-1238), brown seeded soybean (SHEIKH-1277), grain chenopod (SHEIKH-1282, SHEIKH-1291), awned red rice (SHEIKH-1292) and thornless hawthorn with tasty fruits (SHEIKH-1296).

Exploration and germplasm collection of *Allium* spp. (*atropurpureum*, *astrosanguineum*, *barsczewaskii*, *caesioides*, *chitralicum*, *farcatum*, *oreoprasum*, *gilgitum*) in Kupwara (Neelam valley) and Bandipur districts of Jammu & Kashmir: The exploration was carried out in collaboration with ICAR-NBPGR RS Bhowali and with the help of SKUAST-Kashmir from September 28th

to October 4th and a total 53 germplasm accessions belonging to 26 (23 wild & 03 cultivated) genera and 31 (28 wild & 03 cultivated) species were collected. The maximum numbers of 18 accessions have been collected in genus Allium belonging to 4 species, 3 wild (*Allium consanguineum* - 9 accessions, *Allium auriculatum* - 2 accessions, *Allium farcatum* - 6 accessions) and one cultivated (*Allium sativum*). Cultivated *Allium sativum* collection *i.e.*, SHEIKH/R-1345 is unique single clove garlic. Dried foliage/bulbs of wild Alliums (Local "Pharan" or "Bazun") preferably *Allium farcatum* and *Allium consanguineum* are fondly used for culinary preparations in Gurez. Apart from these Allium collections, other significant collections of medicinal and aromatic plants include SHEIKH/R-1323 and SHEIKH/R-1327 of *Saussurea costus*, SHEIKH/R-1337 of *Lilium polyphyllum* (Local "Noolie"), SHEIKH/R/MAGRAY-1340 of *Polygonatum verticillatum* (Local "Shalamisri") and SHEIKH/R/MAGRAY-1341 of *Bistorta amplexicaulis* (Local "Metchri mool") collected for the first time from the region. Particularly important and significant first time collection is SHEIKH/R-1361 of *Linum perenne* collected from remote and far-flung border Sikander village area of Telail Gurez. Small populations of this valuable CWR of linseed grow on sharp hill slopes. Earlier it has been collected from Ladakh area. Other important collection is SHEIKH/R-1368 of *Physalis alkekengi* collected from Keran area of Kupwara district. Fragmented populations of this medicinal plant can be seen growing wild on hill slopes. It bears smaller fruits compared to that cultivated in Ladakh for ornamental purpose.

Exploration and germplasm collection of minor millets, soybean and other *kharif* pulses, cucurbits, local *Mau-Mangat* Rajmash, buckwheat, amaranth from Reasi and Rambhan districts of Jammu & Kashmir: The exploration was carried out in collaboration with SKUAST-Jammu from September 25th to October 1st and a total of 94 germplasm samples were collected. During this exploration several far flung and difficult to reach areas of Ramban district including Gandhri and Kabbhi were explored for the first time. The germplasm collected during the exploration includes

Fig. 16.1. Interesting Germplasm Collected: SHEIKH-1314 (*Taxus wallichiana*) from Teller Marwah Kishtwar, SHEIKH-1315 (*Elymus nutans*) collected near Margan Top (3529 m) Warwan Kishtwar, SHEIKH/R-1333 (*Atropa belladonna*) collected near Kishan Ganga Dam Gurez, SHEIKH/R/MAGRAY-1338 (*Ribes nigrum*) from Shalput Nalla Gurez, SHEIKH/R-1352 (*Hippophae rhamnoides* ssp. *turkestanica*) from Sheikhpora Telai Gurez and SHEIKH/R-1361 (*Linum perenne*) from Sikander Telail Gurez

Phaseolus vulgaris, *Vigna uniguiculata*, *Capsicum frutescens*, *Cucurbita pepo*, *Lageneria siceraria*, *Cucumis sativus*, *Allium sativum*, *Coriandrum sativum*, *Amaranthus cruentus*, *Trigonella foenum-graecum*, *Momordica charantia*, *Abelmoschus esculentus*, *Solanum melongena*, *Macrotyloma uniflorum*, *Sorghum bicolour*, *Pennisetum typhoides*, *Paspalum scrobiculatum*, *Vigna mungo*, *Sesamum indicum*, *Lupinus angustifolius* and *Spinacia oleracea*. Significant collections include local "Maho-Mangat Rajma" SR/BNM-470 and SR/BNM-471 from Ramban district, Kodo millet (*Paspalum scrobiculatum*) SR/BNM-555 and sweet lupin (*Lupinus angustifolius*) local "Dal" SR/BNM-7 from remote areas in Reasi district.

16.2. Germplasm characterization

One hundred and twenty seven (127) germplasm accessions of fababeans, barley and wheat were characterized for their agro-morphological traits as per the minimal descriptors during *rabi* 2022-23 under rain fed conditions and promising accessions for these traits were identified in each of these crops.

Characterization of local fababean (*Vicia faba*) germplasm: Forty one (41) local germplasm accessions of faba beans (*Vicia faba*) were characterized and evaluated along with three checks (HFB-1, HFB-2 and Vikrant) using randomized block design (Table 16.1).

Characterization of faba bean (*Vicia faba*) genotypes under AICRN Potential Crops: As a cooperating centre of AICRN on potential crops, 25 germplam lines and 13 IVT/AVT entries of fababean (*Vicia faba*) were also characterized during *rabi* 2022-23.

Characterization of barley germplasm: Forty seven (47) germplasm accessions of barley along with two checks Jyoti and DL-36 and thirty nine (39) germplasm accessions of wheat along with four checks Raj-3765, WR-544, HD-2967 and H-240 were characterized for their agro-morphological traits as per the minimal descriptors under rainfed conditions using randomized block design (Table 16.2).

16.3. Germplasm supplied/received

Five (5) accessions of finger millet, proso millet and foxtail millet were supplied to Division of Biotechnology, SKUAST-Kashmir. Small quantities of tubers of fifteen (15) accessions of *Dioscorea deltoidea* were supplied to the Division of Germplasm Evaluation, ICAR-NBPGR for biochemical analysis. Sixteen (16) accessions of multicrop germplam including *Medicago sativa* var. *falcata* (3), *Melilotus officinalis* (4), *Avena sterilis* subsp. *ludoviciana* (1) originally collected from the region were received from ICAR-NBPGR RS Thrissur for multiplication. Thirty seven (37) cryo-preserved accessions of blackberry and blueberry were received from Cryopreservation Unit, Division of Germplasm Conservation for evaluation in the field. Twenty five (25) faba bean (*Vicia faba*) germplasm lines and six (6) entries under IVT/AVT were received from AICRN-PC for evaluation.

16.4. Germplasm conservation

More than one hundred germplasm accessions of agri-horticultural crops including vegetables collected from different parts of Jammu and Kashmir have been conserved under LTS at National Genebank. Forty five (45) mostly cryo-preserved blackberry germplasm accessions have been transferred to the field for maintenance/evaluation.

Table 16.1: Superior accessions identified for some important traits in faba bean (*Vicia faba*)

Trait	Range	Mean	CV%	Best check value	Superior accessions
Pod yield/ plant (g)	38.500 - 178.333	97.902	30.9	68.225 (HFB-1)	IC-0637965 (178.333), SHEIKH/SR-903A(169.067), SHEIKH/SR-906A (160.233), SHEIKH/SR-904 (150.933)
Green seed yield/plant (g)	27.833 - 127.900	63.406	33.2	HFB-1	IC-0637965 (127.900), SHEIKH/SR-906A (112.733), SHEIKH/SR-904 (103.700), SHEIKH/SR-903A(98.433)
Mature seed protein content (%)	20.52 - 23.59	22.19	3.8	21.71 (HFB-1)	IC-0637962 (23.59), IC-0637968 (23.42), IC-0637974 (23.25), IC-0637966 (23.03)
Total phenols (%)	0.17 - 0.20	0.18	4.4	0.18 (Vikrant)	IC-0637966 (0.20), IC-0637978 (0.20), IC-0637967 (0.19), 226527(A) (0.19)
Vicine Convicine content (%)	0.77 - 0.90	0.84	4.6	0.77 (Vikrant)	IC-0637960 (0.77)
100-seed weight (g)	41.118 - 89.966	62.302	23.0	26.713 (Vikrant)	IC-0637978 (89.966), IC-0637962 (88.684), SHEIKH/SR-924 (86.146)

Table 16.2: Promising accessions identified for some important agro-morphological traits in barley and wheat

Trait	Range	Mean	CV%	Best check value	Superior accessions
Barley					
Dwarf plant height (cms)	59.3-117.6	101.6	9.1	94.5(DL-36)	IC-0634056 (59.3), EC-578671 (80.2), EC-50667 (88.0)
Days to 80% maturity	203.5-214.0	208.7	1.1	210.5(Jyoti)	EC-578677 (203.5), EC-0667567 (204.0), EC-578705 (204.5)
No. of seeds/ spike	19.2-48.8	35.3	24.8	40.2(Jyoti)	IC-329137 (48.8), EC-50667 (47.2), IC-445542 (47.0)
Seed yield/ plant (g)	10.970 - 47.970	25.842	33.4	31.390 (Jyoti)	IC-247753 (47.970), IC-138156 (45.230), EC-0667567 (41.190)
100-seed weight (g)	2.900-5.250	3.869	17.4	4.400 (Jyoti)	IC-138120 (5.250), IC-542197 (5.200), IC-138278 (5.150)
Wheat					
Dwarf plant height (cms)	66.0-142.0	107.2	15.6	101.5 (HD-2967)	EC-0520997 (66.0), EC-0521007 (67.9), IC-0591073 (82.3)
Flag leaf length (cm)	16.2-28.5	21.9	11.9	24.1 (Raj-3765)	IC-539315 (28.5), IC-542494 (26.1), IC-0611303 (25.2)
Flag leaf width (cm)	1.0-2.1	1.6	15.5	1.7(WR-544)	IC-539531 (2.1), IC-539315 (2.0), IC-0599622 (1.9)
Days to 80% maturity	175.0 - 216.0	191.7	6.1	179(Raj-3765)	IC-0611303 (175.0), SHEIKH/KP-701 (175.0), IC-574476 (177.0)
No. of seeds/ spike	30.8 - 47.7	36.7	10.2	38.9 (H-240)	KV-6 (47.7), SHEIKH/KP-716 (42.8), IC-0611303 (42.4)
Seed yield/ plant (g)	3.621 - 27.650	15.572	41.8	24.650 (WR-544)	IC-0599622 (27.650), EC-0597850 (26.070), IC-539531 (25.700)
100-seed weight (g)	2.050 - 5.500	3.138	25.7	3.900 (Raj-3765)	IC-0599622 (5.500), IC-0611303 (5.350), EC-0597850 (4.250)

Fig. 16.2. (a) Variability in seed shape, size and color in faba beans (*Vicia faba*), protein content of 20.5 - 23.6% has been recorded in these genotypes; (b) *Prunus tomentosa* in the field with impressive fruit length (1.2 cm), width (1.1 cm), fruit weight (0.865 g) and Brix (16.5%)

Institute Research Projects (Code, Title**, Programme leader,** CoPI**)**
PGR/PGC–BUR-SRI-01: Augmentation, Characterization, Evaluation, Maintenance, Regeneration, Conservation, Documentation and Distribution of Germplasm Resources of various crops from Jammu & Kashmir region (**Sheikh M Sultan**; Susheel Kumar Raina)

17 REGIONAL STATION, THRISSUR

सारांशः मिलेट्स, दालें, तिल और फसल के वन्य संबंधियों के जर्मप्लाज्म के संग्रह के लिए तमिलनाडु में पूर्वी घाट और कलक्कड़ मुंडनथुराई टाइगर रिजर्व (केएमटीआर) क्षेत्रो मे दो पादप अन्वेषण और जननद्रव्य संग्रहण किए गए। तमिलनाडु के पूर्वी घाट (139) और केएमटीआर (38) क्षेत्र से कुल 177 नमूने एकत्र किए गए। कृषि और बागवानी फसलों [कद्दू (29), कटहल (45), कोकम (49), गिनीयन ओकरा (*एबेलमोस्कस कैली*) (24), हल्दी (19) और यार्डलोंग बीन (41)] की कुल 207 परिग्रहणों को विशिष्ट गुणो के लिए मूल्यांकित किया गया। उच्च प्रकंद उपज के साथ हल्दी की दो किस्मों [IC420559 और IC211360] और बहुत जल्दी फूल और परिपक्वता वाले कोकम के चार जीनोटाइप [IC136687–1, IC136687–3, IC552528–1 और IC552528–3] की पहचान की गई। विग्ना और सोलनम प्रजातियों में पादप वर्गीकरण अध्ययन पूरा किया गया। जंगली प्रजातियों से वाईवीएमवी रोग प्रतिरोध को स्थानांतरित करने के उद्देश्य से भिंडी में पूर्व–प्रजनन के एक भाग के रूप में, 34 क्रॉस में सफल बीज सेट हासिल किया गया जिसमें मादा के रूप में भिंडी और नर के रूप में छह अन्य एबेलमोस्कस प्रजातियां शामिल थीं। बैक्टीरियल विल्ट के खिलाफ 183 सोलनम परिग्रहणों की जांच की गई, जिनमें से 13 में इस खतरनाक बीमारी के प्रति 'अत्यधिक प्रतिरोधी' प्रतिक्रिया देखी गई। एमटीएस में कुल 10444 परिग्रहण (110 प्रजातियां) और स्टेशन के एफजीबी में 2204 (448 प्रजातियां) संरक्षित की जा चुकी है, जबकि 197 परिग्रहण (94 प्रजातियां) दीर्घकालिक भंडारण के लिए राष्ट्रीय जीनबैंक में भेजे गए। विभिन्न फसलों पर कुल चार जर्मप्लाज्म जैव विविधता दिवस आयोजित किए गए।

Summary: Two exploration and collection trips were undertaken covering the Eastern Ghats and Kalakkad Mundanthurai Tiger Reserve (KMTR) in Tamil Nadu for the collection of millets, pulses, sesame and crop wild relatives' germplasm. A total of 177 samples were collected from the Eastern Ghats (139) and KMTR (38) area of Tamil Nadu. A total of 207 accessions of field and horticultural crops [pumpkin (29), jackfruit (45), kokum (49), Guinean okra (*Abelmoschus caillei*) (24), turmeric (19) and yardlong bean (41)] were characterized. Two turmeric accessions [IC420559 and IC211360] with high rhizome yield and four genotypes of kokum [IC136687-1, IC136687-3, IC552528-1 and IC552528-3] with very early flowering and maturity were identified. Taxonomic studies were accomplished in *Vigna* and *Solanum* species. As a part of pre-breeding in okra aiming to transfer YVMV disease resistance from wild species, successful seed set was achieved in 34 crosses involving okra as female and six other *Abelmoschus* species as male. Among 183 *Solanum* accessions screened against bacterial wilt, 13 showed a 'Highly Resistant ' reaction to this dreaded disease. A total of 10444 accessions (110 species)were conserved in MTS and 2204 (448 species) in FGB of the station, whereas, 197 accessions (94 species) were sent to National Genebank for long-term storage. A total of four germplasm biodiversity days were conducted on different crops.

17.1. Germplasm Exploration and Collection

Two exploration and collection trips were undertaken covering the Eastern Ghats and Kalakkad Mundanthurai Tiger Reserve in Tamil Nadu.

***A) Eastern Ghats of Tamil Nadu*:** An exploration and collection trip (18.02.2023 to 27.02.2023) was conducted to Erode and Namakkal Districts of Tamil Nadu for collection of millets, pulses, sesame and crop wild relatives' germplasm. On this trip, total of 139 accessions were collected. Unique collections made were as: 1) Foxtail millet (Fig. 17.1) landraces – *Mookanthinai* (farmers harvest only inflorescence), *Koran thinai* (90 days crop) and *chenthinai* (red coloured seed); 2) *Setaria pumila* (syn. *S. glauca*) – a semi-domesticated millet 'korala'; 3) Highly aromatic turmeric (PT/23-137).

***B) Kalakkad Mundanthurai Tiger Reserve of Tamil Nadu*:** An exploration and collection trip (12.12.2023 to 19.12.2023) was conducted in collaboration with Botanical Survey of India, Southern Regional Centre, Coimbatore in this protected area located in Tirunelveli District, for collection of germplasm of crop wild relatives. A total of 38 samples (belonging to 34 species) were collected, the predominant genera being *Piper* (5 spp.), *Solanum* (5), *Syzygium* (3), *Jasminum* (3), *Cinnamomum* and *Meistera* (earlier under *Amomum*) (2 each). Important CWR species collected include *Piper argyrophyllum* (Fig. 17.2), *P. attenuatum*, *P. galeatum*, *Cinnamomum filipedicellatum*, *Curcuma aromatica*, *Sesamum mulayanum*, and *Vigna dalzelliana*. For the first time, *Solanum vagum* and *Bentinckia condappana* having restricted distribution in KMTR were also collected. Trait-specific germplasm includes linear-leaved wild curry leaf and very tall (5 m) growing bird's eye chilli (*Capsicum annuum* var. *frutescens*).

Apart from the above, one short collaborative trip with ICAR-IIHR in Dharmapuri, Namakkal, Virudhunagar and Salem districts of Tamil Nadu for elite wood apple germplasm yielded the collection of scions of eight accessions. In two miscellaneous trips in Tamil Nadu and Kerala, 15 collections were made, important being wild *Musa acuminata* and *Trichosanthes cucumerina* subsp. *villosula* from high ranges of Idukki district of Kerala.

Fig. 17.1. Variability in foxtail millet germplasm collected from Eastern Ghats of Tamil Nadu

Fig. 17.2. *Piper argyrophyllum* (PVKS/23-21), a close relative of black pepper from KMTR region in Tamil Nadu

17.2. Germplasm Characterisation and Evaluation

A total of 207 accessions of horticultural crops [pumpkin (29), jackfruit (45), kokum (49), Guinean okra (*Abelmoschus caillei*) (24), turmeric (19) and yardlong bean (41)] were characterized.

Pumpkin (*Cucurbita moschata*)

Twenty-nine accessions of pumpkin were characterized for morphological traits consisting of 16 qualitative and 09 quantitative traits. Maximum variability was observed in fruit weight (CV 45.54%) followed by fruit length (29.85%) and least in fruit diameter (19.99%). Accession IC599435 showed better performance for thickness of flesh (5.10 cm) against check variety, Saras (3.15) (Table 17.1). Among 16 qualitative traits, only fruit characters (immature and mature fruit skin colour, shape at peduncle and blossom end, shape) exhibited good variation (Fig. 17.3).

Jackfruit

Forty-five seedling-origin jackfruit accessions [38 '*varikka*' (firm-fleshed type), six '*koozha*' (soft-fleshed fibrous type) and one intermediate flesh type (IC91781-1A)] conserved in the FGB have been characterized for 34 fruit and seed descriptors (17 qualitative & 17 quantitative traits). Good variability was observed in qualitative traits, as 12 out of 17 traits with presence of all character states. Whereas, four traits *viz*., fruit shape, fruit rind colour, pulp colour and seed shape exhibited additional character states. The predominance of accessions possessing 'sweet' pulp taste (86.67%) and 'ellipsoid' fruit shape (73.33%) was found among collections. Eleven accessions had 'low' latex exudation and seven had 'excellent' fruit quality. Relatively, a higher proportion of pulp to seed was observed in IC97630-2A (83.4%) and IC645396 (81.46%). Higher TSS of >25° Brix was exhibited by 31 accessions, the highest value being 28.6 °Brix (IC645268, IC97632-2A). Elite accessions identified are IC645394 (early maturing), IC95550-1B (for chips purpose) IC95550-1A, IC95550-2A, IC97628-1A and IC91761-2A (for yield) (Table 17.2).

Kokum (*Garcinia indica*)

Kokum is popularly cultivated in coastal Karnataka as a fruit cum spice crop. In general, fruit maturity of kokum

Table 17.1: Variability parameters of quantitative traits in pumpkin

Character	Min	Max	Mean ± SE	CV (%)	Check
Node number at which first (♀) flower appears	14.00(JB/11-64A)	22.34(IC599437)	19.09±1.41	28.24	20.25
Fruit length (cm)	17.12(JB/11-56A)	26.00(PPT/22-01)	24.71±1.48	29.85	29.60
Fruit diameter (cm)	9.00(PPT/22-01)	22.72(IC599426)	15.60±0.79	19.99	15.01
Thickness of flesh (cm)	2.00(PPT/22-01)	5.10(IC599435)	2.77±0.40	24.32	3.15
Fruit weight(g)	750.00(PPT/23-01)	3562.50(IC395804)	1709.55±18.83	45.54	2475.0
100 seed weight (g)	7.35(JB/11-45A)	17.60(IC599435)	10.52±0.81	24.92	12.93

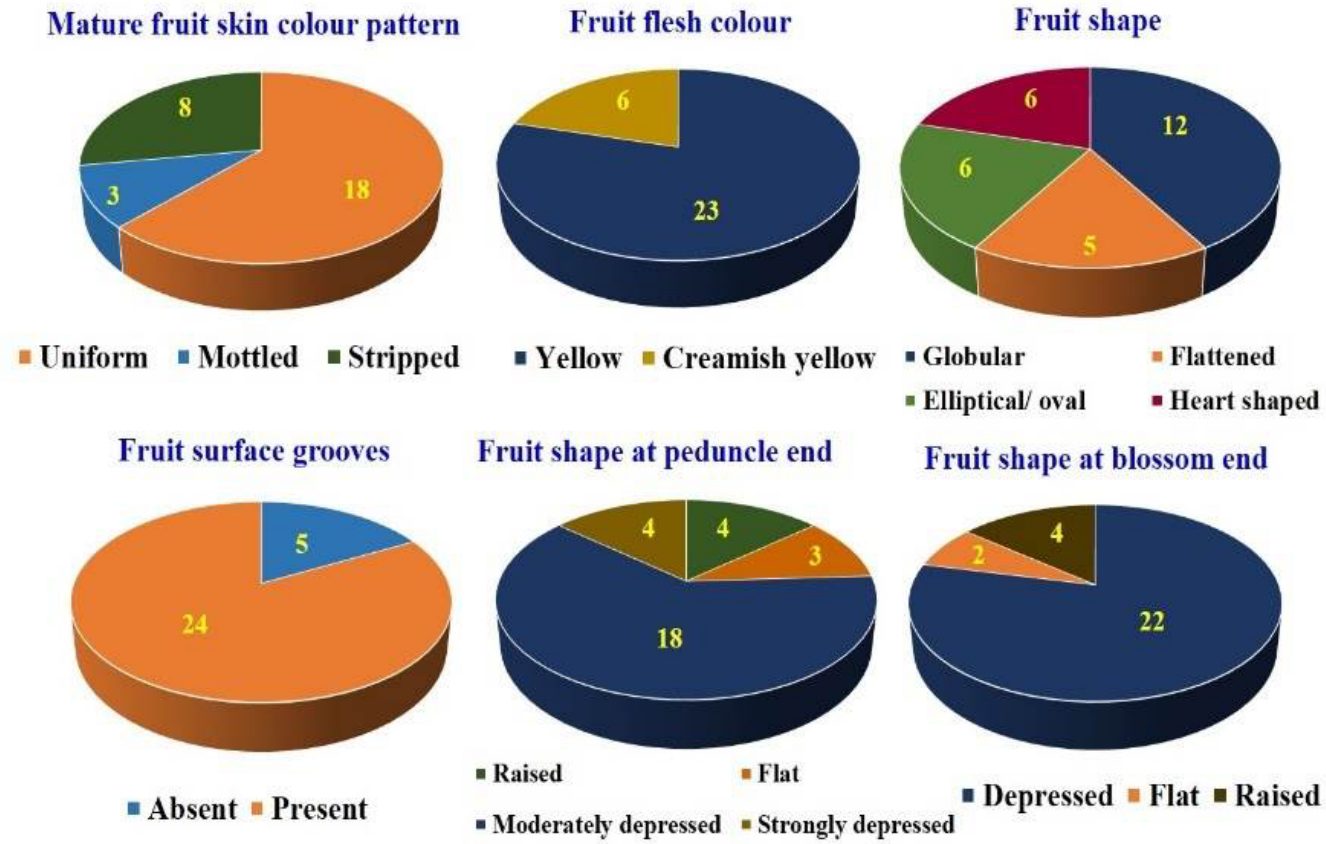


Fig. 17.3. Frequency distribution of qualitative traits in pumpkin germplasm

Table 17.2: Descriptive statistics of quantitative traits in jackfruit

Trait	Min	Max	Mean± SE	SD	CV (%)
Fruit length (cm)	12.95	46.25	34.68±1.10	7.38	21.29
Fruit diameter (cm)	12.10	27.80	21.83±0.45	3.00	13.75
Fruit weight (kg)	0.70	10.93	7.33±0.37	2.51	34.26
Weight of flakes including seed (g)	6.30	45.30	23.37±1.41	9.46	40.49
Flake length (mm)	38.57	77.25	58.80±1.43	9.59	16.31
Flake width (mm)	16.81	44.48	30.67±0.87	5.82	18.97
Flake thickness (mm)	1.39	6.77	2.80±0.16	1.06	37.99
TSS (°Brix)	15.00	28.60	24.52±0.48	3.25	13.25
Seed weight (g)	3.40	11.00	6.55±0.26	1.74	26.60

takes place during the peak monsoon season (July-August) in Karnataka state leading to difficulty in the collection, drying and processing of fruits. Interestingly, in Kerala state, fruit maturity occurs in post-monsoon season (January to March). Hence, this temporal difference in the phenological process may be exploited by kokum industries for the drying and processing of fruits. In the study conducted on fruiting behaviour of kokum at Thrissur [49 acc.; 75% from Karnataka state alone], four acc. (IC136687-1, IC136687-3, IC552528-1 and IC552528-3) were found to be extra early in fruiting (January 1st week).

Guinean okra (*Abelmoschus caillei*)

Twenty-four accessions of *A. caillei* (both indigenous and exotic) were characterized using six quantitative and three qualitative characters. Fruit surface was velvety in 21 out of 24 accessions, rest with bristle hairs [one in whole fruit (EC930800) and two on ridges only (EC930819 and

Table 17.3: Variability parameters of quantitative traits in *Abelmoschus caillei*

Character	Range	Mean	CV (%)
Fruit weight (g)	12.50 (LSV/21-20) - 60.00 (EC930800)	39.48	26.21
Fruit length (cm)	9.45 (EC930819) -15.10 (MAN/18-1)	12.63	14.06
Fruit diameter (cm)	2.10 (IC469550) -4.70 (EC930820)	3.16	21.11
No. of ridges	5.00-10.00 (EC930804, EC930820)	7.69	16.48
Fruit stalk length (cm)	1.40-3.00 (EC930827)	2.34	14.27
No. seeds/fruit	25.50-92.00	60.56	26.62

EC930820)]. The number of accessions that showed green-coloured fruits and those with fruit surfaces with red/ purple patches as 6 and 18, respectively (Table 17.3).

Turmeric (*Curcuma longa*)

Nineteen accessions identified with high curcumin content in 2022 (at Shillong) were subjected to morphological evaluation for 16 quantitative and 11 qualitative characters. Experiment was conducted in augmented block design with five checks namely, Sona, Varna, Sobha, Megha and Lakadong. Nine economically important yield contributing characters showed significant variation among accessions except rhizome length and width on the basis of PCV (%). Among the qualitative characters studied, wide variability was observed only in the rhizome inner core colour (Fig. 17.4).Two accessions [IC420559 (770.76g), IC211360 (559.25g)] were identified with high rhizome yield (Table 17.4).

Yard longbean (*Vigna unguiculata* subsp. *sesquipedalis*)

Forty-one collections of yard long bean (constituted those from recent explorations and landraces from farmers) were characterized for 19 morphological traits in a Randomized Block design. Extensive variability was observed in single pod weight (PCV 59.58%), number of pods per cluster (22.66%), 100-seed weight (22.31%) and days to 50% flowering (20.91%) (Table 17.5). A peculiar landrace *Karkoondal* (meaning long as tress) having a mean pod length of 78.12 cm and with less mean number of seeds (8.8 nos.) was a notable one. Variability was found only in three qualitative characters (immature pod colour, seed crowding and seed colour), out of eight studied (Fig. 17.5).

Poly-embryonic study in mango

A total of 36 acc. of mango germplasm conserved in FGB were studied for their germination and poly-embryonic

Fig. 17.4. Rhizome variability in curcumin-rich turmeric germplasm

Table 17.4: Range of variation for quantitative traits in turmeric

Characters	Range	Mean	PCV (%)	CD(5%)	Best check
No. of mother rhizome	1.33-7.50	3.79	40.23	2.68	4.93 (Megha)
No.of 1^0 rhizome	7.80-32.0	14.10	51.01	10.21	15.34 (Varna)
No.of 2^0 rhizome	4.0-45.20	15.30	60.99	17.61	26.47 (Varna)
Rhizome length (cm)	10.50-15.38	12.83	11.7	4.21	13.92 (Sona)
Rhizome width (cm)	15.37-24.17	18.59	21.71	4.93	21.19 (Varna)
Rhizome weight (g)	200-770.76	358.57	38.69	230.31	428.70 (Sona)
Weight of mother rhizome (g)	31.66-220.0	123.10	50.39	83.36	174.00(Megha)
Weight of 1^0 rhizome (g)	74.0-364.0	159.66	42.86	130.31	375.90 (Varna)
Weight of 2^0 rhizome (g)	20.66-250.0	78.13	75.82	109.17	126.53 (Sona)

Table 17.5: Variability parameters of quantitative traits in yard long bean

Characters	Mean	Range	SD	PCV%
Days to 50% flowering	64.24	36.00-95.00	13.43	20.91
Leaf length (cm)	14.45	11.16-16.46	1.43	9.86
Leaf width (cm)	9.7	6.84-11.86	1.1	11.36
Number of pods/cluster	1.79	1.20-3.20	0.41	22.66
Number of seeds/pod	16.36	8.80-19.80	1.97	12.03
Peduncle length (cm)	32.18	21.82-45.90	5.83	18.10
Pod length (cm)	36.86	16.90-78.12	16.75	15.45
Single pod weight (g)	19.46	10.00-50.00	11.59	59.58
100 seed weight (g)	15.8	10.42-22.20	3.53	22.31

Fig. 17.5. Variability in yardlong bean germplasm; Right: Landrace *Karkoondal*

behaviour. Good germination was observed in IC470624 (96%), IC202216 (90%) and IC470615 (86%). Fourteen accessions exhibited mono-embryony while the remaining had varying levels of poly-embryonic expression. The highest expression of polyembryony was observed in IC470653-A (41.7%) (Fig. 17.6) followed by IC470619 (37.5%), IC470632 (36.4%) and IC470616-A (33.3%)with three or more seedlings from germinating stones.

Fig. 17.6. Poly-embryonic mango accession IC470653-A

Screening germplasm of brinjal and its related species to bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* is one of the most devastating diseases of brinjal causing 11-100% yield losses throughout India, particularly severe in high rainfall area of western and southern coastal states & in North-eastern states. A total of 183 accessions of brinjal and its wild relatives including checks Arka Keshav, Neelima and Haritha were screened against this pathogen. About one-month-old transplanted seedlings were inoculated with 50 ml of bacterial culture containing 1 x 10^7cfu/ml through soil

drenching. One-third root system of each cultivar was slightly injured by inserting a sharp sterilized knife about 2 cm away from the collar region before drenching to facilitate penetration of the bacterium (Fig. 17.7). The plants showing symptoms were examined and confirmed using ooze test. Observations on bacterial wilt incidence were recorded at an interval of 10 days till harvesting and percentage disease incidence (PDI) was calculated at the harvest stage. Based on the PDI, the accessions were categorized as highly resistant to highly susceptible using 0 to 5 scales. Thirteen accessions [IC383102, IC255748, IC255708, IC89906, IC636521, IC624240, IC624237 (*S. melongena*); IC638984, IC641418 (*S. insanum*); IC618024, IC624241, IC618026 (*S. aethiopicum*) and IC624213 (*S. violaceum*)] showed 'Highly Resistant' reaction to bacterial wilt along with two checks (Haritha and Neelima).

Fig. 17.7. Inoculation of bacterial culture at the collar region of the one-month-old brinjal

17.3. Taxonomic & prebreeding works

Vigna

Taxonomic databases often synonymize *V. trinervia* (B.Heyne ex Wight & Arn.) Tateishi & Maxted with mung bean, *V. radiata* (L.) R.Wilczek. Our analysis on protologue, type specimen and field studies clearly distinguished former species from the latter in terms of habit (twinning vs erect), flower colour (bright yellow vs pale greenish yellow), seed (rectangular, maroon to brown vs elliptic-oblong, shiny green to pale brown) and hilum characters (linear, 1.5-2.00 mm long vs oblong, <1.5 mm long), therefore suggesting to reinstate its species status. Key characters distinguishing two poorly studied endemic species closely related to mung bean namely *V. hainiana* Babu, Gopin. &S.K.Sharma and *V. subramaniana* (Babu ex Raizada) Raizada were also worked out.

Pre-breeding in okra

In order to transfer genes conferring resistance/ tolerance to YVMV and ELCV diseases, inter-specific hybridization was attempted between *A. esculentus* (*cv*. Arka Anamika, Pusa Sawani, Parbhani Kranti, Salkeerthi and Ruchi) as female parents and six other *Abelmoschus* species. Crossed

Fig. 17.8. Advanced *Abelmoschus* amphidiploids with okra-like morphology a. AM23 × AM6 (Derivative 5); b. AM23 x AM6 (Derivative 11); c. *A. esculentus* cv. Ruchi x AM25; d. AM23 x AM6 (Derivative 14)

seeds were obtained in *A. esculentus*× *A. tuberculatus* (06 cross combinations), *A. esculentus*× *A. enbeepeegeearensis* (06), *A. esculentus*× *A. caillei* (01), *A. esculentus* × *A. ficulneus* (02), *A. esculentus* × *A. tetraphyllus* (01), *A. esculentus* × *A. moschatus* (18). New amphidiploids were developed in 04 crosses involving *A. esculentus* × *A. tuberculatus* (15 derivatives), *A. esculentus* × *A.* sp. nova (31 derivatives), *A. esculentus* × *A. manihot* (35 derivatives), and *A. esculentus* × *A. pungens* var. *mizoramensis* (08). Generation advancement and seed multiplication were done for 33 advanced amphidiploid derivatives. Amphidiploid cross derivatives of AM23* × AM6**(3 nos.) and Ruchi × AM25*** with okra like morphology (Fig. 17.8) will be worth screening against the above diseases. Thirty-five F_1 cross derivatives with ornamental value were developed between both direct and reciprocal crosses involving *A. moschatus* and *A. sagittifolius* and one involving *A. sagittifolius* and *A. crinitus*. The average number of seeds per fruit in F_1 derivatives ranged from 3-10. Seed development was observed only under assisted hand pollination. Seeds were harvested for studying the segregation pattern in F_2 generation.

(*AM23: Arka Anamika × *A. angulosus* var. *grandiflorus* IC613527; **AM6: *A. esculentus*IC265657 × *A. pungens* var. *mizoramensis* IC0624222; ***AM25: *A. esculentus* IC265657 × *A caillei*)

Solanum

Published work on enumeration of Indian Solanums is still at large since 1980, although piecemeal information does exist for this economically important crop genus. Based on germplasm collections from all over the country, herbaria visits (5 herbaria), consultation in the GBIF database and relevant online herbaria/portals, experimental study of germplasm collections, as well as analysis from literature, a total of 68 species (72 taxa) representing 23 native/wild, 15 naturalised, 22 casually cultivated/introduced, and 5 crop species were documented in India from this study. Preliminary studies point out to the occurrence of African elements - *S. incanum* L., *S. anguivi* Lam., and *S. coagulans* Forssk. in India; the same were not included in the recent publication emanated from PBI *Solanum* Project. Experimental studies on *S. aethiopicum* L. collections from NE India reveals presence of parallel variation (for >10 traits) in this minor vegetable with the related brinjal crop. In case of wild relatives, *S. insanum* L. and *S. violaceum* Ortega exhibited diverse morphological variation across the distribution ranges. These studies have also helped to work out updated synonymy (e.g., *S. kurzii* synonymized under *S. violaceum*) and distribution (including new reports), correcting misidentifications and developing field identification keys.

Sesame

A total of 25 distant cross combinations comprising sesame (5 parents) with four species – *Sesamum latifolium*, *S. angustifolium*, *S. triphyllum* and *S. alatum* were made, out of which, capsule/seed set was achieved in 19 cross combinations. Seed multiplication and characterization of 122 wild sesame (*S. mulayanum*, *S. malabaricum*, suspected natural introgressions) germplasm was accomplished for 47 descriptors. A confirmatory field trial on earlier identified 20 primary genepool accessions for phyllody tolerance was conducted during February 2023 as the summer season is favourable for vector buildup and disease progress. It was found that only three accessions (IC280497, IC248155 and IC032096) had the disease incidence below 25 per cent. Experiments in progress include advancing 14 F_3 generations of wide hybrids of sesame (involving *S. mulayanum* and *S. malabaricum*) and 11 F_2 generations of wide hybrids (involving suspected variants and *S. mulayanum*) and simultaneously screening for tolerance to phyllody, besides other important agronomic traits (determinate types, mono-stem/shy/high branching, 3 capsules/node, multilocular capsules, more no. of capsules/plant, early maturity, low capsule shattering, smooth seed-coat, high seed yield/plant). Need-based works on backcrossing and colchiploidisation are also carried out.

Okra

Seed multiplication and regeneration were undertaken for 207 accessions involving 12 *Abelmoschus* species [*A. enbeepeegeearensis* (02), *A. angulosus var. grandiflorus* (56), *A. caillei* (26), *A. ficulneus* (11), *A. pungens* var. *mizoramensis* (13), *A. tetraphyllus* (45), *A. moschatus* (24), *A. tuberculatus* (08), *A. sagittifolius* (01), *A. pungens* (05), *A. crinitus* (02), and *A. esculentus* (14)]. Crossability studies were done in 72 cross-combinations involving seven *Abelmoschus* spp. (5 wild - *A. tuberculatus*, *A. enbeepeegeearensis*, *A. ficulneus, A. tetraphyllus* and *A. moschatus* and two cultivated - *A.esculentus*, *A. caillei*) and the crossed fruits were harvested, seeds extracted and stored for further studies.

17.4. Germplasm Conservation and Regeneration

MTS: A total of 10444 accessions belonging to 110 species comprising cereals (3123), millets (138), oilseed (49), pulses (3040), vegetables (3224) and crop wild relatives (870) were conserved in the MTS facility of the station. Besides, a total of 1623 accessions of wheat germplasm from IARI RS, Wellington are also maintained.

Field GeneBank: A total of 2204 accessions in 448 species are being maintained in field and pots under the shade, net, mist and poly houses (Table 17.6).

Table 17.6: Field genebank holdings at Thrissur station

Crops	Acc.	Crops	Acc.
Fruits	**450**	*Curcuma* spp.	88
Mango	133	*Piper* spp.	79
Jackfruit	184	*Garcinia* spp.	66
Indian gooseberry	37	**M & A Plants**	**257**
Musa spp.	23	**Other econ. imp. spp.**	**374**
Citrus spp.	46	**Tubers**	**164**
Artocarpus spp.	27	Taro	75
Spices	**906**	Elephant foot yam	25
Turmeric	146	Greater yam	7
Black pepper	92	*Dioscorea* spp.	39
Malabar tamarind	273	*Amorphophallus* spp.	18
Kokum	95	**Vegetables**	**53**
Curry leaf	47	Teasel gourd	12
Zingiber spp.	20	Drumstick	41

On-Farm Conservation: Twenty accessions of *Amaranthus tricolor* were distributed to Utopia Sustainable Society, Vaikom as well as farmers of Irinjalakuda locality, Thrissur (through Asst. Director of Agriculture, Irinjalakuda) as part of promoting agro-biodiversity conservation in farmers' fields. Seeds of 21 accessions of brinjal were received back from farmers as a part of last years' on-farm conservation activities. Supplied 31 samples of different crops (13 landraces of *Dioscorea alata*, 11 of yard long bean, six of brinjal and one of sweet gourd) to a farmer Conservator, Kannur Dist., Kerala.

Mr. ER Vinod, a custodian farmer of RS Thrissur, has received National Plant Genome Saviour Award -2023 (Category-Individual) for conserving primitive and rare landraces of tubers and other horticultural crops. He conserves tapioca (58 types), taro (89) and greater yam (43), ginger (16), turmeric (14), banana (25), mango (15) and jackfruit (14) (Fig. 17.9).

Fig. 17.9. Shri ER Vinod, a custodian farmer of RS Thrissur, receiving Plant Genome Saviour Award

Seed multiplication: A total of 373 samples (25 of *Cucumis sativus* and 40 of wild *Cucumis* spp., 153 of *S. melongena*, 42 of wild *Solanum* sp., and 113 samples of various agri-horticultural crops) were multiplied, besides 23 exotic wild rice germplasm (*Oryza latifolia*, *O. grandiglumis* and *O. australiensis*).

17.5. Germplasm Exchange

Supply to user agencies: Under Material Transfer Agreement (MTA), 1251 accessions of germplasm of various crops/ species were supplied to 28 user agencies, comprising 3 ICAR institutes (256 acc.), 24 State Agricultural Universities (852) and 4 other agencies (14).

Supply for Long term storage: A total of 197 accessions belonging to94 species (under 48 genera) were sent to National Genebank for long term storage.

Supply for In-vitro/ Cryopreservation: Thirteen accessions belonging to 12 species were sent to TCCU for in-vitro/ cryopreservation.

Research programme (Code, Title**, Programme leader,** CoPI**)**
PGR/ DGE-BUR-THR-01.01: Plant Genetic Resources Management of field crops and their wild relatives. **M Latha,** K Pradheep,PP Thirumalaisamy, K Venkatesan,Suma A, S Mani (till 28.02.2023) and A Indiradevi
PGR/ DGE-BUR-THR-01.02: Plant Genetic Resources Management of vegetables, tropical tubers and their wild relatives. **Suma A,** M Latha, K Pradheep, PP Thirumalaisamy,K Venkatesan, S Mani (till 28.02.2023), and A
PGR/ DGE-BUR-THR-01.03: Plant Genetic Resources Management of spices, fruit crops and their wild relatives, medicinal and other economic plants. **K Pradheep**, M Latha, PP Thirumalaisamy, K Venkatesan, Suma A, S Mani (till 28.02.2023), and A Indiradevi

18 AICRN ON POTENTIAL CROPS

सारांश: खरीफ 2022 और रबी 2022–23 के दौरान तीस स्थानों पर कुल 295 प्रयोग आवंटित किए गए थे जिनमें पीजीआर प्रबंधन (98), फसल सुधार (115), फसल उत्पादन (23), फसल सुरक्षा (14) और गुणवत्ता (45) शामिल थे। दस संभावित फसलों सहित कुल 295 परीक्षणों के आवंटन मे से, पूरे भारत में विभिन्न केंद्रों पर 276 परीक्षण आयोजित किए गए। अनुसंधान उपलब्धियों का सारांश नीचे दिया गया है:

Summary: A total of 295 experiments were allotted at thirty locations during *Kharif* 2022 & *Rabi* 2022-23 which included PGR Management (98), Crop Improvement (115), Crop production (23), Crop protection (14) and Quality (45). Against a total allocation of 295 trials, comprising of ten potential crops, 276 trials were conducted at various centres all over India. A summary of the research achievements is given below:

18.1. Genetic Enhancement for Productivity, Quality and Stress Tolerance

18.1.1. Plant genetic resource management

- During *Kharif* 2022 & *Rabi* 2022-23, 45 accessions of different potential crops were collected through different explorations within the country, and 594 accessions were introduced from abroad. A total of 1256 accessions were evaluated at different AICRN on PC centres and 266 accessions were received and conserved in the National Genebank, while 711 accessions of potential crops were supplied to the indenters for research purposes within the country.
- A total of 1256 accessions (Hills 623, Plains 633) of different crops (some of them tested at more than one location) were evaluated at nineteen locations. The promising accessions identified for various useful traits in different crops are as follows.

  i. *Faba bean (Hills)*: The multi-location performance of faba bean seed yield (q/ha) over two years of testing indicated that the accessions RFBGP-38 (6.12), RFBGP-41 (5.95), RFBGP-31 (5.91), RFBGP-50 (5.73), RFBGP-44 (5.21) are superior to the other entries and checks *Plains:* Seed yield ranged from 14.39 to 29.82 (g/plant). The check HFB-2 (29.82 g/plant), Vikrant (27.98 g/plant) and HFB-1 (27.22 g/plant) were superior to all other entries.

  ii. *Buckwheat (Hills):* The multi-location performance of buckwheat seed yield (q/ha) over two years of testing at five locations indicated that the accessions IC037288 (12.08), IC042413 (10.79), IC037280 (10.51), IC014890 (10.03) and IC037312 (9.2) are superior to check variety Himpriya (8.6) during kharif 2022, seed yield ranged from 2.13 to 18.98 (g). The check Shimla B-1 (18.98 g) was superior to all other entries.

  iii. *Quinoa*: Grain yield per plant under *Hills* conditions ranged from 13.10 to 35.40 (g). The check Him Shakti (35.40 g) and IC447573 (34.00 g) were superior in seed yield compared to other test entries. On the other hand, under the *Plain* conditions, seed yield per plant ranged from 16.47 to 29.49 (g). The entries EC896204 (29.49 g) and EC896133 (26.10 g) were superior in seed yield compared to other test entries and checks. During *Kharif* 2022, seed yield ranged from 0.61 to 35.70 (g). The entries EC896213 (35.70 g), EC896209 (28.54 g), EC896211 (26.15 g), EC896227 (23.74 g) and EC896201 (23.42 g) were superior in seed yield to all the entries and checks.

  iv. *Grain amaranth*: The entries IC038478 (40.45 g), EC289395 (38.60 g), IC313275 (37.09 g), IC035700 (34.05 g) and IC038494 (33.09 g) were superior in seed yield to the check varieties under *Hills*. The check BGA-2 (21.65 g) were superior in seed yield to other entries and check varieties under Plains.

  v. *Winged bean*: The entries EC038823 (63.00 g), IC017009 (30.03 g), IC017006 (29.98 g), IC041980 (27.90 g) and EC142600 (24.60 g) were superior to check variety under plain.

  vi. *Chenopodium album:* Seed yield ranged from 6.19 to 47.60 (g). The entries IC341710 (47.60 g), EC201618 (43.63 g), IC540846 (39.12 g) and NIC22490 (31.56 g) were superior in seed yield to all the entries and checks.

  vii. *Adzuki bean:* The entries IC100072 (15.75 g), EC240251 (15.66 g) and IC108857 (15.13 g) were superior to check variety.

  viii. *Job's tear:* The entry RJTGP-58 (24.24 q/ha) was superior to all other entries.

  ix. *Kalingada*: The entries SKGPK-2004 (4.93 q/ha), SKGPK-2009 (4.75 q/ha), SKGPK-2005 (4.65 q/ha),

SKGPK-2012 (4.63 q/ha) and SKGPK-2006 (4.47 q/ha) in plain were superior to check variety

18.1.2. Crop improvement

- On the basis of varietal trial performance of entries over three years of testing, the best genotype with respect to yield and quality traits were identified during *Kharif* 2022 & *Rabi* 2022-23:

  i. *Faba bean:* Seed yield ranged from 9.15 to 16.92 (q/ha) in case of Hills. The entry HB-18-10 (16.92 q/ha), HFB-1 (16.28 q/ha) were superior to all other entries with high protein content HB-19-10 (22.94%). Under *Plains,* the entry HB-19-14 (23.73 q/ha) is significantly superior over the check for seed yield, whereas, HB-18-10, HB-19-4, HB-19-12 and HB-19-13 were found to be moderately resistant to Alternaria Blight at Ayodhya and Hisar Centre.

  ii. *Quinoa:* The entry RHRCQ-1 (19.04 q/ha) ranked first among all and found significantly superior over the best check with high protein in RHRCQ-1 (13.40%) and oil content in ACQS 21-1 (8.50%) during *Rabi* 2022-23. During *Kharif* 2022, NIC22506 (12.81 q/ha) was higher (107.50%) in grain yield than the best check with maturity duration 99.00 days.

  iii. *Buckwheat:* Seed yield ranged from 4.44 to 7.70 (q/ha). The check PRB-1 (7.70 q/ha) was superior to all test entries.

  iv. *Grain amaranth (Hills):* VL-140(16.86 q/ha) was higher (22.78%) for grain yield than the best check with high protein (13.88%) and oil (8.31%) contents.

  v. *Adzuki bean:* IC469174 (11.13 q/ha) was higher (29.72%) for grain yield than the best check with protein (21.90%).

  vi. *Perilla:* IC6155369 (11.15 q/ha) was higher (36.64%) for grain yield than the best check with high protein (18.41%) and oil (39.86%) contents.

- **Fresh Crosses**–Total 32 fresh crosses were made in grain amaranth. The centre-wise distribution of these crosses were Ambikapur (10), Bengaluru (2), Ranchi (10) and Mandor (10). Similarly, 59 fresh crosses were attempted in faba bean including Ambikapur (10), Hisar (24), Ludhiana (13), Palampur (2) and Ranchi (10). The fresh crosses were also made in *C. quinoa* at Mandor (16); buckwheat at Palampur (6); spine guard at Ambikapur (20); winged bean at Ambikapur (5) and Ranchi (5); kalingada at S.K. Nagar (5), Mandor (21) and in adzuki bean at Palampur (8) using diverse genotypes identified by different centres.

18.1.3. Quality analysis

- During *Rabi* 2022-23, a total of 58 entries from different crop improvement trials and 172 accessions from germplasm trials were analysed for crop-specific quality traits, while during *Kharif* 2022, a total of 304 genotypes including 76 varietal trials material and 228 germplasm accessions of different potential crops namely Amaranth (hills and plains), buckwheat, *Chenopodium quinoa* and *C. album*, perilla, kalingda, adzukibean, wingedbean and job's tear were analysed for various quality traits at New Delhi, Hisar and Palampur centres. The important findings include:

  i. In grain amaranth, AVT-I entry SKNA1804 had the highest protein content (13.28%) whereas AGA-20-2 had the highest oil content (8.0%) along with high lysine content (5.20 g/16g N). Four AVT-II entries SKNA-1407, RMA- 062, BGA-21 and RMA- 120 had lysine content >5.0 g/16g N with 5.43, 5.28, 5.14 and 5.00 g/16g N. During *Kharif* 2022, Amaranth (plains) AVT-II entry SKGPA-146 had protein content (14.11%) and lysine content (5.45 g/16g N).

  ii. Faba bean (plains) AVT-I entries viz. RFB-40 (25.31%), RFB-40 (24.58%) and RFB-37 (24.02%) had protein content more than 24.0%. AVT-I entry RFB-40 also had the lowest phenol content with 0.16%. Faba bean (plains) germplasm (second year) Set-I, genotype RFBGP-26, (29.13 and 0.15%), RFBGP-29 (26.50 and 0.16%) and RFBGP-41(26.50 and 0.15%) were found superior for protein and low phenol content, respectively.

  iii. Quinoa (plains) AVT-I entry EC896275 had high protein (13.12%), oil (8.03%) and Zn (1.97 mg/100g) contents. AVT-II entry EC896219 had the highest protein content (13.50%) whereas entry EC896218 had high protein content (13.35%) as well as high oil content (8.26%).

  iv. Buckwheat AVT-I entry IC047929 had protein and phenol content 14.13% and 0.33% respectively.

  v. *C. album* AVT-I entry IC540831 was found superior for protein content (14.04%), Fe (9.28 mg/100g) and Zn content (5.28 mg/100g).

  vi. Perilla AVT-II entries found superior for oil and protein content are IC0615369 (39.86 and 18.41%) and IC0615372 (39.80 and 18.13%), respectively.

  vii. Kalingda AVT-II entry SKNK-1407 had high phenol content (0.19%), high Fe and Zn content (5.97 and 3.16 mg/100g, respectively) along with 33.35% oil and 18.13% protein contents.

viii. Winged bean AVT-II entry IC-096946 had high protein content (26.58%), high antioxidant activity 2.72 (uM TE/g), Zn content (2.65 mg/100g) and good amount of Fe content (4.04 mg/100g).

ix. Job's tear AVT-I entry IC12703 had high protein content (14.93%) along with high antioxidant activity 85.91 % inhibition at 1mg/mL.

18.1.4. Crop protection

During *Rabi* 2022-23 total 123 genotypes of faba bean were evaluated for disease and insect pest screening at Ayodhya and Hisar Centre under natural field conditions, while during *Kharif* 2022, total 107 genotypes of grain amaranth were evaluated for disease and insect pest screening at Bengaluru centre under natural field conditions. The following findings were recorded:

- In Faba bean the entry HB 18-10 was highly resistant and 4 entries i.e., HB 18-15, HB 19-4, HB 19-10 and HB 19-11 were resistant against leaf curl virus in IVT at Ayodhya Centre.
- At Hisar centre, the Faba bean AVT-I entry HB 16-15 was moderately resistant against Alternaria leaf blight and AVT-II entry HB-15-38 was resistant against root rot wilt complex.
- In IPM trial conducted at Hisar and Ayodha, fungicides and botanicals (axoxystrobin, chlorothalonil, NSKE and garlic extract) were tested against Alternaria blight disease under field conditions. A combination of seed treatment of azoxystrobin @ 10 ml/kg seed + Chlorothalonil 75 WP 0.15% spray significantly reduced the Alternaria blight disease (61.43% control) over check followed by seed treatment with Azoxystrobin @ 10 ml/kg seed + Garlic extract @ 5 % spray (53.66 control).
- At Bengaluru centre, leaf spot and leaf rust severity were not found in genotypes namely IC35496 and KBGA-15. No phyllody was noticed in all the genotypes including checks.
- Insect pest reaction: The stem weevil population ranged from 0.13 to 0.93 per plant. The sucking pest population varied from 2.00 to 2.73 per plant. The defoliators population ranged from 1.97 to 2.40 per plant whereas the percent defoliation ranged from 4.67 to 5.67 per plant.

18.2. Resource management for higher crop productivity

- During *Rabi* 2022-23, the following recommendations were considered for package of practices in faba bean, grain amaranth and Quinoa.

i. Intercropping faba bean with other crops resulted in higher faba bean equivalent yield (FEY) compared to sole cultivation. The highest FEY (32.70 q/ha) was obtained with a combination of faba bean and wheat (4:9), surpassing the yield of sole faba bean cultivation at 19.30 q/ha.

ii. Highest grain yield was produced in sole amaranth crop (16.72 q/ha) followed by amaranth + fenugreek (only 1 cut) (16.42 q/ha) and amaranth + fenugreek (Two cuts) (16.28 q/ha) at S.K. Nagar.

iii. At Bengaluru among different combinations the treatment of 50% RDF + 50 % N through Vermicompost (VC) + Seed treatment (Azotobactor + PSB) has the highest grain yield (22.76 q/ha) followed by 50% RDF + 50 % N through Vermicompost (VC) (22.05 q/ha).

iv. Average performance of plant growth retardants (PGR) at two centres i.e. S.K. Nagar and Bhubaneswar was evaluated. Maximum grain yield on average of both the centres found in control (14.29 q/ha) and is significantly higher than all other treatment combinations. The average of benefit cost ratio (4.44) of both centres is highest in the control treatment, which indicates that PGR has no significant effect in improving the grain yield.

- During *Kharif* 2022, following recommendations were considered for the package of practices in grain amaranth and quinoa.

v. Weedicides Quizalofop ethyl 5% EC @ 50 g a.i/ha was found effective in controlling grassy weeds in grain amaranth when it applied at 20-25 DAS at early post-emergence in Karnataka.

vi. For getting higher grain yield and net returns of quinoa, the crop should be sown at 30 cm × 10 cm of spacing with NPKS (40:20:20:20 N:P:K:S) in Uttarakhand.

18.3. Extension research and value-addition for greater impact of technology

- Total of 389 Front Line Demonstrations (FLDs) covering an area of about 391.85 ha were conducted in the states of Chhattisgarh, Jharkhand, Gujarat, Uttarakhand, Haryana, Maharashtra, Karnataka and Himachal Pradesh to popularize potential crops of the region.
- A total of 2575.10 kg seeds were produced in grain amaranth (1680.20),faba bean (593.00), winged bean (86.00), buckwheat (22.00), rice bean (60.00), adzuki bean (25.00), chia (53) and *Chenopodium* (0.50)at different centres for distribution to farmers and other agencies (Fig. 18.1).



Fig. 18.1. Field view of grain Amarnath and Faba bean

- Total 60 training programmes were conducted and 3887 farmers have been trained in 57 sessions to create awareness on the package of practices of different potential crops grown during the *Rabi* & *Kharif* seasons. The programmes were also supported by village's local leaders and they were present during both sessions (Fig. 18.2).
- **Wide Publicity of Potential Crops and their Products:** Literature in the local language has been published in the form of leaflets and brochures to popularize the health benefits of potential crops. Demonstrations were conducted in KVK's (Nutri Garden Concept). Publicity is given through Radio talks, TV programmes and print media (Fig. 18.3).
- Recipes of various value-added products from potential crops were developed and standardized from CSKHPKV, Palampur (Chilla/Chillra, Thispole, Aktori, Poltu), UAS, Dharwad (Upma Mix, Payasa Mix, Nippattu, Chakali, Laddu, Cookies), SDAU, SK Nagar and UAS, Bengaluru for utilization of grain amaranth, buckwheat and quinoa. Local bakery "Adarsh" in Palampur is preparing potential crop grain-based biscuits of rice beans using the standardized recipe and process (Fig. 18.4).


Fig. 18.2. Training on improved potential crops cultivation

Fig. 18.3. For promotion of potential crops through electronic and print media

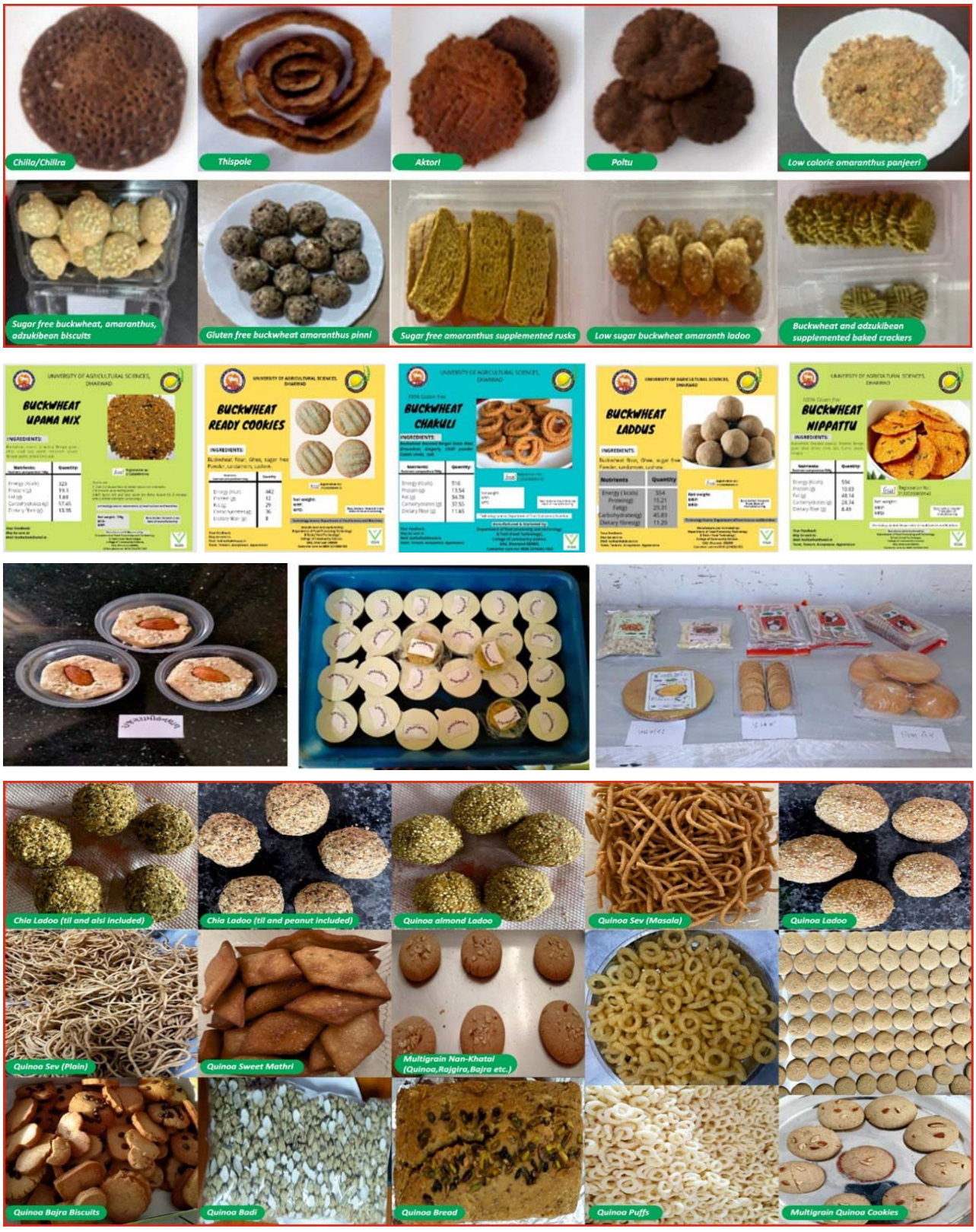


Fig. 18.4. Value added products from potential crops

18.4. Identified genotypes

It is a very significant outcome during the year that sixteen varieties including grain amaranth (GA7, Him Gauri, Jodhpur Rajgira 1, Jodhpur Rajgira 2, VL Chau 140, GA8 & GA9), buckwheat (Him Tara), faba bean (HFB-3), adzuki bean (Him Jwala), winged bean (PWB17-18 and BIRSA KAMRENGA-1), perilla (Poorvottar Perilla 1 and Poorvottar Perilla 2), kalingada (GK3) and pillipesara (Prathama) were recently identified by varietal identification committee (VIC) on crop standards notification and release of varieties (Fig. 18.5). The characteristics of these varietiesare shown in Table 18.1.

Table 18.1: Characteristics of varieties identified by VIC

S. No.	Varieties	Av. Yield (q/ha)	Characteristics	Recommended area
		I. GRAIN AMARANTH		
1.	Gujarat Amaranth 7 (SKNA 808)	15.91	Yield superiority	North West Plain Zone and Central Zone
2.	Him Gauri (IC037156)	16.71	Yield superiority	Mid and high hill areas of Northern Zone
3.	Jodhpur Rajgira 1 (RMA 62)	14.01	High protein content	Plains areas of the Country
4.	Jodhpur Rajgira 2 (RMA 120)	14.05	High protein content	Plains areas of the Country
5.	VL Chua 140	16.86	Yield superiority and high protein content	Northern Hill Zone
6.	GA 8 (SKNA 1407)	14.55	Yield superiority and high protein content	Plains areas of the Country
7.	GA 9 (SKNA 1701)	14.12	Yield superiority and high protein content	Plains areas of the Country
		II. Buckwheat		
8.	Him Tara (EC125940)	6.95	Yield superiority	North Hill Zone (Himachal Pradesh and Uttarakhand)
		III. Faba bean		
9.	HFB 3	23.65	High protein content	Irrigated, timely sown conditions of Plain Zones
		IV. Adzuki bean		
10.	Him Jwala (IC341939)	11.74	Yield superiority	Hill areas of Northern Zone
		V. Winged bean		
11.	PWB 17-18	13.53	Yield superiority	Maharashtra, Uttar Pradesh, Chhattisgarh and Jharkhand state
12.	BIRSA KAMRENGA-1 (RWB-13)	14.29	Yield superiority and High protein	All rainfed and irrigated area of Jharkhand
		VI. Perilla		
13.	Poorvottar Perilla 1 (IC 615369)	11.15	Yield superiority and high oil content	Uttarakhand, Manipur, Meghalaya, Mizoram, Sikkim, Arunachal Pradesh and Nagaland
14.	Poorvottar Perilla-2 (IC 615382)	10.33		
		VII. Kalingada		
15.	GK 3 (SKNK 1407)	2.77	Yield superiority and high oil content	Gujarat and Rajasthan
		VIII. Pillipesara		
16.	Prathama (IC 524667)	1.82	Yield superiority	Odisha and Tamil Nadu

RMA 62 (Rajgira 1)

RMA 120 (Rajgira 2)

SKNA 1407 (GA 8)

SKNA 1701 (GA 9)

Fig. 18.5. Varieties identified by VIC

The IX[th] All India Potential Crops Research Workers' Meet held at AU, Jodhpur on November 09, 2023 was jointly organized by the ICAR-National Bureau of Plant Genetic Resources, New Delhi – 110012 and AU, Jodhpur. The meeting was inaugurated by the Chief guest Dr TR Sharma, DDG (CS), ICAR. Other dignitaries Dr BR Chaudhary, Vice Chancellor, AU, Jodhpur, Dr DK Yadava, ADG (Seed), ICAR and Dr GP Singh, Director, NBPGR & Network Coordinator graced the occasion. The meeting reviewed the results of the *Rabi* 2022-23 crop season and based on the deliberations and presentations, the technical programme for the ensuing *Rabi* crop season 2023-24 was finalized. Emerging issues in potential crop production and crop protection along with quality were discussed by eminent speakers during various special sessions (Fig. 18.6).

Fig. 18.6. IX[th] *Rabi* Group Meet of AICRN on Potential Crops held at AU, Jodhpur on November 09, 2023

19 TRAININGS AND CAPACITY BUILDING

19.1 Trainings/workshops/visits/fairs organized in 2023

S. No.	Title of programme	Duration	Venue
1	"Virtual training programme on Management and Utilization of Plant Genetic Resources"	February 1-21, 2023	ICAR-NBPGR, New Delhi
2	Organized 5 days training programme "On farm conservation of native diversity for improved livelihood opportunities" for technology managers and farmers under Rashtriya Krishi Vikas Yojna project	March 15, 2023 to March 19, 2023	ICAR-NBPGR, Base Centre, Ranchi
3	"PGR Awareness Programme & Nursery Managament of Temperate Fruits" for SC farming community under SCSP	March 28, 2023	ICAR-NBPGR, RS Bhowali
4	Organized two orientation trainings on "PGR management and Herbarium techniques" for B.Sc. (Hons.) students of Garhbeta College, West Bengal and B.Sc. /M.Sc. (Botany) students of Rajdhani College, Bhubaneswar on respectively	April 18, 2023 to September 18, 2023	ICAR-NBPGR, RS Cuttack
5	TSP programme onplant genetic resources conservation for improving nutritional and livelihood security	April 28, 2023	Nigulsari Panchayat of Nichar Block district Kinnaur Himachal Pradesh by ICAR-NBPGR, RS, Shimla
6	Professional Attachment Training (PAT) to Dr. Prabhu P, Scientist ICAR-CIARI, Port Blair, A&N Islands (112th FOCARS) on 'Morphological characterization and taxonomic delimitation of wild relatives of sesame'	August 28,2023 to November 11,2023	ICAR-NBPGR, RS, Thrissur
7	हिन्दी साप्ताहिक पखवाड़ा आयोजित किया गया जिसमें विभिन्न प्रतियोगिताओं निबन्ध, नारा लेखन, कविता पाठ, कंप्यूटर में हिन्दी टाइपिंग का आयोजन किया गया और प्रतिभागियों के बीच विभिन्न पुरस्कार, प्रमाण पत्र और प्रशंसा पत्र वितरण किए गए	September 14-22, 2023	ICAR-NBPGR, RS, Shimla
8	Genomic Tools in Plant Genetic Resource Management	September 1-29, 2023	ICAR-National Bureau of Plant Genetic Resources, New Delhi.
9	SC-SP programme on strengthening backyard gardens for conserving plant genetics resources	October 10, 2023	Rampur Keonthal Panchayat of Block Totu District Shimla, HP by ICAR-NBPGR, RS, Shimla
10	Organized a Kisan Gosthi on Waste to Wealth' and 'Swachhata Programme' on the occasion of observance of Special Campaign 3.0	October 12, 2023	NBPGR, Issapur Farm
11	A training programme on "Management of Plant Genetic Resources"	November 02-08, 2023	Virtual
12	A Gram Sabha for awareness Building about Public Interest Disclosure and Protection of Informers (PIDPI) resolution' to inculcate the true spirit of participative vigilance among the public	November 10, 2023	Issapur Village
13	Organized a KisanGosthion the occasion of World Soil Day	December 05, 2023	NBPGR, Issapur Farm

NAHEP sponsored National Training Program on Genomic Tools in Plant Genetic Resource Management from September 18-29, 2023 was conducted at ICAR-NBPGR. Total 25 trainees from 13 states of India representing ICAR institutes, SAU, ICFRE and other universities and most of them are Ph.D. students. Total 21 lectures and 10 hands on training practicals were conducted during the training program. The subject specialist from the Division of Genomic Resources, ICAR-NBPGR and renowned subject experts from NIPB, IARI, IASRI, NIPGR, DU and NABI delivered lectures in different specialized areas of plant genomics and its application in plant genetic resource management. The hands-on training was provided for DNA and RNA isolation, generation of molecular markers, whole genome sequencing,

transcriptome and provided hands-on practicals on genomic data analysis for core development, transcriptome analysis and GWAS. During the program trainees also visited facilities of ICAR-NBPGR, Discovery Centre at IARI and ASHOKA at IASRI.

Fig. 19.1. NAHEP sponsored National Training Program on Genomic Tools in Plant Genetic Resource Management was organized at ICAR-NBPGR from September 18-29, 2023

Virtual Training Programme on "Management and Utilization of Plant Genetic Resources" during 1-21 February 2023

The objective of the training was to aware participants about different aspects of PGR management, such as germplasm exploration and collection, plant quarantine, germplasm conservation, evaluation and utilization, genomics, PGR informatics, national and international policies governing PGR, etc. A total of 83 researchers from ICAR institutions, State Agricultural Universities, other government institutions, ICARDA-FLRP, India and private

universities benefited from the training. A total of 73 invited lectures including 15 practical classes covering all core activities of PGR management were delivered by 81 resource persons including external experts: Dr. Shiv Kumar from ICARDA; Dr. A K Joshi, CIMMYT;Dr. H D Upadhyaya, Ex-Genebank Head, ICRISAT; Dr. JC Rana, Alliance of BioversityInternational and CIAT; Dr. PV Varaprasad, Kansas State University; Dr. C. Viswanathan, Joint Director (Research).

Training Programme on "Management of Plant Genetic Resources" during 2-8 November, 2023

ICAR-National Bureau of Plant Genetic Resources, New Delhi organized a training program on **"Management of Plant Genetic Resources**" during 2-8 November, 2023 for 30 students of B.Sc. (Hons.) Agriculture, College of Agriculture, Bawal, CCS, HAU, Hisar.

Fig. 19.2. Glimpses of SCSP & TSP programmes respectively by RS, Shimla

19.2. Trainings Imparted to Individual Students

Trainee details	Duration	Dissertation/thesis title	Faculty
Mr Thakur Aryan, Bachelor of Science in Agriculture (Hons.) of the Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Allahabad)	December 16, 2022 - January 15, 2023	Plant Tissue Culture and Cryopreservation Techniques for Conservation of Bulbous and Ornamental Crops	Subhash Chander
Ashutosh Johnson Beng	January 01 - June 30, 2023	Studies on micropropagation of *Zingiber wightianum* Thw.	Era Vaidya Malhotra
Fazleen Fatima, B. Tech. in Biotechnology, Jacob Institute of Biotechnology and Bioengineering, SHUATS, Prayagraj, Uttar Pradesh	January 01 - June 30, 2023	Micropropagation and synthetic seed development in *Sauropus androgynus* (L.) Merr.: a multi vitamin plant	Dr. Gowthami R.
Ms.Nisha, M.Sc. (Applied Microbiology and Biotechnology), Banasthali Vidyapith	January 01 - June 30, 2023	*In vitro* shoot multiplication studies in wild species of banana	Vartika Srivastava
Gouri Pradeep Totad, B.Sc. (Biotechnology), V.G. Shivdare College of Arts, Commerce and Science, Solapur, Maharashtra	August 01 - August 31, 2023	Biotechnological Tools for Germplasm Conservation (Plant Tissue Culture, Cryopreservation and Molecular Techniques	Gowthami R.
Niranjan VN, B.Sc. (Biotechnology), V.G. Shivdare College of Arts, Commerce and Science, Solapur, Maharashtra	August 01 - August 31, 2023	Biotechnological Tools for Germplasm Conservation (Plant Tissue Culture, Cryopreservation and Molecular Techniques	Gowthami R.
Zainab Mujeeb, B.Sc. (Biotechnology), V.G. Shivdare College of Arts, Commerce and Science, Solapur, Maharashtra	August 01 - August 31, 2023	Biotechnological Tools for Germplasm Conservation (Plant Tissue Culture, Cryopreservation and Molecular Techniques	Gowthami R.
Kumud Kumari	August 01 - October 31, 2023	Tools and Techniques of Plant Tissue Culture	Era Vaidya Malhotra
Ms. Shreya, School of Agriculture, Galgotias University	August 01 - October 31, 2023	Tissue Culture and Cryopreservation: Techniques for Germplasm Conservation	Subhash Chander
Kanakratnam Kumari	3 months August 01 - October 31, 2023	Techniques in *in vitro* conservation and cryopreservation of plant genetic resources	Sangita Bansal
Arpita Madhesiya	3 months August 01 - October 31, 2023	Germplasm exploration, characterization and Herbarium formanagement of Plant Genetic Resources (PGR) /Agriculture	Pavan Kumar Malav
Saurabh Kumar	3 months August 01 - October 31, 2023	Exploration, Herbarium and GIS for management of Plant Genetic Resources (PGR)/Agriculture	DP Semwal

Fig. 19.3. Orientation training of B.Sc. /M.Sc. (Botany) students of Rajdhani College (A), Bhubaneswar on 18.09.23

19.3. Trainings undertaken during 2023

Name of employee	Title of training programme	Period	Place
Scientific staff			
Rakesh Bhardwaj	Python for Artificial Intelligence in Agriculture	Feb. 02-11, 2023	ICAR-IASRI, New Delhi
Ishwar Singh	RIS-26-ReservationinServices for SC/ST/OBC/ ExSM/PwBDs	Feb. 06-09, 2023	New Delhi
Amit Kumar Singh	Computational Biology and its Applications in Agriculture	Feb. 21 to Mar. 02, 2023	ICAR-IASRI, New Delhi
Dhammaprakash P. Wankhede	Computational Biology and its Applications in Agriculture	Feb.21 to Mar. 02, 2023	ICAR-IASRI, New Delhi
Ishwar Singh	Introduction to Emerging Technologies	Feb. 22, 2023	New Delhi
VikenderKaur	DataVisualization using R (Online)	Mar. 01-08, 2023	ICAR-NAARM, Hyderabad
Mamta Singh	"National Training Workshop on Big Data Analysis in Agriculture"(Online Mode)	Mar. 09-10, 2023	ICAR-NAARM, Hyderabad
Vikender Kaur, Mamta Singh	Multivariate Data Analysis (online)	Mar. 20-27, 2023	ICAR-NAARM, Hyderabad
Sunil Gomashe	Capacity Building Training progrmme on Introduction to Emerging Technologies	Mar. 29, 2023	Capacity Building Commission, Department of Personnel and Training (Online Mode)
Pankaj Kumar Kannaujia	Agri-drone training	July 05-15, 2023	Agni College of technology, Chennai
B Parameswari	Pedagogical Development Programme on Enhancing Pedagogical Competencies for Agricultural Education	Jul. 31, 2023 to Aug. 5, 2023	In Person
Bharat Hanamant Gawade	Advances in mobile application development	Aug. 7-11, 2023	ICAR-NAARM, Hyderabad
KuldeepTripathi	Analysis of experimental data	Aug. 21-25, 2023	ICAR-NAARM, Hyderabad
Celia Chalam Vasimalla	2023 Seed Pathology Fundamentals: Regional to Global Implications	Sept. 19 to Dec. 5, 2023	Virtual course (12 Sessions) by American Phytopathological Society, USA
Kodaru Anitha, Bhaskar Bajaru	12-weeks online training programme on "Seed Pathology Fundamentals: Regional to Global Implications" by the American Phytopathological Society	Sept. 19, 2023 to Dec. 5, 2023	Virtual
Bharat Hanamant Gawade	Omics Data Analysis: Genome to Proteome	Oct. 09-18, 2023	ICAR-IASRI, New Delhi
Technical staff			
Ankur Tomar	Agri-drone training	Jul. 05-15, 2023	Agni College of technology, Chennai

19.4. Deputation/ Visits Abroad

- Dr.RakeshBhardwaj visited Institute of Soil Science and Plant Cultivation - State Research Institute in Pulawy, Poland to participate the 15th International Symposium on Buckwheat, held from July 2nd-8th, 2023
- Dr Kavita Gupta participated as resource person to conduct a Workshop on In-depth Pest Risk Assessment of Prioritized Pests in Bangladesh as a regional resource person with NPPO Bangladesh and CABI-South Asia in **Dhaka, Bangladesh** from 17-20 June, 2023.
- Dr. V. Celia Chalam participated in 12th International Congress of Plant Pathology ICPP2023 held on 20th to 25th August 2023 at **Lyon, France** and presented an oral paper entitled "Quarantine of Germplasm for Plant Biosecurity against Transboundary Viruses: Importance of Diagnostics and Phytosanitary Regulations".

- Dr. V. Celia Chalam participated in Workshop on Capacity Building on Pest Risk Assessment for seeds (ISPM2 and 11) held on 17th to 18th October 2023 at **Manila, the Philippines** and presented keynote paper entitled "An overview of status of PRA in India with special reference to seed transmitted pests".
- Dr. V. Celia Chalam participated in Workshop on Quality Management System for Plant Tissue Culture held on 14th to 15th December 2023 at **Thailand, Bangkok** and presented a paper as Expert on Quality Management Practices: Virus Indexing, Documentation, Record Keeping and Traceability.
- Dr Sundeeep Kumar was on deputation from March 17-24, 2024 to visit CIMMYT HQ, El Batan& CIMMYT, Obregon, Mexico to attend scientific meetings and visitor's week.

19.4. Participation in Seminars/ Conferences/ Symposia/Workshops/meetings

19.4.1. Webinar/Conference/Symposium attended

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
Ishwar Singh	Delivered lecture on 'Good Agriculture Practices for Sugarcane'	Jan.20-Feb.03, 2023	Division of Agronomy, ICAR-IARI, New Delhi
Safna K	Good Agricultural Practices (GAP's) for enhancing resource-use efficency and farm productivity	Jan. 20-Feb. 03, 2023	ICAR-IARI, New Delhi (Virtual mode)
Celia Chalam Vasimalla	Consultation Workshop for India's Clean Plant Programme for Horticulture	Jan. 30-31, 2023	Ministry of Agriculture and Framers Welfare, Govt. of India and Asia Development Bank
Celia Chalam Vasimalla	IPS Platinum Jubilee Conference on Plant and Soil Health Management	Feb. 2-4, 2023	Indian Phyto-pathological Society and University of Mysuru, Mysuru
Sandhya Gupta	Progressive Horticulture Conclave: Transforming Horticulture Science into Technology	Feb. 3-5, 2023	Pantnagar, Uttarakhand,
KuldeepTripathi	ICPulse23	Feb. 10-12, 2023	NASC, New Delhi
Jameel Akhtar	International Conference on '*Pulses: Smart Crops for Agricultural Sustainability and Nutritional Security (ICPulse 2023)*' organized by Indian Society of Pulses Research and Development, Kanpur	Feb. 10-12, 2023	NASC Complex, New Delhi
Dhammaprakash Wankhede	International Conference on Pulses: Smart Crops for Agricultural Sustainability and Nutritional Security	Feb.10-12, 2023	NASC, New Delhi
Amit Kumar Singh	International Conference on Pulses: Smart Crops for Agricultural Sustainability and Nutritional Security	Feb. 10-12, 2023	NASC, New Delhi
Mamta Arya	Attended the inaugural session of Rural Science Congress under the aegis of 17th Uttarakhand State Science and Technology Congress 2023	Feb. 10, 2023	Virtual
PP Thirumalaisamy, K Venkatesan, A Suma	Kerala Science Congress	Feb. 10-14, 2023	Mar Baselios Christian College of Engineering & Technology, Kuttikkanam, Idukki
Jameel Akhtar	2nd Indian Rice Congress	Feb. 11-14, 2023	ICAR-NRRI, Cuttack
Raj Kumar Gautam, Kuldeep Tripathi	International Conference on Communication and Dissemination of Traditional Knowledge, CDTK-2023	Feb. 14-15, 2023	NASC, New Delhi
Celia Chalam Vasimalla	Post-Budget Webinar on Atmanirbhar Horticulture Clean Plant Programme	Feb. 24, 2023	Ministry of Agriculture and Framers Welfare, Govt. of India

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
Vijay Singh Meena, Neelam Shekhawat	International Conference on Development and Promotion of Millets and Seed Spices for Livelihood Security	Feb. 24-26, 2023	Agriculture University, Jodhpur & ICAR-AICRP on Pearl millet, Jodhpur
Mamta Singh	International interactive webinar on "Recent advances in breeding for healthier rice"	Feb. 25, 2023	BIOINGENE (an online platform)
PP Thirumalaisamy, K Venkatesan, A Suma	*Pachakkuda-Kumbhavithumela* Programme	Mar. 10, 2023	Irinjalakkuda, Thrissur
Bharat Hanamant Gawade	15th IUPAC International Congress of Crop Protection Chemistry	Mar. 14-17, 2023	NASC Complex, New Delhi
Mamta Singh, Jyoti Kumari	"International Shree Anna Conference" on Enhancing 'productivity and Value Addition in Millets'	Mar. 18-19, 2023	ICAR-Indian Agricultural Research Institute, New Delhi
Sunil Gomashe	Global Millets (Shree Anna) Conference	Mar. 18-19, 2023	NAAS, New Delhi
Sandhya Gupta, Subhash Chander, Gowthami R.	International Conference on Blended Learning Ecosystem for Higher Education in Agriculture	Mar. 21-23, 2023	Virtual
Celia Chalam Vasimalla	Virtual Webinar on a retrospective on the evolution o f plant virus diagnostics	Mar. 22, 2023	American Phytopathological Society, USA
Sandhya Gupta, Sangita Bansal	Editor's Virtual Conclave: Vegetos (2023-2024)	Mar. 24, 2023	Virtual
Celia Chalam Vasimalla	Expert Meet on Atmanirbhar Bharat National Clean Plant Programme	Apr. 4, 2023	National Academy of Agricultural Sciences, New Delhi
Sapna	"66th Annual Maize Workshop" of All India Coordinated Research Project on Maize (ICAR)	Apr. 12-14, 2023	G.B. Pant University of Agri-culture and Technology, Pantnagar
KuldeepTripathi	Meeting of Agriculture Chief Scientists of G-20 countries and Exhibition	Apr. 17-19, 2023	Hotel Taj Ganges and Deen Dayal Hastkala Sankul (Trade Facilitation Centre-TFC), Varanasi
Monika Singh	Nominated member from ICAR-NBPGR, New Delhi in the online Meeting - Capacity of Laboratories with reference to DNA testing and traceability of cotton fibre, organized by the Textiles Committee, Ministry of Textiles (for technical inputs for GM detection in cotton fibre)	Apr. 18, 2023	Virtual mode
Celia Chalam Vasimalla, Kavita Gupta	National Consultative workshop for the preparation of the project document on "Mainstreaming of Biosafety and Institutional Capacity Building to Strengthen the effective implementation of Cartagena Protocol on Biosafety"	Apr. 19, 2023	Ministry of Environment, Forest and Climate Change
RC Misra	Participated in "78th Foundation Day & Dhan Diwas" and workshop on "Technical transformation in Rice Ecosystem	Apr. 23, 2023	ICAR-NRRI, Cuttack
Pankaj Kumar Kannaujia	Attended the "World Intellectual Property Day 2023" on. The theme for the year 2023 is "Women and IP: Accelerating Innovation and Creativity". On topic "Copyrights © and Plagiarism" delivered by Dr.Kanika Malik, Senior Principal Scientist	Apr. 26, 2023	CSIR-NIScPR, New Delhi through virtual mode.
K Pradheep	Mango Festival	May 01, 2023	Kannapuram Mango Heritage Village, Kannur, Kerala
Jameel Akhtar	42nd Annual Conference and National Symposium-2023 on 'Plant Health Management: A Way Forward for Food Safety, Security and Sustainability' organized by the Indian Society of Mycology & Plant Pathology, Udaipur, Rajasthan, India	May 10-12, 2023	Anand Agricultural University, Anand

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
RC Misra	Participated in the "Regional Workshop on PPV & FRA Act and Exhibition Agro-biodiversity"	May 11-12, 2023	ICAR-NRRI, Cuttack
Padmavati Ganapat Gore	Crop Improvement- Tools and Techniques	May 13-22, 2023	International Center for Agricultural Research in the Dry Areas (ICARDA), Morocco
Mamta Arya	Participated as panelist during one day Strategic Policy Dialogue on Stepping Forward for in situ On Farm Conservation Promotion for Food Security and Nutrition in South Asia Region	May 15, 2023	NASC Complex, New Delhi
Sushil Pandey	"Strategic Policy Dialogue on Stepping forward for in situ on-farm conservation and promotion of food and nutrition security in South Asia"	May 15, 2023	The Alliance of Bioversity International and CIAT, Asia-India Office at NASC Complex, New Delhi
Raj Kumar Gautam, KuldeepTripathi	Strategic Policy Dialogue on Stepping forward for *in-situ* on-farm conservation and promotion of food and nutrition security in South Asia	May 15, 2023	GEF, alliance, ICAR, NBPGR and ISPGR, National Agricultural Science Complex, New Delhi
Dinesh Prasad Semwal, Pankaj Kumar Kannaujia	Attended webinar on "Climate Change and Impact on Indian Agriculture: An Economic Perspective" on in virtual mode mode organizing by ICAR-IIWBR, Karnal under the Azadika Amrit Mahotsav	May 16, 2023	Banaras Hindu University, Varanasi.
Sangita Bansal	Project Screening Committee (PSC) for "R&D"	May 18, 2023	NMPB, New Delhi
Ishwar Singh	Participated in a Panel Discussion cum Scientist-farmers interaction on the topic: खेतों के संतुलित पोषण से पौष्टिक आहार तक	May 29, 2023	Division of Agronomy, ICAR-IARI, New Delhi
Raj Kumar Gautam	Group Meet and Brainstorming session of All India Coordinated Research Network on Potential Crops	Jun. 07, 2023	GKVK, Bangalore
Mamta Arya	Participated in UNEP-GEF Project Closing Workshop	Jun. 28, 2023	NASC Complex, New Delhi
Sushil Pandey	Workshop on UNEP-GEF project "Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability"	Jun. 28, 2023	The Alliance of Bioversity International and CIAT, Asia-India Office at NASC Complex, New Delhi
Sudhir Pal Ahlawat, Ranbir Singh Rathi, Dinesh Prasad Semwal, Pavan Kumar Malav	UNEP-GEF Project Closing Workshop	Jun. 28, 2023	NASC Complex, Pusa Campus, New Delhi.
Archana P. Raina	Intellectual Property Rights and Effective Patent Drafting by Lt Dr. A K Priya, Visiting Professor to ICAR-IISWC and Young Scientist Fellow of Tamil Nadu State Council for Science and Technology	Jun. 30, 2023	Virtual
Mamta Arya	Participated and presented her work at National symposium on *"Sustainable Mountain Agriculture: Challenges and Opportunities for Harnessing Zero Hunger and Nutritional Security"* is organized by the ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora and BoshiSen Society for Sustainable Mountain Agriculture (BoSSMA)	Jul. 5-6, 2023	ICAR-VPKAS, Almora, Uttarakhand.
Archana P. Raina	National Conference on Traditional and Alternative Medicine-Exploring New Horizons and Advancements organized by ASSOCHAM	Jul. 19, 2023	New Delhi

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
RC Misra	Invited as key speaker and delivered a lecture on "Genetic resources of wild vegetables of Odisha" in the National Seminar on "Past, present & Future of Similipal"	Jul. 22, 2023	MSCB University (formerly NOU), Baripada
Mamta Arya	Participated in Training-cum-Workshop on 'Awareness on Plant Variety Protection and Farmers' Right Act'	Jul. 25, 2023	GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand
Vartika Srivastava, Subhash Chander, Gowthami R	CRYO2023, 60th annual meeting of the society for cryobiology	Jul. 25-27, 2023	Virtual
Monika Singh	Nominated Member (Alternate Member) from ICAR-NBPGR for FAD-23 meetings/events - 16th and 17th Meetings of Biotechnology for Food & Agriculture Sectional Committee, FAD 23 (for technical inputs in GM detection and review of SOPs in molecular biology and biotechnology)	Jul. 27-Nov. 8, 2023	Virtual mode
Smita Karale, Rakesh Lathar	Town Official Language Implementation Committee (TOLIC), Akola half yearly meeting	July 27, 2023	NARAKAS, Akola
KM Rai	Conduct viva voce exam of M Sc. (Ag) student on thesis titled "Effect of stratification, growing media and seed treatment on germination and seedling growth of Peach"	Aug. 05, 2023	Department of Horticulture, GBPUAT, Pantnagar (virtual mode)
Celia Chalam Vasimalla	12th International Congress of Plant Pathology ICPP 2023	Aug. 20-25, 2023	International Society of Plant Pathology and French Phytopathological Society, Lyon, France
K Pradheep	TOLIC meeting	Aug. 23, 2023	Thrissur
Vijay Singh Meena, Kartar Singh	National Symposium on enhancing farming sectors income through integration, diversification & commercialization of technologies	Sept. 1-2, 2023	Agriculture University Jodhpur (Raj.)
PP Thirumalaisamy	Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues	Sep. 04-14, 2023	ICAR-NBPGR, New Delhi (Online mode)
Sangita Bansal, Vartika Srivastava, Era Vaidya Malhotra	First Global symposium on Farmers Rights 2023	Sept. 12-15, 2023	NASC, New Delhi
Anju Mahendru Singh, Anjali Kak Koul, Sushil Pandey, Sherry Rachel Jacob	Global Symposium on Farmers' Rights (GSFR), organized by Department of Agriculture and Farmers Welfare, MoA, GoI through PPVFRA Authority	Sept. 12-15, 2023	ICAR Convention Centre, New Delhi
Raj Kumar Gautam, Jyoti Kumari, Kuldeep Tripathi	'First Global Symposium on Farmers' Rights (GSFR)'	Sept. 12-15, 2023	National Agricultural Science Complex, New Delhi
Ravi Kishore Pamarthi	First Global Symposium on Farmers Rights	Sept. 15-17, 2023	ICAR Convention Centre
Bharat Hanamant Gawade	Review Meeting CRP on Agrobiodiversity (Vegetable crops)	Sept. 18, 2023	IIVR, Varanasi
Sandhya Gupta	Lecture on The Speed of Life: A Deep-Time Perspective organized by Linnean Society of London	Sept. 21, 2023	Virtual
Archana P. Raina	Botany From Evolution and Phylogeny To Bio-diversity And Sustainability (attended)	Sept. 25, 2023	University of Leicester, UK (online)
Sandhya Gupta	Global Conference on Sustainable Agricultural Mechanization (GAMC), organized by FAO, Rome, Italy	Sept 27-29, 2023	Virtual

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
Sherry Rachel Jacob	Training on FieldHub application, organized by Kirkhouse Trust	Sept. 26-27 & Nov. 2, 2023	Virtual
Sandhya Gupta	Webinar on Application of Hydrogel Matrices in Hypothermic and Cryogenic Storage of Cells and Tissues Confirmation organized by Society of Cryobiology, Baltimore	Sept. 28, 2023	Virtual
Jameel Akhtar	National Symposium on 'Crop Health Management: Safeguarding Crop through Diagnostics and Innovations' organized by ICAR-VPKAS, Almora	Sep. 29-30, 2023	Almora (Online)
Sherry Rachel Jacob	PGR conservation, offered by Colorado State University, USA	Sept. 29 – Oct. 28, 2023	Virtual
K Pradheep	Monitoring the field trials regarding AICRN-PC crops	Sep. 29, 2023	Forest College and Research Institute, Mettupalayam, Tamil Nadu
Sandhya Gupta	Joint FAO/ISTA Webinar: New Technologies in Seed Testing by FAO and ISTA	Oct. 4, 2023	Virtual
Sandhya Gupta	Linnean Society & University of Edinburgh Joint Lecture: Is Natural Selection a Team Sport?	Oct. 5, 2023	Virtual
Era Vaidya Malhotra	National Conference on Spices, Aromatic and Medicinal Plants for EconomicProsperity and Ecological Sustainability-2023	Oct. 5-6, 2023	ICAR- CIARI, Port Blair, Andaman & Nicobar Islands, (Hybrid mode)
RC Misra	Attended the "National Millets Expo- 2023"	Oct. 06, 2023	ICAR-NRRI, Cuttack
Sherry Rachel Jacob	A one-day training program for the members of technical committees of Bureau of Indian Standards	Oct.09,2023	National Institute of Training on Standardization (NITS), Noida
M Latha	Research Advisory Group committee meeting	Oct. 11, 2023	ICFRE-IFGTB, Coimbatore (Online mode)
Celia ChalamVasimalla	Workshop on Capacity Building on Pest Risk Assessment for seeds (ISPM2 and 11)	Oct. 17-18, 2023	APAARI, Bangkok, Thailand and BPI, Manila, Philippines
Kavita Gupta, BH Gawade	Review of CRP on Agrobiodiversity (CRP-AB) programme by External Experts for the year 2022-23	Oct. 18, 2023	ICAR-NBPGR, (Online)
Sandhya Gupta	51st Plenary Session of the Committee on World Food Security, organized by FAO, Rome, Italy	Oct. 23-27, 2023	(Hybrid mode)
Susheel Kumar Raina	Attended "ICAR-Industry Stakeholders Consultation Regional Meet"	Oct. 25-26, 2023	ICAR-CITH Srinagar at SKUAST-Kashmir
Sandhya Gupta	National conf. National Conference Enhancing Agricultural Productivity: Integration of Improved Inputs and Technology organized by ASSOCHAM	Oct. 26, 2023	New Delhi
Monika Singh	Invited technical expert from India in 34th ENGL Plenary Meeting, Organized by Joint Research Centre (JRC) Sevilla, Spain in hybrid mode (delivered presentation on 'Detection methods for checking authorized and unauthorized GM events in India')	Oct .27-28, 2023	(virtual mode)
Bharat Hanamant Gawade	International Conference on Biochemical and Bio-technological Approaches for Crop Improvement	Oct. 30-Nov. 1, 2023	NASC Complex, New Delhi
Mamta Arya, KM Rai	Participated in 25th RAC Meeting of ICAR-NBPGR	Oct. 31, 2023	Virtual mode

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
Mamta Arya	Delivered a talk on 'Quality in Germplasm Conservation and Evaluation'	Nov. 8, 2023	Defence Institute of Bio-Energy Research (DIBER), Haldwani on during World Quality Week
Anju Mahendru Singh (as non voting member of the VIC)	Annual Group Meet of the all India Coordinated Research Network on Potential Crops	Nov. 09, 2023	Agriculture University, Jodhpur
Rakesh Singh	All India Coordinated Research Network on Potential Crops	Nov. 9, 2023	Agriculture Research Station Mandor, Agriculture University, Jodhpur, Rajasthan
Raj Kumar Gautam, K S Hooda	Group Meet and Brainstorming session of All India Coordinated Research Network on Potential Crops	Nov. 09, 2023	Agriculture University, Jodhpur
Celia Chalam Vasimalla, Kavita Gupta, Zakaullah Khan, Jameel Akhtar	International Conference on Plant Health Management	Nov. 15-18, 2023	Hyderabad
Mamta Arya	Participated in eHRMS 2.0 trainings for Nodal Officers and Trainers at ICAR Institutes	Nov. 17, 2023	Virtually
KM Rai	Participated for oral presentation at National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in the North-Western Himalayas (PBFSNWH)	Nov. 27-28, 2023	Shoolini University, Solan, Himachal Pradesh
Mohar Singh, Narender Negi	Himalayan plant diversity for food nutrition and health security	Nov. 27-28, 2023	Shoolini University, Solan
Anju Mahendru Singh (as Convener of the session on "In situ and Ex situ Conservation, Community Seed Banks and Access Benefit Sharing")	National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), organised by the Indian Society of Plant Genetic Resources (ISPGR), New Delhi	Nov. 27-28, 2023	Shoolini University, Solan, Himachal Pradesh
Monika Singh	Co-organizing Secretary - National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Organized by ISPGR, ICAR-NBPGR, Shoolini University	Nov. 27-28, 2023	Shoolini University, Solan
Raj Kumar Gautam, Jyoti Kumari, Kuldeep Tripathi, Vikender Kaur	National Seminar on "Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSBWH)"	Nov. 27-28, 2023	Shoolini University, Solan
Ravi Kishore Pamarthi	National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH)"	Nov. 27-28, 2023	Shoolini University, Solan
Sunil Gomashe, Rakesh Lathar	Town Official Language Implementation Committee (TOLIC), Akola half yearly meeting	Nov. 28, 2023	NARAKAS, Akola
Sunil Gomashe	13th Institutional Bio-safety Committee (IBSC) Meeting	Nov. 29, 2023	Centre of Excellence in Plant Biotechnology, Dr. PDKV, Akola
Sandhya Gupta	Vavilov Seminar on PGRs for Food and Sustainable Agriculture	Nov. 29, 2023	Virtual
Celia Chalam Vasimalla	VIROCON 2023, Advancements in Global Virus Research towards One Health	Dec. 1-3, 2023	Indian Virological Society and NRC on Banana, Tiruchirappalli, Tamil Nadu
Sandhya Gupta, SK Malik, Sangita Bansal, Vartika Srivastav, Subhash Chander, Era Vaidya Malhotra, Gowthami R	Citrus: Genetic Resources to Genomics	Dec. 01, 2023	ICAR-NBPGR, New Delhi

Name of the Scientist (s)	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Period	Organizers
Celia Chalam Vasimalla, Kavita Gupta	Training workshop on "Prevention, Control and Management of Invasive Species"	Dec. 06-08, 2023	Amity School of Natural Resources & Sustainable Development (ASNRSD), AMITY University, Noida, UP
Archna P. Raina	3rd International Conference and Buyers Sellers Meet on Medicinal Plants used in Lifestyle Products	Dec. 06-08, 2023	Jadavpur University, Kolkata (Virtual Mode)
Celia Chalam Vasimalla	National Symposium on "Plant Pathology: Sustainable Approaches for Food Security and Human Health"	Dec. 08-09, 2023	Indian Society of Plant Pathologists and Banaras Hindu University, Varanasi, UP
Mool Chand Singh	National Conference of Plant Physiology-2023	Dec. 09-11, 2023	ICAR-IARI, New Delhi
Aravind J	12th National Seed Congress 2023: Innovations and Challenges in Quality Seed Availability under Changing Climate	Dec. 11-13, 2023	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
Celia Chalam Vasimalla	Workshop on Quality Management System for Plant Tissue Culture	Dec. 13-14, 2023	APAARI, Bangkok, Thailand and BCIL, New Delhi, India
Sandhya Gupta	"Training Programme on Blended Learning Techniques for Quality Higher Education"	Dec. 19-26, 2023	ICAR-Indian Agricultural Statistics Research Institute, New Delhi
Sunil Gomashe	1st International Agriculture Conference on Natural vs Organic Farming: In Context to Bhartiya Agriculture	Dec. 24- 26, 2023	GNFSU, Anand, HARWS & IIMTU, Meerut (Hybrid mode)

20 GENERAL INFORMATION

20.1 Institute Management Committee (IMC)

The Director , ICAR-NBPGR, Pusa Campus, New Delhi-110012	Chairman
Director (Agriculture), Government of Delhi, New Delhi	ex- Officio Member
Director (Agriculture), Government of Uttar Pradesh	ex- Offiico Member
Dr. N P Singh, Vice Chancellor, BAUT, Banda UP	ex-officio Member
Shri Mukesh Mann, Village Alipore, Narela, Delhi, Ph-9810012222	Member
Shri Sanjay Maruti Patil, BAIF Office, Amrai Campus, Jauhar, District-Palghar, Maharashtra, Ph-9623931855	Member
Dr. Poonam Jasrotia, Principal Scientist & PI (Coordination) ICAR-IIWBR, Gahoon Vihar, Karnal, Haryana 132001	Member
Dr. (Mrs.) Neelu Jain, Principal Scientist, Division of Genetics, IARI, New Delhi-110012	Member
Dr. Nagendra Rai, Principal Scientist, ICAR-IIVR, Post Bag No. 01, P.O. Jakhini (Shahanshapur), Varanasi - 221 305, U.P.	Member
Dr. Vijay Veer Singh, Principal Scientist, ICAR-DRMR, Bharatpur, Jyoti Nagar, Jail Area, Sewar, Bharatpur, Rajasthan 321303	Member
ADG (Seeds), ICAR, Krishi Bhawan, New Delhi-110001	Member
Sh. D.D. Verma, Sr. Comptroller, ICAR-IARI, Pusa Campus, New Delhi-110012	Member
Chief. Admn. Officer (SG), ICAR-NBPGR, New Delhi-110012	Member Secretary

20.2. Research advisory committee (RAC)

The 25th meeting of RAC of 1CAR-NBPGR was held in hybrid-mode on October 31, 2023 under the chairmanship of Dr. PL Gautam, Ex-Chairman, PPVFRA and was attended as members by Dr. GP Singh, Director, ICAR-NBPGR; Dr. JS Chauhan, Former ADG (Seeds), ICAR; Dr. DK Yadava, ADG (Seeds), ICAR; Dr. M.R. Dinesh, Former Director, ICAR-IIHR; Dr. Paramjit Singh, Former Director, BSI; Dr. Ramesh Venkata Sonti, Director, ICGEB; Dr. K.S. Varaprasad, Former Director, ICAR-IIOR; Dr. S.K. Barik, Former Director, CSIR-NBRI; Sh. Sanjay Maruti Patil, BAIF and Dr. Ashok Kumar, Member Secretary. The following recommendations were formulated after presentation and discussion.

- The committee recognized the relevance of explorations and stressed the importance of securing a standing permission from the respective state biodiversity board and NBA, to facilitate ICAR-NBPGR to conduct explorations in protected areas across all states and Union Territories.

- It was suggested that pre-breeding and core collection development require human resources and matching facilities and ICAR-NBPGR alone cannot accomplish this task. Hence, it is important to prioritize specific crops and associated pre-breeding and core collection efforts with respective crop based institutions. ICAR-NBPGR needs to focus such works on potential crops, where no other institutions are working.
- The practical utilization of identified sources of resistance to various biotic and abiotic stresses remains unutilized. Hence, collaborations of ICAR-NBPGR with crop-based institutes is essential to utilize the identified genetic resources.
- ICAR-NBPGR should actively share information regarding its available germplasm with other institutions. It also needs to establish a system for sharing materials from the *in-vitro* or cryo-bank with other researchers in the country. Comprehensive guidelines and information should be developed for the sharing of materials from the repositories.
- There is a need to streamline the process of introducing plant genetic resources. Hence, ICAR-NBPGR should collaborate with other institutes and State Agricultural Universities to facilitate introduction of the valuable genetic resources. Additionally, ICAR-NBPGR should establish an effective feedback mechanism to assess how these genetic resources are being utilized in crop improvement.
- *In-situ* on-farm and community seed banks should be linked with the national PGR management and conservation. This will help in *ex-situ* conservation of farmers' varieties and landraces from community seed banks in the National Genebank.

Dr. P.L. Gautam, Ex. Chairman, PPV&FRA, New Delhi	Chairman
Dr. M.R. Dinesh, Former Director, ICAR-IIHR	Member
Dr. Paramjit Singh, Former Director, Botanical Survey of India (BSI)	Member
Dr. Ramesh Venkata Sonti, Professor and Chair, Biology and Dean FacultyIndian Institute of Science, Education and Research (IISER)	Member
Dr. K.S. Varaprasad, Former Director, ICAR-IIOR, Hyderabad	Member
Dr. S.K Barik, Director, CSIR-National Botanical Research Institute	Member
Dr. J.S. Chauhan, Former-Assistant Director General (Seeds) ICAR, New Delhi	Member
Dr. J.R. Bhat, Advisor (Climate Change), Minstry of Environment, Forest and Climate Change, Govt of India	Member
Director, ICAR-National Bureau of Plant Genetic Resources, New Delhi	Member
Dr D.K. Yadava, Assistant Director General (Seeds) ICAR, Krishi Bhawan, New Delhi	Member
Sh. Mukesh Maan, Village-Alipore, Narela, New Delhi	Member
Sh. Sanjay Maruti Patil, BAIF Officer, Amrai Campus, Jauhar, District- Palghar, Maharashtra	Member
Dr. Ashok Kumar, Head, Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi	Member

20.3. Institute Research Council (IRC)

The 34th IRC meeting was held in hybrid mode under the Chairmanship of Dr. GP Singh, Director, ICAR-NBPGR with Dr. Jameel Akhtar as Member Secretary, IRC on January 24, 2024. The meeting was attended by all the Heads of Divisions, Officer-in-Charges of the Units of Headquarters physically, and OICs of Regional Stations and all the scientists of ICAR-NBPGR attended through Zoom link. The HoDs and OICs of GEPU, AKMU and all the regional stations presented the progress report of the institute projects operational in the respective divisions and Units at headquarters and regional stations.

20.4. Institute Joint Staff Council (IJSC)

The Director, ICAR-NBPGR, Pusa Campus, New Delhi	Chairman
Chief Admn. Officer (Senior Grade), ICAR- NBPGR, Pusa Campus, New Delhi	Member
Comptroller, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr. S.K. Malik, Principal Scientist, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr. K. C. Bhatt, Principal Scientist, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Dr. K. S. Hooda, Principal Scientist, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Smt. Poonam Singh, Sr. Admn. Officer, ICAR-NBPGR, Pusa Campus, New Delhi	Secretary (Official Side)

Sh. Dev Kumar, Assistant, ICAR-NBPGR, Pusa Campus, New Delhi	Secretary (Staff Side)
Sh. Sanjeev Kumar Paswan, SSS, ICAR-NBPGR, Pusa Campus, New Delhi	Member representing ICAR-NBPGR in CJSC, ICAR
Sh. Yogesh Kumar Gupta, Assistant, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Sh. O.P. Dhariwal, Technical Officer, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Smt. Sadhna, Technical Assistant, ICAR-NBPGR, Pusa Campus, New Delhi	Member
Sh. Mahesh Ram, SSS, ICAR-NBPGR, Pusa Campus, New Delhi	Member

20.5. Prioritization monitoring and evaluation (PME) cell

PME cell coordinated all scientific activities such as project proposals (18), manuscripts (106)/ abstracts (77), training (30)/ fellowship proposals (06) etc. as per the ICAR guidelines. It also coordinated professional attachment training for ARS scientists and training for B.Sc/B.Tech M.Sc/M.Tech students; HoDs and PMC meetings and maintenance of the documents pertaining to these activities. It also conducted orientation programmes for all newly joined staff and training for M.Sc/ M.Tech students; HoDs and PMC meetings and maintenance of the documents pertaining to these activities. Besides, it also submitted monthly target and achievements, Application of Scientists for promotions/ ASRB selections, agenda items and ATRs for Director's conference and the regional committee meetings. Also, inputs for various documents/ issues/reports of CGIAR projects/foreign-aided projects/ parliament questions/audit paras, or any such information as and when required for the council/ any other agencies. PME also facilitated signing of 14 MoUs with various universities for collaborative research, teaching and training.

20.6. HRD Activities

Annual Training Plan (ATP) of all the staff members of the Bureau for the year 2023 was prepared based on the training needs assessment and submitted to the Council. During the reporting period, 19 scientists, 3 technical and 5 admin staff have attended different training programmes and the same is being updated regularly in the ICAR-ERP System as per Council's guidelines. The information on HRD activities was compiled in the form of annual report and submitted to the ADG (HRM).

20.5.1. PME Cell

Dr Kavita Gupta, Nodal Officer
Dr S Rajkumar, Co-Nodal Officer
Dr MK Rana, Member
Dr Sandeep Kumar, Member
Dr Jyoti Kumari, Member, PME & HRD Nodal Officer
Dr Padmavati Gore Ganpat, Member
Mr Ankur Tomar, Member
Dr Jameel Akhtar, IRC Member Secretary
Dr Rakesh Bhardwaj, Nodal Officer Krishi Portal
Ms Shivangi Mathur, Technical Assistant (T-3)

20.7. KRISHI Portal

Knowledge based Resource Information Systems Hub for Innovations in agriculture (KRISHI) is an initiative of ICAR to gather its knowledge resources at one place for all stakeholders. The portal has been developed as a centralized data repository system of ICAR consisting of technology, data generated through experiments/ surveys/ observational studies, geospatial data, publications, learning resources, etc. Safe transfer of raw experimental data in electronic form was ensured on transfer and superannuation of scientists working at ICAR-NBPGR.

20.8. Personnel

The list of staff at NBPGR is provided herewith. It is not a documentary proof of seniority.

(i) Scientific Staff in position as on 31st December 2023

S. No.	Name	Designation	Discipline
1.	Dr. Gyanendra Pratap Singh	Director	Genetics & Plant Breeding
Division of Plant Exploration & Germplasm Collection			
1.	Dr. PK Singh	Principal Scientist & Head	Vegetable Science
2.	Dr. SP Ahlawat	Principal Scientist	Plant Breeding
3.	Dr. KC Bhatt	Principal Scientist	Economic Botany
4.	Dr. RS Rathi	Principal Scientist	Economic Botany
5.	Dr. DP Semwal	Principal Scientist	Economic Botany

S. No.	Name	Designation	Discipline
6.	Dr. Pankaj Kumar Kannaujia	Scientist	Vegetable Science
7.	Dr. Pavan Kumar Malav	Scientist	Economic Botany & PGR
8.	Mr. Ravi Kishore Pamarthi	Scientist	Economic Botany & PGR
9.	Mr. Soyimchiten	Scientist	Fruit Science
Agricultural Knowledge Management Unit			
10.	Dr. Hanuman Lal Raigar	Principal Scientist & OIC	Agril. Statistics
Germplasm Exchange And Policy Unit			
11.	Dr. Sunil Archak	Principal Scientist & OIC	Biotechnology
12.	Dr. Vandana Tyagi	Principal Scientist	Economic Botany
13.	Dr. Pragya	Principal Scientist	Horticulture
14.	Dr. Puran Chandra	Senior Scientist	Agro-forestry
Division of Germplasm Evaluation			
15.	Dr. RK Gautam	Principal Scientist & Head	Plant Breeding
16.	Dr. Ashok Kumar	Principal Scientist	Plant Breeding
17.	Dr. SK Kaushik	Principal Scientist	Plant Breeding
18.	Dr. KS Hooda	Principal Scientist	Plant Pathology
19.	Dr. Archana P. Raina	Principal Scientist	Plant Biochemistry
20.	Dr. Ishwar Singh	Principal Scientist	Agronomy
21.	Dr. KP Mohapatra	Principal Scientist	Agroforestry
22.	Dr. Rakesh Bhardwaj	Principal Scientist	Plant Biochemistry
23.	Dr. Vinod Kumar Sharma	Principal Scientist	Horticulture
24.	Dr. Sandeep Kumar	Principal Scientist	Biochemistry
25.	Dr. Jyoti Kumari	Principal Scientist	Plant Breeding
26.	Dr. Rashmi Yadav	Principal Scientist	Agronomy
27.	Mrs. Sapna	Senior Scientist	Biochemistry
28.	Dr. Vikender Kaur	Senior Scientist	Economic Botany & PGR
29.	Dr Gayacharan	Scientist	Agricultural Biotechnology
30.	Dr. Kuldeep Tripathi	Scientist	Economic Botany & PGR
31.	Dr. Mamta Singh	Scientist	Genetics &Plant Breeding
32.	Dr. Badal Singh	Scientist	Economic Botany & PGR
33.	Mr. Nand Lal Meena	Scientist	Plant Biochemistry
34.	Mr. Kajal Dass	Scientist	Agronomy
Division of Germplasm Conservation			
35.	Dr. Anju Mahendru Singh	Principal Scientist & Head	Genetics and Plant Breeding
36.	Dr. Sandhya Gupta	Principal Scientist	Economic Botany
37.	Dr. Anjali Kak Koul	Principal Scientist	Economic Botany
38.	Dr. S K Malik	Principal Scientist	Economic Botany
39.	Dr. Chitra Devi Pandey	Principal Scientist	Seed Science &Technology
40.	Dr. Sushil Pandey	Principal Scientist	Seed Science &Technology
41.	Dr. Sherry Rachel Jacob	Senior Scientist	Seed Science &Technology
42.	Mr. J Aravind	Scientist	Plant Genetics
43.	Dr. Vartika Srivastava	Scientist	Fruit Science

S. No.	Name	Designation	Discipline
44.	Dr. Subhash Chander	Scientist	Economic Botany & PGR
45.	Dr. Suman Roy	Scientist	Plant Physiology
46.	Dr. Era Vaidya Malhotra	Scientist	Agricultural Biotechnology
47.	Dr. Padmavati G Gore	Scientist	Economic Botany & PGR
48.	Dr. Gowthami R	Scientist	Genetics and Plant Breeding
Division of Plant Quarantine			
49.	Dr. V Celia Chalam	Principal Scientist & Head	PlantPathology
50.	Dr. Kavita Gupta	Principal Scientist	Agril. Entomology
51.	Dr. Moolchand Singh	Principal Scientist	Agronomy
52.	Dr. Zakaullah Khan	Principal Scientist	Plant Nematology
53.	Dr. Jameel Akhtar	Principal Scientist	Plant Pathology
54.	Dr. Bharat H. Gawade	Senior Scientist	Plant Nematology
55.	Dr. Pradeep Kumar	Scientist	Agril. Biotechnology
56.	Mrs. Bharat Raj Meena	Scientist	Plant Pathology
57.	Dr. Pooja Kumari	Scientist	Plant Pathology
58.	Mrs. Raj Kiran	Scientist	Plant Pathology
Division of Genomic Resources			
59.	Dr. Rakesh Singh	Principal Scientist (Head)	Biotechnology
60.	Dr. M C Yadav	Principal Scientist	Genetics/Cytogenetics
61.	Dr. Mukesh Kumar Rana	Principal Scientist	Plant Breeding
62.	Dr. Ambika Baldev Gaikwad	Principal Scientist	Biotechnology
63.	Dr. Lalit Arya	Principal Scientist	Plant Biochemistry
64.	Dr. Manjusha Verma	Principal Scientist	Plant Biochemistry
65.	Dr. Sundeep Kumar	Principal Scientist	Biotechnology
66.	Dr. Rajesh Kumar	Principal Scientist	Plant Biotechnology
67.	Dr. S. RajKumar	Principal Scientist	Genetics/Cytogenetics
68.	Dr. Amit Kumar Singh	Senior Scientist	Biotechnology
69.	Dr. R. Parimalan	Senior Scientist	Biotechnology
70.	Dr. Madhu Bala Priyadarshi	Senior Scientist	Computer Application
71.	Dr. Yasin Jeshima	Senior Scientist	Genetics
72.	Dr. Monika Singh	Senior Scientist	Agril. Biotechnology
73.	Dr. DP Wankhede	Senior Scientist	Plant Genetics
74.	Dr. Sheel Yadav	Scientist	Biotechnology-Plant Science
75.	Dr. Laxmi Sharma	Scientist	Plant Physiology
NBPGR, Regional Station, Hyderabad			
76.	Dr. Natarajan Sivaraj	Principal Scientist & OIC	Economic Botany
77.	Dr. Anitha Kodaru	Principal Scientist	Plant Pathology
78.	Dr. L Saravanan	Principal Scientist	Agricultural Entomology
79.	Dr. Parameswari B	Senior Scientist	Plant Pathology
80.	Dr. Prasanna Holajjer	Senior Scientist	Nematology
81.	Dr. P Pranusha	Scientist	Plant Physiology
82.	Mrs. S Nivedhitha	Scientist	Economic Botany & PGR
83.	Dr. Bhaskar Bajaru	Scientist	Plant Pathology

S. No.	Name	Designation	Discipline
NBPGR, Regional Station, Akola			
84.	Dr. Sunil Sriram Gomashe	Senior Scientist & OIC	Genetics & Plant Breeding
NBPGR, Regional Station, Bhowali			
85.	Dr. Mamta Arya	Scientist & OIC	Plant Genetics
86.	Dr. Krishna Madhav Rai	Scientist	Fruit Science
NBPGR, Regional Station, Cuttack			
87.	Dr. Dipti Ranjan Pani	Principal Scientist & OIC	Economic Botany
88.	Dr. R C Misra	Principal Scientist	Economic Botany
NBPGR, Regional Station, Shimla			
89.	Dr .Mohar Singh	Principal Scientist & OIC	Plant Breeding
90.	Mr. Rahul Chandora	Scientist	Economic Botany &PGR
91.	Dr. Narender Negi	Scientist	Fruit Sciences
NBPGR, Regional Station, Thrissur			
92.	Dr. K Pradheep	Principal Scientist & OIC	Economic Botany
93.	Dr. M Latha	Principal Scientist	PlantBreeding
94.	Dr. Thirumalaisamy, PP	Senior Scientist	Plant Pathology
95.	Dr. Venkatesan K	Senior Scientist	Economic Botany
96.	Dr. Suma A	Scientist	Economic Botany
NBPGR, Regional Station, Srinagar			
97.	Dr. Sheikh Mohd Sultan	Principal Scientist & OIC	Economic Botany
98.	Dr. Susheel Kumar Raina	Senior Scientist	Genetics & Plant Breeding
NBPGR, Regional Station, Jodhpur			
99.	Dr. Vijay Singh Meena	Scientist & OIC	Horticulture-Fruit Science
100.	Dr. Kartar Singh	Scientist	Plant Pathology
101.	Dr. Neelam Shekhawat	Scientist	Genetics & Plant Breeding
102.	Dr. Kirti Rani	Scientist	Genetics and Plant Breeding
NBPGR, Regional Station, Ranchi			
103.	Dr. Shashi Bhushan Choudhury	Senior Scientist & OIC	Genetics & PlantBreeding
104.	Dr. Shephalika Amrapali	Scientist	Economic Botany &PGR
NBPGR, Regional Station, Shillong			
105.	Dr. Harish GD	Scientist & OIC	Genetics &Plant Breeding
106.	Dr. Julius Uchoi	Scientist	Horticulture-Fruit Science
107.	Dr. Subarana Hajong	Scientist	Economic Botany & PGR

(ii) Technical staff in position as on 31st December 2023

S.No.	Name	Designation
Division of Plant Exploration & Germplasm Collection		
1.	Dr. NS Panwar	Chief Technical Officer
2.	Mrs. Rita Gupta	Senior Technical Officer
3.	Mr. Omprakash Dhariwal	Technical Officer
4.	Mrs. Ankur Tomar	Technical Assistant
Germplasm Exchange and Policy Unit		
5.	Dr. Surender Singh	Chief Technical Officer

S.No.	Name	Designation
6.	Mr. PC Binda	Technical Officer
7.	Mr. Vijay Kumar Mandal	Technical Officer
Division of Plant Quarantine		
8.	Mr. AK Maurya	Chief Technical Officer
9.	Mr. DS Meena	Chief Technical Officer
10.	Dr. Smita Lenka	Assistant Chief Technical Officer
11.	Mr. Naresh Kumar	Senior Technical Assistant
12.	Dr. Sadhana Maurya	Technical Assistant
Division of Germplasm Evaluation		
13.	Mr. B.L Meena	Chief Technical Officer
14.	Mr. Babu Ram	Chief Technical Officer
15.	Mr. Bhopal Singh Panwar	Chief Technical Officer
16.	Mr. Lokesh Kumar	Technical Officer
17.	Mr. Mahadev Mourya	Technician
Division of Genomic Resources		
18.	Dr. Sanjeev Kumar Singh	Assistant. Chief. Technical Officer
19.	Dr. Dikshant Gautam	Assistant. Chief. Technical Office
20.	Mr. Manish Tomar (On Study Leave)	Technical Officer
21.	Mrs. Kushaldeep Kaur Sodhi	Technical Assistant
22.	Mrs. Akansha Bajpai	Technical Assistant
23.	Mr. Ramesh Chand	Technician
Division of Germplasm Conservation		
24.	Dr. Axma Dutt Sharma	Chief Technical Officer
25.	Dr. Rajvir Singh	Assistant Chief Technical Officer
26.	Mr. Dharm Pal Singh Meena	Assistant Chief Technical Officer
27.	Mr. Satya Prakash	Assistant Chief Technical Officer
28.	Mrs. Nirmala Dabral	Technical Officer
29.	Mr. Ramesh Chandra	Senior Technical Officer
30.	Mr. Sunil Kumar	Technical Officer
31.	Mr. Lal Singh	Technical Officer
32.	Mrs. Anjali	Technical Assistant
33.	Mr. Suresh Chand Mali	Technical Assistant
34.	Mrs. Neha Sharma	Technical Assistant
Agricultural Knowledge Management Unit		
35.	Mr. Rajiv Gambhir	Chief Technical Officer
36.	Mrs. Shivangi Mathur	Technical Assistant
Library		
37.	Mrs. Sangita Tanwar	Assistant Chief Technical Officer
Director Technical Cell		
38.	Mr. AK Sharma	Senior Technical Assistant
Vehicle Cell		
39.	Mr. Brahm Prakash	Technical Officer (Driver)

S.No.	Name	Designation
40.	Mr. Ram Balak Rai	Technical Assistant (Driver)
41.	Mr. Khuswinder Kumar	Senior Technician(Driver)
42.	Mr. Gopal Singh	Senior Technician(Driver)
Regional Station, Akola		
43.	Mr. Rakesh Lathar	Technician (T-1)
Regional Station, Bhowali		
44.	Mr. Anuj Kumar Sharma	Technician
45.	Mr. Girish Chandra	T1
Regional Station, Hyderabad		
46.	Mr. M Venkata Ramana Reddy	Senior Technical Assistant (Driver)
47.	Mr. M B C K Raju	Technician
Regional Station, Jodhpur		
48.	Mr. Bhatta Ram	Technical Officer
49.	Mr. Dharam Raj Meena	Technical Assistant
50.	Mrs. Chanchal Gaina	Technical Assistant
51.	Mr. Gordhan Gena	Technical Assistant
Base Centre, Ranchi		
52.	Mr. Ashwini Kumar	Technical Assistant
53.	Mr. Narendra Ram	Technical Officer (Driver)
Regional Station, Shimla		
54.	Mr. Dayal Singh	Technical Officer
55.	Mr. Ram Chander	Senior Technical Assistant
56.	Mr. Sukh Dev	Technician (T1)
57.	Mr. Inder Singh	Technician (T1)
Regional Station, Thrissur		
58.	Mr. S Mani	Assistant Chief Technical Officer
59.	Mrs. A Indra Devi	Assistant Chief Technical Officer
60.	Mrs. Safna K	Technical Assistant

(iii) Skilled Supporting Staff in Position as on 31st December 2023

S. No.	Name
	Director's Cell
1.	Mr. Surender Kumar
	Division of Plant Exploration & Germplasm Collection
2.	Mrs. Manju Devi
3.	Mrs. Sharda Devi
	Germplasm Exchange and Policy Unit
4.	Mr. Arun Kumar
	Division of Plant Quarantine
5.	Mr. Sat Narayan Thakur

S. No.	Name
	Division of Germplasm Evaluation
6.	Mr. Suresh Ram
7.	Mr. Braham Dev Paswan
8.	Mr. Ram Kalit Rai
9.	Mr. Om Prakash
10.	Mrs. Rukhmani
	Division of Genomic Resources
11.	Mrs. Agya Devi
	Division of Germplasm Conservation
12.	Mrs. Geeta Devi

S. No.	Name
13.	Mr. Nand Kishore
14.	Mr. Chandeswar Rai
15.	Mr. Sanjeev Paswaan
	AICRN-PC
16.	Mr. Mahadev Maurya
	Experimental Farm, Issapur
17.	Mr. Mahabir Singh
	Regional Station, Akola
18.	Mr. Rajkumar Panjabrao Barse
19.	Mr. Arun Diwakar Gadlinge
20.	Mr. Mukund Bhaurao Nikose
	Regional Station, Bhowali
21.	Mr. Anand Kumar
22.	Mrs. Tulsi Devi
	Base Centre, Cuttack
23.	Mr. Saranga Dhar Barik
	Regional Station, Hyderabad
24.	Mr. G Narsimha Chary
25.	Mr. P Gandhi
26.	Mrs. D Kalamma
27.	Mrs. Manchala Kalamma
28.	Mr. G Narasimha
29.	Mrs. G Rajamani
30.	Mr. Jonnada Sahadev
31.	Mr. N Srinivas
32.	Mr. Kamatam Babu
33.	Mr. Mekala Yellaiah
	Regional Station, Jodhpur
34.	Mr. DS Rajpurohit
	Base Centre, Ranchi
35.	Mr. Vijay Kumar
	Regional Station, Shimla
36.	Mr. Paras Ram
37.	Mr. Rohit
38.	Mr. Daleep Singh
39.	Mr. Shankar Das
40.	Mr. Mangat Ram
41.	Mr. Desh Raj
42.	Mr. Leela Dhar
	Regional Station, Thrissur
43.	Mrs. Anitha Komvalappil

(iv) Administrative Staff in Position as on 31st December 2023

S. No.	Name	Designation
1.	Mr. Suresh Kumar Gajmoti	Chief Administrative Officer (Senior Grade)
2.	Mrs. Neha Agrawal	Senior Administrative Officer
3.	Mr. Pawan Kumar Gupta	Senior Finance and Accounts Officer
4.	Mr. PrasenJit	Administrative Officer
5.	Mr. Sushil Kumar	Administrative Officer
6.	Mr. Avdhesh Kumar	Assistant Administrative Officer (AAO)
7.	Mrs. Sangeeta Gambhir	Assistant Administrative Officer (AAO)
8.	Mrs. Amrita Negi	Assistant Administrative Officer (AAO)
9.	Mrs. Sanjoo Verma	Assistant Administrative Officer (AAO)
10.	Mr. Prabal Das Gupta	Assistant Administrative Officer (AAO)
11.	Mrs. Surbhi Bhagat	Assistant Administrative Officer (AAO)
12.	Mr. Yogesh Kumar Gupta	Assistant
13.	Mrs. Madhu Chawla	Assistant
14.	Mr. Dinesh Sharma	Assistant
15.	Mr. Krishan Chander Kundu	Assistant
16.	Mr. Sanjay Dangwal	Assistant
17.	Mr. Dev Kumar	Assistant
18.	Mr. Umesh Kumar	Lower Division Clerk
19.	Mr. Anant Swarup	Lower Division Clerk
20.	Mr. Kush Kumar Bhargava	Lower Division Clerk
21.	Mr. Sunil Kumar	Lower Division Clerk
22.	Mrs. Sonam Saini	Lower Division Clerk
	Director's Cell	
23.	Mrs. Sunita	Principal Private Secretary
	Division of Germplasm Evaluation	
24.	Mrs. Neelam Khatri	Personal Secretary Hindi Unit

S. No.	Name	Designation
25.	Mr. Ashutosh Kumar Vishwakarma	Deputy Director (OL)
Security		
26.	Mr. Umesh Chander Sati	Security Officer
Regional Station, Akola		
27.	Mr. Purushottam Lalaji Dhoke	Assistant
28.	Mrs. Smita Dadarao Karale	UDC
Base Centre, Cuttack		
29.	Mr. S K Lal	Assistant

S. No.	Name	Designation
Regional Station, Hyderabad		
30.	Mrs. Radha Rani	Assistant Administrative Officer (AAO)
31.	Mr. M Srinivasa Rao	Assistant Administrative Officer (AAO)
32.	Mr. P Suleiman	Assistant
Regional Station, Jodhpur		
33.	Mrs. Leela Sharma	Assistant
Regional Station, Shillong		
34.	Mrs. Lakshmilian Kharnary	Assistant Administrative Officer (AAO)

20.9. Staff transferred /Superannuated/New Appointments/Promotions

20.9.1. Appointments/Joining

Dr. PK Singh, Principal Scientist joined as HoD, Division of Plant Exploration & Germplasm Collection, ICAR-NBPGR w.e.f. May 08, 2023

Dr. Anju Mahendru Singh, Principal Scientist joined as HoD, Division of Germplasm Conservation, ICAR-NBPGR w.e.f. May 08, 2023

Dr. Suman Roy, Senior Scale joined DGC, ICAR-NBPGR w.e.f. April 03, 2023

Mr. S. K. Gajmoti, CAO(SG) joined, ICAR-NBPGR w.e.f. May 26, 2023

Mr. Sunil Kumar, Technical officer joined DGC, ICAR-NBPGR w.e.f. August 30, 2023

Dr. Puran Chandra, Senior Scientist joined to GEPU, ICAR-NBPGR w.e.f. September 01, 2023

Mr. Rajeev Gambhir, Chief Technical Officer joined, Division of Plant Exploration & Germplasm Collection, ICAR-NBPGR w.e.f. October 15, 2023

Mrs. Sunita, Principal Private Secretary, joined Director Cell, ICAR-NBPGR w.e.f. May 01, 2023

Mr. Ankur Tomar, Technical Assistant joined AKMU, ICAR-NBPGR w.e.f. September 01, 2023

20.9.2. Retirements

Dr. S R Pandravada, Principal Scientist superannuated on February 28, 2023

Mrs. Rita Gupta, Chief Technical Officer superannuated on Ocober 31, 2023

Dr. Veena Gupta, Principal Scientist & Act Head DGC on August 31, 2023

Mr. S. Mani (CTO) superannuation on February 28, 2023

Mr. Bhatta Ram, Technical officer (T-5) superannuated on January 31, 2023

Mr. Pushottam L. Dhoke, Assistant at Regional Station, Akola superannuated on December 31, 2023

Mr. Mohd Mazahar Pasha, Skilled Supporting Staff on June 30, 2023

Mr. Ganga Nand, Personal Assistant, DGC on February 28, 2023

Mr. Anang Pal, Assistant Chief Technical Officer DGC on December 31, 2023

Mrs. Kanchan Khurana, PPS Director's Cell on May 31, 2023

Mr. M. S. Yadav, AAO on June 30, 2023

Mr. Surender Kumar, AAO on September 01, 2023 (FN) VRS

20.9.3. Promotions

Mrs. Indiradevi A., ACTO promoted to CTO w.e.f. June 12, 2022.

Mr. Dayal Singh promoted from Senior Technical Assistant to Technical Officer w.e.f. May 22, 2022.

Mr. Prabal Dasgupta, Assistant promoted to AAO w.e.f. July 13, 2023

Mrs. Surbhi Bhagat, Assistant promoted to AAO w.e.f. December 28, 2023

20.9.4. Transfers

Mr. P. K. Jain, CAO(SG) transferred to ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly (UP) w.e.f May 22, 2023

Mr. Gopal Singh, T4 (Driver), transferred to ICAR-NBPGR New Delhi on November 20, 2023 and relieved on November 28, 2023.

Dr. Harish GD, Senior Scientist transferred to ICAR-NBPGR Regional Station Shillong w.e.f December 01, 2023

Dr. Sangita Bansal, Principal Scientist transferred to DGR ICAR-NBPGR w.e.f December 12, 2023

Dr. Badal Singh, Scientist transferred to Evolution Division ICAR-NBPGR w.e.f May 16, 2023

Dr. Smita Lenka Jain, Assistant Chief Technical Officer transferred to PQD ICAR-NBPGR w.e.f. August 25, 2023

Dr. Sanjeev Kumar Singh appointed as Senior Scientist cum Head, KVK Phek, Nagaland on October 01, 2023

20.9.5. Death

Mr. Mahabir Singh, SSS, Isapur-farm, expired on December 30, 2023

20.9.6. Study Leave

Mr. Rahul Chandora relieved for study leave w.e.f. January 06, 2023

20.9.7. Awards

The Regional Station, Hyderabad won the "Rajabhasha Shield" for the recognition as the First best institute in implementation of Hindi as the Official Language for the Hindi non-speaking region (''ग'' क्षेत्र) for the year 2023.

Dr Kuldeep Tripathi was awarded the NAAS Young Scientist Award (Crop Sciences), NAAS, New Delhi, 2024.

Mrs. Sapna received NAHEP-ICAR Hackathon 3.0: A National Level award on "Speed Breeding for Crop Improvement", and secured II position as Team Amrit Poly in KRITAGYA (2023).

Dr B. Parameswari, Senior Scientist was awarded S. Sinha Memorial Young Scientist Award (2022)" at the University of Mysore, Mysuru, Karnataka, India, during IPS Platinum Jubilee Conference on 'Plant and Soil Health Management: Issues and Innovations' conducted on February 2-4, 2023.

Dr Pardeep Kumar was awarded the Young Scientist Awardduring the International Conference on "Agricultural Sciences and Technology for Food Security and Sustainability (ICAFS-2K23)" organized by IIMT University, Meerut, Uttar Pradesh, May 5-6, 2023.

Dr Kuldeep Tripathi was awarded Indian Society of Pulses Research and Development(ISPRD) Young Scientist Award 2023, ISPRD, Kanpur, 2023

Mrs. Sapna received the "Outstanding Scientist Award" for contribution in the field of Biochemistry by National Environment Science Academy (NESA) Distinguished Award SASE-2023.

Dr V Celia Chalam was awarded D.P. Misra and R.N Pandey IPS Best Women Scientist Award by the Indian Phytopathological Society, New Delhi.

Dr Jameel Akhtar was awarded Dr Bap Reddy Award (2018-2020) by the Plant Protection Association of India, Hyderabad in 2023 for outstanding contribution to Plant Pathology, especially integrated pest management.

Dr Sherry Rachel Jacob, Senior Scientist, DGC participated as a member of the Indian delegation for the third plenary meeting of ISO/TC 331- Biodiversity, held in virtual mode, from April 17-21, 2023 in France.

Dr Sherry Rachel Jacob was nominated as a conservation expert from India, in the Adhoc Committee on Conservation and Sustainable Use (ACSU) of the International Treaty of Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Dr R.C. Misra, Principal Scientist, received an appreciation award for best research in Similipal Biosphere Reserve by MSCB University, Baripada on July 22, 2023.

Dr R.C. Misra, Principal Scientist, was conferred with Dr. M. Brahmam Memorial Award for "Plant Diversity Conservation" with citation by Orissa Botanical Society, Bhubaneswar on December 17, 2023 during the 46th Annual Conference & National Seminar, held at Dhenkanal Autonomous College, Dhenkanal, Odisha.

Dr N. Sivaraj, Principal Scientist conferred with Biodiversity Conserver Award by the Andhra Pradesh State Biodiversity Board on May 22, 2023.

Dr. B. Parameswari, Senior Scientist was nominated as one of the members of the Award Screening Committee (2022-23) for online evaluation of the various awards of the Indian Phytopathological Society, New Delhi.

Dr K. Anitha, Officer In-charge and Principal Scientist, nominated as a selection committee member in January 2023 for choosing the best paper published in the Journal of Oilseeds Research by the Indian Society of Oilseeds Research located IIOR, Hyderabad.

Dr Prasanna Holajjer, Senior Scientist won the Kavuri Sarada Memorial Award for the Best paper published in Indian Journal of Plant Protection, vol 50 (1): 51-55 for the year 2022.

Dr K Anitha, Principal Scientist won the Outstanding Contribution Award for her services to the Plant Protection Association of India on the occasion of Golden Jubilee Celebrations of PPAI during the ICPHM 2023, held in Hyderabad during November 15-18, 2023.

Dr R. C. Misra received an appreciation award from MSCB University, Baripada on 22.07.2023 and Dr M Brahmam Memorial Award for "Plant Diversity Conservation" by Orissa Botanical Society, Bhubaneswar on December 17, 2023.

20.9.8. Fellowship

Dr Sandhya Gupta was conferred with the Fellowship of The Linnaean Society of London in March 2023.

Dr Sundeep Kumar was conferred with the Fellowship (2021) of the National Academy of Biological Sciences (NABS), Chennai, India on January 25, 2023.

Dr Sherry Rachel Jacob and Dr Amit Kumar Singh were conferred with the Fellowship of the Indian Journal of Plant Genetic Resources for the year 2022.

Dr Pragya was conferred with the Fellowship of the Indian Society of Vegetable Science (ISVS-2022), Varanasi.

Dr Jameel Akhtar was conferred with the Fellowship of ISPRD (2022) by the Indian Society of Pulses Research and Development, Kanpur for his contribution to the field of Pulse Pathology.

Dr Jameel Akhtar, Dr L Saravanan, Dr Prasanna Holajjerand Dr Pardeep Kumar were conferred with the Fellowship of the Plant Protection Association of India (PPAI-2022), Hyderabad for their contribution to the field of Plant Pathology.

Dr. B. Parameswari, was conferred with the Fellowship 2023 ofthe Society for Plant Research at Pondicherry University during International Conference cum Workshop on Plant Molecular Biology and Bioinformatics on February 13, 2023.

20.9.9. Best Oral presentation

RK Pamarthi, DP Semwal, Soyimchetin and PK Singh were awarded Best Oral Presentation for the paper entitled "Expedition of PGR diversity in North Western Himalaya of India" in National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

Jyoti Kumari was awarded Best Oral Presentation for the topic "Search of novel donor germplasm for powdery mildew resistance in wheat minicore" in the National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

Pooja Pathania, Venugopal Gowda R. and S. Rajkumar received best oral presentation for the paper entitled "Molecular and tepal morphology in delineating vegetable Amaranthus species complex conserved in Indian National Genebank" in National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

Akansha Bajpai, SR Pandravada, Mamta Singh, Sushil Pandey, Manjusha Verma, Kirti Rani Sharma, Lalit Arya received the best oral presentation award for the "Identification of browntop millet (*Brachiaria ramosa* L.Stapf.) germplasm for its usage in agriculture diversification"in II International Conference on "Prospects and challenges of environment and biological sciences in food production system for livelihood security of farmers (ICFPLS-2023)" during September 18-20, 2023 at ICAR-CIARI, Port Blair, Andaman & Nicobar Islands, India.

Panda RR and Gupta S (2023) received the best oral presentation award for the "Sustaining Wild Edible Fruit Treasures: Ex Situ Conservation of *Artocarpus lacucha*Buch.-Ham"in National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

Jacob SR, Shashank HG, Saha S, Mishra A, Aravind J, Gore PG and Singh AM (2023) received the best oral presentation award for the "Conservation of wheat and barley genetic resources of North-Western Himalayas in the National Genebank". in National Seminar on Plant

Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

Saha S, Jacob SR, Abhijith KP, Arun Kumar MB, Mishra A, Aravind J, Kumar S, Kumari J, Navathe S and Kumar Y (2023) received the best oral presentation award for the "Exploring the Genetic Basis of Seed Longevity in Wheat (*Triticum aestivum* L.) - A Genebank Perspective" presented at the 12th National Seed Congress 2023: Innovations and Challenges in Quality Seed Availability under Changing Climate, December 11-13, 2023, Indian Society of Seed Technology, New Delhi &Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, December 12.

Dr B Bhaskar, received the best oral presentation award for the paper entitled, "Identification and Characterization of *Colletotrichum* Species Associated with Stem Anthracnose Disease of Dragon Fruit" in the ICPHM 2023 Conference, held in Hyderabad during November 15-18, 2023.

Dr. Thirumalaisamy, P.P.received the best oral presentation award in the National Symposium on "Crop Health Management: Safeguarding Crop through Diagnostics and Innovations"held on September 29-30, 2023 at ICAR-VPKAS, Almora (online).

20.9.10. Best Poster presentation

Thendral US, DP Semwal, and Kuldeep Tripathi received the best poster award for "Impact of climate change on the temporal and spatial distribution of crop wild relatives (CWRs) of Vigna spp. in India using the BioClim model" during the National Seminar on "Plant Biodiversity for Food, Nutrition, and Health Security in the North-West Himalayas (PBFSNWH) held from November 27–28, 2023, at Shoolini University, Himachal Pradesh.

D Pal, R Aminedi, AK Singh, V Srivastava & M Singh received the best poster award for "Detection strategies for checking unauthorized GMOs in fruit and vegetable crops of North-Western Himalayan Region: a precautionary approach" in the National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

G Prasanna Kumar, Pooja Pathania, Prabhanshu Kumar and S. Rajkumar received the best poster award for "Comparative studies on diversity in Safflower germplasm with SSR and SNP markers" in National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Organized by ISPGR, ICAR-NBPGR and Shoolini University from November 27-28, 2023.

K Venkatesan, RK Gautam, PK Singh, K Sakthivel, SK Zamir Ahmed and SS Rao receivedthe best poster presentation(Online session)on the topic "Effect of controlled irrigation on greengram and blackgram genotypes grown under Micro-plot facility for yield and yield related traits in Andaman Islands" during the 6th International Conference on Advances in Agriculture Technology and Allied Sciences (ICAATAS-2023) held in hybrid mode on June 19-21, 2023 at Loyola Academy, Secunderabad, Telangana organised by SARSD, New Delhi & Loyola Academy, Secunderabad.

20.9.11. Other recognitions

Dr Sundeep Kumar was elected Member, National Academy of Sciences, India-2023.

Tomar A, Pandey A, Bhatt KC, Panwar NS and SP Ahlawat were granted with copyright for the invention entitled "NBPGR-PDS is a mobile assisted passport data book that helps explorers to record the passport information of the collected germplasm in a digital manner".

Dr V Celia Chalam and Kavita Gupta were recognized as Expert Member, National Network of Plant Health Management, NIPHM, Hyderabad

Dr V Celia Chalam, Kavita Gupta, Dr Rakesh Singh Dr Amit Kumar Singh and Kuldeep Tripathi were nominated as Editors of the Indian Journal of Plant Genetic Resources

Dr V Celia Chalam was recognized as South Asia Representative to the International Committee for Plant Virus Epidemiology (ICPVE).

Dr V Celia Chalam was recognized as Vice President, Plant Protection Association of India, Hyderabad, India.

Dr V Celia Chalam recognized as Member, APS Collections and Germplasm Committee, American Phytopathological Society, USA

Dr V Celia Chalam recognized as Expert Member, Accreditation Panel, National Certification System for Tissue Culture-raised Plants, DBT, Govt. of India

Dr V Celia Chalam recognized as Expert Member, Inter-Ministerial Committee for Certification of BSL-3 Facilities, DBT, Government of India

Dr V Celia Chalam nominated as expert Member, Departmental Research Committee (DRC) meeting of AMITY Institute of Virology and Immunology, AMITY University, Noida, U.P.

Dr S. Rajkumar is a member of the Plant & Agricultural Biotechnology panel for BioCARE program of the Department of Biotechnology, GOI.

Dr S. Rajkumar is a member of the PCR evaluation committee for Organismal and Evolutional Biology (OEB)- Plant Sciences of SERB, Department of Science and Technology, GoI.

Dr MC Yadav was nominated as IMC member, ICAR-Directorate of Mushroom Research, Solan (H.P.) w.e.f. July, 2021 to July, 2024 and attended one IMC meeting on March 27, 2023 at DMR, Solan.

Dr K. Anitha, Principal Scientist, nominated as an Expert member for reviewing the synopses of MSc and PhD students of Plant Pathology discipline from PJTSAU screened the applications on December 13, 2023.

Dr K. Anitha, Principal Scientist, was nominated as an expert committee member for screening the applications for FMC fellowship by PJTSAU and screened the applications on December 19, 2023.

Dr Jameel Akhtar was nominated as editor-in-chief (2023-2025) of the Journal of Mycology and Plant Pathology by the Indian Society of Mycology & Plant Pathology.

Dr Rakesh Singh is the editor of the journal 'Agriculture' MDPI, Basel, Switzerland, and Associate Editor of the Indian Journal of Genetics and Plant Breeding".

Dr Amit Kumar Singh and Dr Kuldeep Tripathi are inducted into editorial board of Plos One.

Dr Amit Kumar Singh is inducted into the editorial board of BMC Plant Biology and BMC Notes.

Dr Kuldeep Tripathi is inducted into the editorial board of Genetic Resources and Crop Evolution.

Dr S. Rajkumar is a member of the Editorial Board Indian Journal of Plant Genetic Resources and the journal "Biotech Today – Pulse of Global Science"

Dr Sundeep Kumar was Guest associate editor in the special issue of Frontiers in Genetics, 'Accelerating Genetic Gain for Key Traits Using Genome-Wide Association Studies and Genomic Selection: Promising Breeding Tools for Sustainable Agriculture.

Dr Sundeep Kumar was Guest Editor of a special issue of MDPI Journal 'Agriculture Basel' Application of Genome-Wide Association Analysis and Genomic Selection in Crop Genetic Research'.

Dr R. Parimalan is an editorial board member of BMC Genomics.

Dr R. C. Misra was elevated as 'Executive Editor' of the journal "*e-planet*" (NAAS Jrn ID E001), and 'Area Editor' of the"Emerging Science", a quarterly journal.

Dr Jameel Akhtar was nominated as zonal President 2023 (Delhi Zone) of the Indian Phytopathological Society, New Delhi, India.

Dr Pardeep has been elected as Zonal Councillor (2023) (Delhi Zone) of the Indian Phytopathological Society, New Delhi, India.

Mrs Sapna was elected as "Treasurer" of the Maize Technologists Society of India (MTAI).

20.10. Publications

20.10.1. Research papers

Adhikari S, Kumari J, Bhardwaj R, Jacob SR, Langyan S, Sharma S, Singh AM and Kumar A (2023). Unlocking the potential of ancient hexaploid Indian dwarf wheat, *Tritium sphaerococcum* for grain quality improvement. *Peer J*, *11*, e15334.

Aggarwal SK, Hooda KS, Kaur Harleen, Gogoi R, Chauhan P, Bagaria PK, Kumar P, Choudhary M, Tiwari RK and Lal MK (2023). Comparative evaluation of management modules against maydis leaf blight disease in maize (*Zea mays*). *Eur. J. Plant Pathol.* 1-11

Ahmad S, Bhat SS, Sultan SM, Mir NH, Raina SK, Sivaraj N, Dikshit N and Pala NA (2022). Diversity and ecological niche modelling studies in *Trifolium repens* L. (white clover) in the region of north-western Himalaya, India. *Genetika* 54(3): 1083-1100

Akhtar J, Kumar P, Kiran R, Meena BR, Sadhana, Gupta V, Pandey S and Dubey SC (2023). First report of *Diaporthe phaseolorum* infecting Indian trumpet flower (*Oroxylum indicum*) from India. *BioResources* 18(2): 3101-3108

Akhtar J, Kumar P, Kiran R, Meena BR, Tripathi A, Sadhana, Pandey S and Dubey SC (2023). First report of *Diaporthe helianthi* infecting safflower: A threat to its cultivation in India. *J Phytopath.* 171: 145-149

Anuradha N, Patro TSSK, Triveni U, Jogarao P, Priya PK, Elangovan M and Pandey S (2023). Assessment of Genetic Diversity in Finger Millet [*Eleusine coracana* (L.) Gaertn.] Genotypes. *Indian Journal of Plant Genetic Resources* 36 (1): 105-115

Aochen C, Kumar A, Jaiswal S, Kekungu PU, Shimray PW, Hajong S, Sangma RHC, Aochen S, Iangrai B, Bhattacharjee B, Jamir L, Angami T, Pattanayak A and Mishra VK (2023). *Perilla frutescens* L.: A dynamic food crop worthy of future challenges. *Frontiers in Nutrition* doi: 10.3389/fnut.2023.1130927

Arya RK, Dahiya GS, Kumar R, Gill RK, Tiwari JK, Yadav CB, Raiger HL, Kumar S and Kant K (2023). Development of novel faba bean (*Vicia faba* L.) for release as a new cultivar with high yield and protein content. *Genetic Resources and Crop Evolution* 1-12.

Ashvin Kumar K, Hossain F, Zunjare R, Chhabra R, Vinutha T, Duo H, Kumar B, Karjagi C, Jacob S, Pandey S, Naga NC, Vasudev S and Muthusamy V (2023). Multilocus functional characterization of indigenous and exotic inbreds for dgat1-2, fatb, ge2 and wri1a genes affecting kernel oil and fatty acid profile in maize. *Gene* 895.

Aswin M, Yadav MC, Gopalakrishnan S, Tiwari S and Mondal TK (2023). Phenotypic characterization of crop genetic resources of AA-genome species in rice (*Oryza* spp.). *Indian J Plant Genet Resour.* 36(3): 402-414

Aswin M, Yadav MC, Tiwari S, Bairwa RK, Gopalakrishnan S, Rana MK, Singh R and Mondal TK (2023). Population structure and genetic differentiation analyses reveal high level of diversity and allelic richness in crop wild relatives of AA-genome species of rice *(Oryza sativa* L.) in India. *J. Appl. Genet.* 64: 645-666

Bairwa RK, Yadav MC, Gopalakrishnan S, Kushwaha AK and Joshi MA (2023). Morphological and molecular analyses of grain traits in aromatic rice landrace accessions from Indo-Gangetic plain region of India. *Indian J Plant Genet Resour.* 36 (2): 290-300

Bansal S, Sharma MK, Joshi P, Malhotra EV and Malik SK (2023). Meta-topolin mediated enhanced in vitro propagation and genetic integrity assessment in sweet potato (*Ipomoea batatas* (L.) Lam). *South African J. Bot.* 157: 27-36

Bansal S, Sharma MK, Singh S, Joshi P, Pathania P, Malhotra EV, Rajkumar S and Misra P (2023). Histological and molecular insights in to in vitro regeneration pattern of *Xanthosoma sagittifolium*. *Sci. Rep.* 13: 5806

Barik SR, Moharana A, Pandit E, Behera A, Mishra A, Mohanty SP, Mohapatra S, Shangamitra P, Meher J, Pani DR, Bhadana VP, Datt S, Sahoo CR, Reshmi Raj KR and Pradhans K (2023). Transfer of Stress- Resilient QTLs and Panicle Traits into the Rice Variety Reeta through Classical and Marker-Assisted Breeding Approaches. *Int. J. Mol. Sci.* 24

Bartwal A, John R, Padhi SR, Suneja P, Bhardwaj R, Wankhede DP and Archak S (2023). NIR spectra processing for developing efficient protein prediction Model in Mungbean. *Journal of Food Composition and Analysis,* 116

Basavaraj YB, Parameswari B, Kumar Ashwini, Jain RK and Tripathi S (2023). Papaya ring spot virus: Status of 80 years of global research: 135-172, Ed: Rajarshi Kumar Gaur, Basavaprabhu L. Patil, Ramasamy Selvarajan, Plant RNA Viruses, Academic Press, 2023, ISBN 9780323953399

Basavaraja T, Anupam T, Chandora R, Pratap A, Manjunatha L, Gurumurthy S, Singh M, Rana JC, Kumar SD, and Katiyar PK (2023). Evaluation of phenological development and agronomic traits in exotic common bean germplasm across multiple environments. *Plant Genetic Resources, Cambridge*. doi.org/10.1017/S1479262123 000618

Bhanushree N, Tomar BS, Akhtar J, Behera TK, Ellur RK, Sevanthi RMV, Jaiswal S and Saha P (2023). Genetic analysis and QTL identification for Phomopsis blight resistance in egg plant. *Plant Breeding* 142: 700-710

Bhardwaj R, Lone JK, Pandey R, Mondal N, Dhandapani R, Meena SK, Khan S and Gayacharan (2023). Insights into morphological and physio-biochemical adaptive responses in mungbean (*Vigna radiata* L.) under heat stress. *Front. Genet.* 14: 1206451

Bhardwaj R, Yadav R, Vishwakarma H, Sharma K, Chandora R, Rana JC and Riar A (2023). Agro morphological and nutritional assessment of chenopod and quinoa germplasm-Highly adaptable potential crops. *Food Science* & Nutrition, DOI: 10.1002/fsn3.3502

Bharti H, Das A, Mishra AK, Srivastava A, Mangal M and Sharma VK (2023). Phytophthora leaf blight resistance sources in *Capsicum annum* Leo and determination of isolate mating type. *Agricultural Mechanization in Asia*. 54(7): 15459-15467

Bhutia ND, Sureja AK, Verma M, Gopala Krishnan S, Arya L, Bhardwaj R, Dash PK and Das Munshi A (2023). Inheritance and molecular mapping of solitary/cluster fruit-bearing habit in Luffa. *Molecular Genetics and Genomics* 1-12

Bishnoi SK, Malav PK, Singh K, Phuke RM, Choudhary SB, Sharma HK and Ahlawat SP (2023). Eco-geographic Survey, In-situ Characterization and Spatial Analysis of Phenotypic Traits Diversity among the Maize Landraces Collected from Chhattisgarh. *Indian J Plant Genetic Resources* 36(2): 233-242

Chander S, Ghosh D, Pawar D, Dasari S, Chethan C. and Singh PK (2023). Elevated CO2 and temperature influence on crop-weed interaction in soybean. *Indian Journal of Weed Science* 55(3): 287–293

Chander S, Ghosh D, Tyagi VC, Chethan CR, Pawar D, Gharde Y, Kumar B and Singh PK (2023). Imazethapyr-Resistant Jungle Rice (*Echinochloa colona*) in Soybean Growing Belt of Central India: A Case Study. *Agricultural Research* 12: 298–307

Chander S, Gowthami R, Pandey R, Shankar M and Agrawal A (2023). Cryoconservation of in vitro grown shoot tips of *Cicer microphyllum*: a crop wild relative of chickpea. *Cryoletters* 44 (6): 360-368

Chandra T, Jaiswal S, Iquebal MA, Singh R, Gautam RK, Rai A and Kumar D (2023). Revitalizing miRNAs mediated agronomical advantageous traits improvement in rice. *Plant Physiol. Biochem*. 107933

Choudhury DR, Kumar R Maurya A, Semwal DP, Rathi RS, Gautam RK, Trivedi AK, Bishnoi SK, Ahlawat SP, Singh K, Singh NK, and Singh R (2023). SSR and SNP marker-based investigation of Indian rice land-races in relation to their genetic diversity, population structure, and geographical isolation. *Agriculture 13*(4): 823

Darjee S, Shrivastava M, Langyan S, Singh G, Pandey R, Sharma A, Khandelwal A and Singh R (2023). Integrated nutrient management reduced the nutrient losses and increased crop yield in irrigated wheat. *Archives of Agronomy and Soil Science 69*(8): 1298-1309

Das P, Grover M, Chauhan D, Mishra DC, Kumar S, Chaturvedi KK, Bhardwaj SC, Singh AK and Rai A (2023). Comparative transcriptome analysis of wheat isogenic lines provides insights into genes and pathways associated with stripe rust resistance. *Indian J. Genet. Plant Breed*. 25;83(01): 52-8

Das P, Grover M, Mishra DC, Guha Majumdar S, Shree B, Kumar S, Mir ZA, Chaturvedi KK, Bhardwaj SC, Singh AK and Rai A (2023). Genome-wide identification and characterization of *Puccinia striiformis*-responsive lncRNAs in *Triticum aestivum*. *Front Plant Sci*.15;14:1120898

Das S, Singh D, Meena HS, Jha SK, Kumari J, Chinnusami V and Sathee L (2023). Long-term nitrogen deficiency alters the expression of miRNAs and alters nitrogen metabolism and root architecture in Indian dwarf wheat (*Triticum sphaerococcum* Perc.) genotypes. *Sci Rep* 13: 5002

Dasari S, Pawar DV, Kumar R, Ratnakumar P, Sondhia S, Singh PK, Mishra JS, Chander S, Mukkamula N and Kumar BK (2023). Biochemical and physiological responses of rice as influenced by *Alternanthera paronychioides* and *Echinochloa colona* under drought stress. *Plant Growth Regulation* 103: 119-137

Deepika DD, Padhi SR, Gore Padmavati G, Tripathi K, Katral A, Chandora R, Abhishek GJ, Kondal V, Singh R, Bharadwaj R, Bhatt KC, Rana JC and Riar A (2023). Nutritional potential of Adzuki bean germplasm and mining nutri-dense accessions through multivariate analysis. *Foods* 12(22): 4159

Deepika DD, Tripathi K, Abhishek GJ, Singh N, Sharma R, Sharma VD, Maurya AK and Chalam VC (2023). Detection and identification of BCMV resistant germplasm in mungbean (*Vigna radiata*) using serological and molecular diagnostics. *Indian Journal of Agricultural Sciences* 93 (1): 98-101

Dev M, Kumar P, Singh S and Singh R (2023). Role of Mutant Phosphate Solubilizing Microorganism on Growth of *Brassica juncea* (L.) cv RH 30. *Indian Journal of Microbiology 63*(4): 461-466

Devindrappa M, Kamra A, Singh D, Gawade B and Sirohi A (2023). Plant growth promoting Bacillus species elicit defense against *Meloidogyne incognita* infecting tomato in polyhouse. *J Basic Microbiol*. 63(11):1233-1241

Dutta H, Shivaprasad KM, Aski MS, Mishra GP, Sinha SK, Dunna, Vijay, Manjunath Prasad CT, Das S, Pawar PAM, Mishra DC, Singh AK, Kumar A, Tripathi K, Kumar RR, Gupta S, Kumar S and Dikshit HK (2023). Morpho-biochemical characterization of a RIL population for seed parameters and identification of candidate genes

regulating seed size trait in lentil (*Lens culinaris* Medik.). *Frontiers in Plant Science* 14: 1091432

Elangovan M, Hariprasanna K, Pandey S, Pradheep K, Vetriventhan M, Alercia A, Cerutti AL and Lopez F (2023). Key descriptors for foxtail millet. ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India; ICAR-National Bureau of Plant Genetic Resources, New Delhi, India; International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Telangana, India and FAO on behalf of the International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy.https://doi.org/10.4060/cc7531en

Elangovan M, Hariprasanna K, Pandey S, Pradheep K, Vetriventhan M, Alercia A, Cerutti AL and Lopez F (2023). Key descriptors for fonio millets. ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India; ICAR-National Bureau of Plant Genetic Resources, New Delhi, India; International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Telangana, India and FAO on behalf of the International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy. https://doi.org/10.4060/cc8563en

Elangovan M, Singode A, Venkatesh K, Bellundagi A, Karthik S, Pandey S and Pandey CD (2023). Agro-morphological Characterization of Proso millet germplasm for Utilization. *International Journal of Plant & Soil Science* 35(16): 381-392

Francis A, Singh N, Singh M, Sharma P, Gayacharan, Joshi D, Semwal DP, Varshney N, Tyagi V, Wankhede D, Bhardwaj R, Singh Amit, Parida SK and Debasis C (2023). A near-complete genome assembly and pan genome of rice bean (*Vigna umbellata*) provide insights into the *Vigna* genome evolution and accelerated agronomic trait improvement. *Plant Biotech Journal.* doi: 10.1111/pbi.14075

Francis A, Singh N, Singh M, Sharma P, Gayacharan, Kumar D, Basu U, Bajaj D,Varshney N, Joshi D, Semwal DP, Tyagi V, Wankhede DP, Bharadwaj R, Singh A, Parida S and Chattopadhyay D (2023). The ricebean genome provides insight into *Vigna* genome evolution and facilitates genetic enhancement. *Plant Biotechnology Journal* (21):1522–1524

Gautam A, Khan FN, Priya S, Kumar K, Sharda S, Kaul T, Singh I, Langyan S and Yadava P (2023). Cloning and comparative modeling identifies a highly stress tolerant Cu/Zn cytosolic super oxide dismutase 2 from a drought tolerant maize inbred line. *PeerJ*. 11, p.e14845

Gautam RK, Singh PK, Krishnan S, Venkatesan K, Rao SS, Kumar MS, Vijayan J, Rakesh B, Soham Ray, Akhtar J, Meena BR, Langyan S and Krishnamurthy SL (2023). Marker assisted enhancement of bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) resistance in a salt tolerant rice variety for sustaining rice production of tropical islands. *Front. Plant Sci.* 15: 1221537

Gautam RK, Singh PK, Venkatesan K, Rakesh B, Sakthivel K, Swain S, Srikumar M, Zamir Ahmed SK, Devakumar K, Rao SS and Vijayan J (2023). Harnessing intra-varietal variation for agro-morphological and nutritional traits in a popular rice landrace for sustainable food security in tropical islands. *Frontiers in Nutrition* 10: 1088208

Gautam RK, Langyan S, Devi SV, Singh R, Semwal DP, Ali S, Mangat GS, Sarkar S, Bagchi TB, Roy S and Senguttuvel P (2023). Genetic resources of sticky rice in India: status and prospects. *Genetic Resources and Crop Evolution* 70(1): 95-106

Gavhane NA, Sarode SB, Gaikwad SA and Gomashe SS (2023). Assessment of Genetic Diversity in Linseed (*Linum usitatissimum* L.). *Emergent Life Sciences Research* 9(1): 43- 53

Gayacharan, Parida SK, Mondal N, Yadav R, Vishwakarma H and Rana JC (2023). Mining legume germplasm for genetic gains: An Indian perspective. *Front. Genet.,* 23;14: 996828

Gowda BC, Kumar A, Lal SK, J Akhtar J, Mishra GP, Tiwari SK, Kumar R and Javeria S (2023). Evaluation of biocontrol agents for management of fruit rot and its effect on seed quality in chilli. *Indian J Horticulture* 79 (4): 450-457

Gowthami R, Chander S, Pandey R, Shankar M and Agrawal A (2023). Development of efficient and sustainable droplet-vitrification cryo-conservation protocol for shoot tips for long-term conservation of Dahlia germplasm. *Sci. Hort.* 321: 112329

Gowthami R, Chander S, Pandey R, Shankar M and Agrawal A (2023). Development of cryoconservation protocol for In-vitro shoot bases of *Allium ampeloprasum* L. for long-term conservation. *Indian J. Plant Genet. Resour.* 36(3): 396-401

Gowthami R, Sharma N, Chandra R, Kurian JS, Malhotra EV and Agrawal A (2023). Development of an improved

and simple shoot tip cryoconservation protocol for cryobanking of *Bacopa monnieri* (L.) Wettst. Germplasm. *In Vitro Cell. Developmental Bio. Plant* 59: 74-756

Gupta K, Sankaran KV and Kumar PS (2023). Exchange of biological control genetic resources in India: prospects and constraints for access and benefit sharing. *BioControl* 68: 281–289

Haider MW, Kaur J, Bala R, Singh S, Srivastava P, Sharma A, Singh R and Kumari J (2023). Stripe rust resistance gene (s) postulation in wheat germplasm with the help of differentials and tagged molecular markers. *Scientific Reports 13*(1): 9007

Hemavati R, Rao GP, Chalam VC, Rawat K and Shreenath YS (2023). Mixed infection of phytoplasmas and potyvirus in *Phlox drummondii* in India. *Phytopathogenic Mollicutes* 13 (1): 89-90

Htwe CSS, Rajkumar S, Pathania P and Agrawal A (2023). Transcriptome Profiling during Sequential Stages of Cryopreservation in Banana (*Musa* AAA cv Borjahaji) Shoot Meristem. *Plants* 12: 1165

Jadav S, Kumar A, Lal SK, Akhtar J, Aski M, Mishra GP and Javeria S (2023). Effect of *Fusarium oxysporum* f. sp. *lentis* on seed quality parameters in lentil. *Indian J Plant Genet Resour* 35(4): 1-4

Janani R, Sureja AK, Dey SS, Krishnan SG, Bhardwaj R, Rudra SG and Tomar BS (2023). Selection of inbreds with better combining ability is instrumental in developing CMS-based heterotic hybrids in tropical carrot (*Daucus carota* L.). *Plant Genetic Resources 21*(3): 237-247

John R, Bartwal A, Jeyaseelan C, Sharma P, Ananthan R, Singh AK, Singh M, Gayacharan, Rana JC and Bhardwaj R (2023). Rice bean-adzuki bean multitrait near infrared reflectance spectroscopy prediction model: a rapid mining tool for trait-specific germplasm. *Frontiers in Nutrition 10*: 1224955

John R, Bollinedi H, Jeyaseelan C, Padhi SR, Nath D, Singh R, Ahlawat SP, Bhardwaj R and Rana JC (2023). Mining nutri-dense accessions from rice landraces of Assam, India. *Heliyon 9*(7)

Kale S, Indore N, Nath P, Kannaujia PK and Dukare A (2023). Low-cost inorganic phase change material improves the storage conditions of on-farm storage chamber. *J Food Process Eng.* e14395

Kanishka RC, Gayacharan, Basavraj T, Chandora R and Rana JC (2023). Moth bean (*Vigna aconitifolia*): a minor legume with major potential to address global agricultural challenges. *Front. Plant Sci.* 14: 1179547

Kannaujia PK, Dukare A, Kale S, Nath P and Singh RK (2023). Effect of mulch type on physico-chemical quality of tomato (*Solanum lycopersicum*) in semi-arid region of India. *Indian Journal of Agricultural Sciences* 93(6): 676–679

Kartar Singh, Ranebennur H, Rawat K, Meena VS, Chaoudhary M, Chalam VC, Ashutosh Rao, Shekhawat N, Meena BR, Chawla MP, Sharma M, Ram D and Singh GP (2023). First Report of *Candidatus Phytoplasma* asteris (16SrI-B Subgroup) associated with phyllody disease of moth bean in world. *Plant Disease* https:// doi/10.1094/PDIS-05-23-0963-PDN

Kashyap A, Kumari S, Garg P, Kushwaha R, Tripathi S, Sharma J, Gupta NC, Kumar RR, Yadav R, Vishwakarma H, Rana JC, Bhattacharya R and Rao M (2023). Indexing resilience to heat and drought stress in the wild relatives of rapeseed-Mustard. *Life 13*(3): 738

Kashyap A, Kumari S, Garg P, Kushwaha R, Tripathi S, Sharma J, Gupta NC, Kumar RR, Vishwakarma H, Bhattacharya R, Yadav R, Rana JC and Rao M (2023). Morpho-Biochemical Responses of Brassica Coenospecies to Glyphosate Exposure at Pre- and Post-Emergence Stages. *Agronomy* 13(7): 1831

Katoch A, Katoch S, Padder BA, Kapoor P, Singh M and Sharma PN (2023). Assessing anthracnose resistance in common bean accessions: identification of resistance genes using SCAR markers against *Colletotrichum lindemuthianum*. *Indian Phytopathology* doi.org/10.1007/s42360-023-00656-3

Kaur V, Gomashe SS, Aravind J, Yadav SK, Sheela, Singh D, Chauhan SS, Kumar V, Jat B, Tayade NR, Saroha A, Kaushik N, Langyan S, Singh S, Wankhede DP, Singh K, Kumar A and Singh GP (2023). Multi-environment phenotyping of linseed (*Linum usitatissimum* L.) germplasm for morphological and seed quality traits to assemble a core collection. *Ind. Crops Prod.* 206: 117657

Kaur V, Singh M, Wankhede DOP, Gupta K, Langyan S, Aravind J, Boopathi T, Yadav SK, Kalia S, Singh K and Kumar A (2023). Diversity of *Linum* genetic resources in global genebanks: From agro-morphological characterisation

to novel genomic technologies – A Review. *Front. Nutr.* 10: 1165580

Kaur V, Yadav SK, Arya SS, Aravind J, Jacob SR, and Gautam RK (2023). Development and evaluation of barley mini-core collection for salinity tolerance and identification of novel haplotypic variants for HvRAF. *Plant and Soil* 1-21

Kumar GP, Pathania P, Goya N, Gupta N, Parimalan R, Radhamani J, Gomashe SS, Kadirvel P and Rajkumar S (2023). Genetic Diversity and Population Structure Analysis to Construct a Core Collection from Safflower (*Carthamus tinctorius* L.) Germplasm through SSR Markers. *Agriculture* 13: 836

Kumar P, Akhtar J, Kiran R, Meena BR, Sadhana and Chalam VC (2023). Phylogenetic analysis and species level identification of seed-borne *Bipolaris, Exserohilum* and *Curvularia*. *Indian Phytopathology* 76: 115–121

Kumar S, Basu S, Aravind J and Anand A (2023). Assessment of storage potential of onion varieties using variables extracted from a mathematical model 4-parameter hill function (4-PHF). Seeds 2: Multidisciplinary Digital Publishing Institute: 195–207. https://doi.org/10.3390/seeds 2020015

Kumar S, Saini DK, Jan F, Jan S, Tahir M, Djalovic I, Latkovic D, Khan MA, Kumar S, Vikas VK and Kumar U (2023). Comprehensive meta-QTL analysis for dissecting the genetic architecture of stripe rust resistance in bread wheat. *BMC Genomics* 24 (1): 1-9

Kumari J, Lakhwani D, Jakhar P, Sharma S, Tiwari S, Mittal S, Avashthi H, Shekhawat N, Singh K, Mishra KK, Singh R, Yadav MC, Singh GP and Singh AK (2023). Association mapping reveals novel genes and genomic regions controlling grain size architecture in mini core accessions of Indian National Genebank wheat germplasm collection. *Frontiers in Plant Science* 14: 1148658

Kumari M, Padhi SR, Chourey SK, Kondal V, Thakare SS, Negi A, Gupta V, Arya M, Yasin JK, Singh R, Bharadwaj C, Kumar A, Bhatt KC, Bhardwaj R, Rana JC, Joshi T and Riar A (2023). Unveiling diversity for quality traits in the Indian landraces of horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.]. *Plants* 12 (22): 3803

Kumari N, Choudhary SB, Amrapali S, Jha BK, Sharma HK, Kumar CB and Singh ON (2023). Status, changing landscape and farmers' criteria for the continuity of paddy (*Oryza sativa*) landraces in the upland ecosystem of Jharkhand, India: A conservation perspective. *Genet Resour Crop Evol* 70: 2773-2783

Kumawat KL, Raina SK, Kumar D, Verma MK, Singh DB, Mir JI, Sultan SM and Sharma OC (2023). Association of reproductive phenology with air temperature in almond (*Prunus dulcis* [Mill.] DA Webb) cultivars under North Western Himalayan conditions. Erwerbs-Obstbau. https://doi.org/10.1007/s10341-023-00991-9

Langyan S, Yadava P, Khan FN, Sharma S, Singh R, Bana RS and Kumar A (2023). Trends and advances in pre-and post-harvest processing of linseed oil for quality food and health products. *Critical Reviews in Food Science and Nutrition* 1-24

Laxmisha KM, Bhatt KC, Arya M, Bhardwaj R, Semwal DP and Gupta V (2023). Agro-morphological characterization and digitization of Job's Tears (*Coix lacryma-jobi* L.) germplasm: a minor cereal crop of north-eastern India. *Indian Journal of Plant Genetic Resources* 36 (3): 362-370

Madhubala R, Nakkeeran S, Anitha K, Renuka Devi P and Malathi VG (2023). Seed transmission of an Indian isolate of Cucumber mosaic virus infecting chilli (*Capsicum annuum* L.). *Int. j. plant soil sci.* 35 (22): 1-8

Madhubala R, Nakkeeran S, Anitha K, Renukadevi P, Prasanthi Y and Malathi VG (2023). Occurrence and confirmation of Cucumber mosaic virus infecting chilli (*Capsicum annuum* L) of Telangana. *Pharm. Innov*. 12(7): 1744-1748

Mahapatra S, Sureja AK, Behera TK, Bhardwaj R and Verma M (2023). Variability in antioxidant capacity and some mineral nutrients among ninety-one Indian accessions of bottle gourd [*Lagenaria siceraria* (Molina) Standl.]. *South African Journal of Botany* 152: 50-62

Malhotra EV, Bansal S, Pathania P, Mali SC and Agrawal A (2023). Regeneration of plantlets through protocorm-like bodies: An alternative method for vanilla micro propagation. *Indian J. Biotech*. 20: 388-395

Manju A, Sindhumole P, Joseph Jiji, Pradheep K, Sangeeta Kutty M and Seeja TP (2023). Estimation of heterosis in hybrid seedlings of drumstick (*Moringa oleifera*). *Biological Forum – An International Journal* 15(9): 424-428

Manju A, Sindhumole P, Joseph Jiji, Pradheep K, Sangeeta Kutty M and Seeja TP (2023). Reproductive biology of

two *Moringa oleifera* L. varieties PKM1 and Jaffna under Kerala condition. *The Pharma Innovation Journal* 12(9): 2408-2413

Manju, Yadav SK, Wankhede DP, Saroha A, Jacob SR, Pandey R, Sharma AD, Sheela, Kumar M and Kaur V (2023). Screening of barley germplasm for drought tolerance based on root architecture, agronomic traits, and identification of novel allelic variants of *HVA1*. *J. Agron. Crop Sci*. 209: 705–723

Meena NL, Maheshwar C and Tyagi A (2023). Computational study of Sucrose non-fermenting 1-related kinase 2 (SnRK2): An in-silico approach for homology modelling and structural characterization of drought-related SAPK9 gene in rice (*Oryza sativa* L.). *Genetic Resources and Crop Evolution*, https://doi.org/10.1007/s10722-023-01642-4

Meena VS, Singh K, Shekhawat N, Bhardwaj R, Lal H, Rani K, Gupta V, Kumar A, Singh A, Gora JS and Kumar P (2023). Assessment of Genetic Variability for Fruit Nutritional Composition in the Ex-Situ Collection of Jujube (*Ziziphus spp*.) Genotypes of Arid Regions of India. *Horticulturae 9*(2): 210

Meena VS, Singh K, Shekhawat N, Gupta V and Kumar A (2022). Genetic Variability of Ker (*Capparis decidua*) Germplasm in Hot Arid Region of India. *Annals of Arid Zone* 61(3&4): 203-207

Mehta S, Dhawi F, Garg P, Rao M, Bhattacharya RC, Akthar J, Yadav R, Singh M, Singh K and Nallathambi P (2023). Potential Source of Resistance in Introgressed, Mutant and Synthetic *Brassica juncea* L. Lines against Diverse Isolates of White Rust Pathogen, *Albugo candida*. *Agronomy* 13(5): 1215

Mehta S, Rao M, Bhattacharya RC, Akhtar J, Yadav R, Singh M, Nallathambi P, Meena PD, Gangwar GP, Harun M and Gupta AK (2023). Novel broad range resistance sources against pan India isolates of *Albugo candida* causing white rust disease of oilseed brassica. *Gesunde Pflanzen* 75(6): 1-11

Mir ZA, Chandra T, Saharan A, Budhlakoti N, Mishra DC, Saharan MS, Mir RR, Singh AK, Sharma S, Vikas VK and S Kumar (2023). Recent advances on genome-wide association studies (GWAS) and genomic selection (GS); prospects for Fusarium head blight research in Durum wheat. *Mol. Bio. Rep*. 50(4): 3885-901

Mir ZA, Chauhan D, Pradhan AK, Srivastava V, Sharma D, Budhlakoti N, Mishra DC, Jadon V, Sahu TK, Grover M and Gangwar OP (2023). Comparative transcriptome profiling of near isogenic lines PBW343 and FLW29 to unravel defense related genes and pathways contributing to stripe rust resistance in wheat. *Funct. Integr. Genomics*. 23(2): 169

Misra RC (2023). *Abelmoschus odishae* (Malvoideae: Malvaceae): a new wild okra from tropical Eastern India. *Phytotaxa* 607 (5): 291-300

Misra RC and Singh PK (2023). *Malva sylvestris* L. (Malvaceae): A new distributional species record for Odisha and Eastern India. *e - planet* 21 (1): 35-39

Misra RC, Raina AP, Singh PK and Singh GP (2023). *Ocimum basilicum* var. *pilosum* (Willd.) Benth: A new distributional record of wild sweet basil from Odisha. e - *planet* 21 (2): 144-149

Mohanty SP, Nayak DK, Sanghamitra P, Barik SR, Pandit E, Behera A, Pani DR, Mohapatra S, Reshmi Raj KR, Pradhan KR, Sahoo CR, Mohanty MR, Behera CR, Panda A, Jena BK, Behera L, Dash PK and Pradhan SK (2023). Mapping the Genomic Regions Controlling Germination Rate and Early Seedling Growth Parameters in Rice. *Genes* 14(4): 902

Mohapatra KP, Mahajan R, Langyan S, Kumar S, Sarkar S, Semwal DP, Soyimchiten and Chandra P (2023). Indian horse chestnut *[Aesculus indica* (Wall.ex Cambress.) Hook. Hippocastanaceae]: a wild forest tree used for food and medicine by the tribes of Chamba, Himachal Pradesh, India. *Genet Resour Crop Evo*. doi.org/10.1007/s10722-022-01455-x

Nagar A, Gowthami R, Sureja AK, Munshi AD, Verma M, Singh AK, Mallick N, Singh J, Chander S, Shankar M, Pathani P and Rajkumar S (2023). Simple cryopreservation protocol for Luffa pollen: enhancing breeding efficiency. *Front. in Plant Sci*. 14: 1268726

Nagar A, Sureja AK, Pandey C, Verma M, Arya L, Gupta N and Munshi AD (2023). Effects of Different Treatments on Seed Germination and Breaking Seed Dormancy in Wild Luffa Species. *Indian J. Plant Genetic Resources*. 36(3): 429-433

Nair B, Biradar VK, Nagaich VP, Singh CM, Singh BK, Kumar SB, Shah KM, Tekale ND, Jadhav RA, Tripathi A, Kumar

S, Aravind J, Gupta K, Kumar A and Kaur V (2023). Multi-environment screening of *Linum* germplasm collection for dissecting the potential of bud fly (*Dasyneura lini* Barnes) resistance and assembling a reference set for efficient utilization in genetic improvement. *Ind. Crops Prod.* 207: 117743

Natarajan RB, Pathania P, Singh H, Agrawal A and Subramani R (2023). A Flow Cytometry-Based Assessment of the Genomic Size and Ploidy Level of Wild *Musa* Species in India. *Plants* 12: 3605

Nehra A, Gothwal DK, Yadav R, Jakhar ML, Rajesh C, Jeeterwal and Kunwar R (2023). Gene action for morpho-biochemical traits of sesame (*Sesamum indicum*) in different environments. *Indian J. of Agri. Sci.* 93(3): 263-268

Nishmitha K, Singh R, Dubey SC, Akhtar J, Tripathi A, Baishal BM and Kamil D (2023). Expression profiling and characterization of key RGA involved in lentil *Fusarium* wilt Race 5 resistance. *World J Microbiol Biotech* 39: 306

Nishmitha K, Singh R, Dubey SC, Akhtar J, Tripathi K and Kamil D (2023). Resistance screening and in-silico characterization of cloned novel RGA from multi-race resistant Lentil germplasm against Fusarium wilt (*Fusarium oxysporum* f. sp. *Len* lentils. *Front. Plant Sci.* 14: 1147220

Nithya K, Kiran K, Parameswari B and Tiwarekar B (2023). Updates on phytoplasma diseases associated with sugarcane in Asia. ISBN 9780323918978. Editor(s): A.K. Tiwari, Kadriye Caglayan, Trinh Xuan Hoat, Ali Al Subhi, Naghmeh Nejat, Gurivi Reddy, In Phytoplasma Diseases in Asian Countries, Phytoplasma Diseases of Major Crops, Trees, and Weeds. Academic Press 2: 215-232

Nithya K, Parameswari B, Adhini SP, Annadurai A, Nithyanantham R and Viswanathan R (2023). Identification of Sugarcane yellow leaf virus resistance in Saccharum parental hybrids in India. *J. Sugarcane Res.* https://doi.org/10.37580 /JSR.2021.2.11.205-211.

Nithya K, Parameswari B and Kumar S (2023). Prospecting true ScYLV resistance in Saccharum hybrid parental population in India by symptom phenotyping and viral titre quantification. *3 Biotech* 13: 125

Palanisamy M, Singh GJ, Kalia P, Pandey CD, Raman S, Kumara, Kumar S and Tomar BS (2023). Screening and validation of Ty-1, Ty-3 and Ty-3a specific markers in Solanum chilense accessions for resistance to tomato leaf curl virus. *Genet Resour. Crop Evo.* 70: 2567–2574

Panda RR, Pandey A, Gupta S and KC Bhatt (2023). Use of fruit and seed characters for identification of edible *Artocarpus* species in India. *Indian Journal of Plant Genetic Resources* 36 (2): 309-312

Pandey A, Nivedhitha S, Pradheep K, Malav PK Gupta R and Ahlawat SP (2023). An Overlooked Weed "Purpletop Vervain" *Verbena incompta* P. W. Michael (Verbenaceae) Forms a New Record to the Flora of India. *Indian J. Plant Genetic Resources* 36(1): 56-61

Pandey B, Yadav R, Ramawat N, Vishwakarma H and Pandey S (2023). Optimization of sowing dates in Indian mustard (*Brassica juncea* L.) to combat yield losses caused by high temperature at reproductive stage. *Plant Science Today* httpa://doi.org/10.14719/pst.2605

Panika N, Singh Y, Singh S, Sharma S and Pani D (2023). Multivariate analysis for evaluation of indigenous rice (*Oryza sativa* L.) accessions collected from Madhya Pradesh. *ORYZA-An International Journal of Rice* 60 (1): 132-139

Parameswari B, Bajaru B, Karthikaiselvi L, Sivaraj N, Mangrauthia SK, Nagalakshmi S, Prasanna H, Srinivas M, Chalam VC and Anitha K (2023). First report of the association of *Zygocactus Virus X* with dragon fruit (*Hylocereus* spp.) plants from Telangana, India. *Plant Disease* 107: 1249

Parameswari B, Bhaskar B, Karthikaiselvi, Sivaraj N, Pranusha P, Brahmi P, Mangrauthia SK, Saravanan L, Chalam VC and Anitha K (2022). Interception of *Bean common mosaic virus* in bambara groundnut accessions imported from Ghana through reverse transcription polymerase chain reaction (RT-PCR). *Indian Journal of Plant Protection* 50: 2&3: 80-85

Parameswari B, Sharma SK, Karthikaiselvi L, Baby Wangkhem, Nithya K, Viswanathan R, Rao GP, Chalam VC and Anitha K (2023). A simplified isothermal recombinase polymerase amplification assay for detection of *Sugarcane bacilliform virus* infection. *Sugar Tech*. https://doi.org/10.1007/s12355-023-01258-z

Patidar A, Yadav MC, Kumari J, Tiwari S, Chawla G and Paul V (2023). Identification of Climate-Smart Bread Wheat Germplasm Lines with Enhanced Adaptation to Global Warming. *Plants* 12(15): 2851

Patil HE, Pali V, Elangovan M, Vadodariya GD, Ramani MP, Pandey S and Pandey CD (2023). Genetic Analysis for Yield and Morphological Traits in Finger Millet [*Eleusine coracana* (L.) Gaertn.]. *Biological Forum* 15(2): 1-7

Plaha NS, Kaushik N, Awasthi S, Singh M, Kaur V, Langyan S, Kumar A and Kalia S (2023). Comparison of nutritional quality of fourteen wild Linum species based on fatty acid composition, lipid health indices, and chemometric approaches unravelling their nutraceutical potential. *Heliyon 9*(11)

Pooja BK, Sethi S, Bhardwaj R, Chawla G, Kumar R, Joshi A and Bhowmik A (2023). Isoelectric precipitation of protein from pea pod and evaluation of its physicochemical and functional properties. *Vegetos* 1-11

Pradhan AK, Budhlakoti N, Chandra Mishra D, Prasad P, Bhardwaj SC, Sareen S, Sivasamy M, Jayaprakash P, Geetha M, Nisha R and Shajitha P (2023). Identification of Novel QTLs/Defense Genes in Spring Wheat Germplasm Panel for Seedling and Adult Plant Resistance to Stem Rust and Their Validation Through KASP Marker Assays. *Plant Dis.* 107(6): 1847-1860

Pradheep K, Parimalan R, John KJ, Nissar VM, Jaisankar I, Thirumalaisamy PP and Latha M (2023). A note on taxonomy and genetic resource potential of *Oryza meyeriana* var. *indandamanica*, a rare wild relative of rice from the Andaman Islands. *Indian J. Plant Genet. Resour.* 36(03): 422-428

Prathyusha BV, Swathi E, Divya D, Bhaskar Reddy BV, Bentur JS, Chalam VC, Wankhede DP, Singh K and Anitha K (2023). Field and agroinoculation screening of national collection of urd bean (*Vigna mungo*) germplasm accessions for new sources of *mung bean yellow mosaic virus* (MYMV) resistance. *3 Biotech* 13: 194

Priyadarshi MB, Sharma A, Chaturvedi KK, Bhardwaj R, Lal SB, Farooqi MS, Kumar S, Mishra DC and Singh M (2023). Comparing various machine learning algorithms for sugar prediction in chickpea using near-infrared spectroscopy. *Legume Research-An International Journal 46*(2): 251-256

Puneeth GM, Gowthami R, Vasudeva R, Laxmisha KM and Archak S (2023). Circa situm Conservation of Tree Genetic Resources: A Case Study from the Central Western Ghats of Karnataka, India. *Indian J. Plant Genet. Resour.* 36 (03): 415-21

Raina AP and Misra RC (2023). Bio-molecular variability of different *Ocimum* species in India. *Medicinal Plants* 15(2): 369-377

Raina AP and Misra RC (2023). Phytochemical evaluation of *Costus speciosus* (Koen.) J.E.Sm. germplasm from Eastern India - An important antidiabetic plant. Medicinal Plants - *International Journal of Phytomedicines and Related Industries* 15(4): 723-731

Ramalingappa PL, Shrivastava M, Dhar S, Bandyopadhyay K, Prasad S, Langyan S, Tomer R, Khandelwal A, Darjee S and Singh R (2023). Reducing options of ammonia volatilization and improving nitrogen use efficiency via organic and inorganic amendments in wheat (*Triticum aestivum* L.). *PeerJ 11*, p.e14965

Ramya KR, Gupta R, Mishra M, Pandey A, Tripathi K, Bhatt KC and Singh R (2023). A modified DNA isolation protocol for high-quality DNA and long-term storability in Grass pea (*Lathyrus sativus* L.). *Indian J. Genet. Plant Breed*. 83 (4): 602-604

Rane P, Thakre M, Verma MK, Prakash J, Kumar C, Srivastava V, Shashank PR and Murukan N (2023). Standardization of pollen collection method and in vitro pollen germination media in grapes. *Pharma Inn. J.* 12(12): 3159-3161

Rangan P (2023). Vavilov's law of homologous series of variation – its relevance in the genomics era. *Phytomorphology* 73: 25-28

Rangan P, Henry R, Wambugu P and Periyannan S (2023) Editorial: Plant genetic and genomic resources for sustained crop improvement. *Front. Plant Sci.* 14: 1266698

Rangan P, Pradheep K, Archak S, Smykal P and Henry R (2023). Editorial: Genomics and phenomics of crop wild relatives (CWRs) for crop improvement. *Front. Plant Sci.* 14: 1221601

Rangan P, Pradheep K, Mahalingam A, Mohan J, Yadav R and Singh K (2023). Trans situ conservation strategies to conserve the extinction risk species, *Sesamum prostratum* Retz., a crop wild relative of sesame being endemic to coastal strand habitat: a case study. *Genet. Resour. Crop Evol*. 71: 511-517

Rao D, Yadav S, Choudhary R, Singh D, Bhardwaj R, Barthakur S and Yadav SK (2023). Silicic and Humic acid Priming

Improves Micro- and Macronutrient Uptake, Salinity Stress Tolerance, Seed Quality, and Physio-Biochemical Parameters in Lentil (*Lens culinaris* spp. *culinaris*). *Plants 12*: 3539

Roy S, Priyanka, Sahi AN, Radhamani J and Kumar R (2023). High-throughput screening identifies robust root trait in Indian mustard seedlings grown under salinity stress. *Genet. Resour. Crop Evol*. https://doi.org/10.1007/s10722-023-01743-0

Ruperao P, Bajaj P, Rajkumar S, Yadav R, Lachagari VBR, Lekkala SP, Rathore A, Archak S, Angadi UB, Singh R, Singh K, Mayes S and Rangan P (2023). A pilot-scale comparison between single and double-digest RAD markers generated using GBS strategy in sesame (*Sesamum indicum* L.). *PLoS One*. 18(6): e0286599.

Ruperao P, Rangan P, Shah T, Thakur V, Kalia S, Mayes S and Rathore A (2023). The progression in developing genomic resources for crop improvement. *Life* 13: 1668

Sagore B, Singh K, Prakash J, Singh SK, Srivastava V, Vignesh M and Yadav BK (2023). Effect of plant growth regulators on fruit quality of papaya. *Pharma Inn. J.* 12(8): 481-485

Sagore B, Singh K, Prakash J, Srivastava V, Vignesh M and Yadav BK (2023). Elucidating the effect of plant bioregulators on embryo maturation for shortening the breeding cycle in papaya. *In. J. Hortic*. 80(3): 233-238

Sakthivel K, Manigundan K, Gautam RK, Singh PK, Balamurugan A, Kumar A and Sharma SK (2023). Microbe-enriched farm yard manure (MFYM) approach for the suppression of *Ralstonia solanacearum* Yabuuchi (Smith) inciting bacterial wilt disease in eggplant (*Solanum melongena* L.). *Plant and Soil* 491(1): 303-315

Sakthivel K, Manigundan K, Sharma SK, Singh R, Das MM, Devi V, Gautam RK, Nakkeeran S and Kumar A (2023). Diversity of antimicrobial peptide genes in Bacillus from the Andaman and Nicobar Islands: untapped island microbial diversity for disease management in crop plants. *Current Microbiology* 80(1): 45

Saravanan L, Nivedhitha S, Pranusha P, Sivaraj N, Pandravada SR, Padmasri A and Anitha K (2023). Evaluation of cowpea [*Vigna unguiculata* (L) W alp.] germplasm against pulse beetle, *Callosobruchus chinensis* (L.) and correlation with morphological seed characters. *Legum. Res*. 46(2): 238-242

Saroha A, Gomashe SS, Kaur V, Pal D, Ujjainwal J. Aravind, Singh M, Rajkumar S, Singh K, Kumar A and Wankhede DP (2023). Genetic dissection of thousand-seed weight in linseed (*Linum usitatissimum* L.) using multi-locus genome-wide association study. *Frontiers in Plant Science* 14: 1166728

Saroha A, Gomashe SS, Kaur V, Pal D, Ujjainwal S, Aravind J, Singh M, Rajkumar S, Singh K, Kumar A and Wankhede DP (2023). Genetic dissection of thousand-seed weight in linseed (*Linum usitatissimum* L.) using multi-locus genome-wide association study. Front. Plant Sci. 14: 1166728

Sasane PR, Vaidya ER, Deshmukh DT, Gomashe SS, Burghate SK, Walke RD and Raut YC (2022). Effect of gamma irradiation on quantitative traits of two genotypes of sesame crop in M1 generation. *The Pharma Innovation Journal* 11(7): 3666-366

Shankar M, Gowthami R, Tripathi K, Deepak DA, Barpete A and Agrawal A (2023). In vitro germination and cryopreservation technique for long-term pollen conservation of underutilized legume: Grasspea (*Lathyrus sativus*). *Indian J. Agric. Sci*. 93 (2): 205–209

Shankar TU, Semwal DP, Gupta V, Archak S, Nair RM and Tripathi K (2023). Spatial Distribution, Diversity Mapping, and Gap Analysis of Wild *Vigna* Species Conserved in India's National Genebank. *Diversity* 15(4): 552

Sharma D, Kumari A, Sharma P, Singh A, Sharma A, Mir ZA, Kumar U, Jan S, Parthiban M, Mir RR and Bhati P (2023). Meta-QTL analysis in wheat: progress, challenges and opportunities. *Theor. Appl. Genet*. 136 (12): 1-25

Sharma P, Goudar G, Chandragiri AK, Ananthan R, Subhash K, Chauhan A, Longvah T, Singh M, Bhardwaj R, Parida SK and Singh AK (2023). Assessment of diversity in anti-nutrient profile, resistant starch, minerals and carbohydrate components in different ricebean (*Vigna umbellata*) accessions. *Food Chemistry* 405: 134835

Shruti, Shukla A, Rahman SS, Suneja P, Yadav R, Hussain Z, Singh R, Yadav SK, Rana JC, Yadav S and Bhardwaj R (2023). Developing an NIRS Prediction Model for Oil, Protein, Amino Acids and Fatty Acids in Amaranth and Buckwheat. *Agriculture 13*(2): 469

Singh A, Mahato AK, Maurya A, Subramani R, Singh AK, Bhardwaj R, Kaushik SK, Kumar S, Gupta V, Singh K and

Singh R (2023). Amaranth Genomic Resource Database (AGRDB): an integrated database resource of Amaranth genes and genomics. *Front. Plant Sci.* 14: 1203855

Singh B, Singh S, Mahato AK, Dikshit HK, Tripathi K and S Bhatia (2023). Delineation of novel genomic loci and putative candidate genes associated with seed iron and zinc content in lentil (*Lens culinaris* Medik.). *Plant Science 335*: 111787

Singh C, Kumar R, Sehgal H, Bhati S, Singhal T, Gayacharan, Nimmy MS and Kumar R (2023). Unclasping potentials of genomics and gene editing in chickpea to fight climate change and global hunger threat. *Front. Genet*. 14: 1085024

Singh K, Kumar M, Rawat K, Ranebennur H, Meena VS, Shekhawat N, Meena BR, Sharma M, Chawala MP, Jadon KS, Ram D, Rao GP and Choudhary M (2023). First Report of Candidatus Phytoplasma asteris (16SrI-B subgroup) associated with phyllody disease of fenugreek in the world. *Plant Dis*. doi: 10.1094/PDIS-12-22-2882-PDN

Singh M, Palit P, Kaur K, Aminedi R, Paliwal A and Randhawa G (2023). Loop-mediated isothermal amplification targeting proteinase inhibitor II terminator sequence: an efficient approach for screening of genetically modified crops. *Eur. Food Res.Technol*. 249: 2311-2319

Singh M, Paliwal A, Kaur K, Palit P and Randhawa G (2023). Development and utilization of analytical methods for rapid GM detection in processed food products: a case study for regulatory requirement. *J. Plant Biochem. Biotechnol*. 32: 511-524

Singh M, Papazova N, Aminedi R, Fraiture MA, Roosens N and Randhawa G (2023). Approaches to check unauthorized genetically modified events in supply chain: Challenges and solutions in the Indian context. *JSFA Rep*. 3(5): 184-195

Singh R, Singh A, Mahato AK, Paliwal R, Tiwari G and Kumar A (2023). De Novo Transcriptome Profiling for the Generation and Validation of Microsatellite Markers, Transcription Factors, and Database Development for Andrographis paniculata. *Int. J. Mol. Sci*. 24: 9212

Singh Ranjana, Arya Mamta, Verma VC and Bisht IS (2023). Genetic Diversity and Food Value of Black Soybean (*Glycine max* (L.) Merr.) in Uttarakhand Hills, North Western India. *Proc. Natl. Acad. Sci.* doi.org/10.1007/s40011-023-01446-7

Singh S, Solomon S, Vijay Anand KG and Ghosh A (2023). Environmental benefits of an alternative practice for sugarcane cultivation using Gracilaria-based seaweed biostimulant. *Sugar Tech* 25(2): 440-452

Singh VK, Chaturvedi D, Pundir S, Kumar D, Sharma R, Kumar S, Sharma S and Sharma S (2023). GWAS scans of cereal cyst nematode (*Heterodera avenae*) resistance in Indian wheat germplasm. *Mol. Genet. Genomics*. 298(3): 579-601

Sivaraj N, Anitha K, Parameswari B, Saravanan L, Holajjer P, Bhaskar B, Karunakaran G, and Srinivas Rao M (2023). Potential Avocado growing regions in India; An ecological niche modeling approach. *J. Plant Dev. Sci.* 15(3): 157-167

Sonia, Kaur V, Yadav SK, Arya SS, Aravind J, Jacob SR and Gautam RK (2023). Development and evaluation of barley mini-core collection for salinity tolerance and identification of novel haplotypic variants for HvRAF. Plant Soil, November. https://doi.org/10.1007/s11104-023-06397-6

Sood S, Malhotra N, Tripathi K, Laibach N and Rosero A (2023). Editorial: Food of the future: underutilized foods. *Front Nutr*. 7;10: 1307856

Srivastav M, Radadiya N, Ramachandra S, Jayaswal PK, Singh N, Singh S, Mahato AK, Tandon G, Gupta A, Devi R, Subrayagowda SH, Kumar G, Prakash P, Singh S, Sharma N, Nagaraja A, Kar A, Rudra SG, Sethi S, Jaiswal S, Iquebal MA, Singh R, Singh SK and Singh NK (2023). High resolution mapping of QTLs for fruit color and firmness in Amrapali/Sensation mango hybrids. *Front Plant Sci.* 14: 1135285

Sultan, SM, Raina SK, Suheel A and Bhat SS (2023). Characterization and Evaluation of *Faba* Bean (*Vicia faba* L.) Germplasm Collected from Kashmir, India. *Indian Journal of Plant Genetic Resources* 36(3): 346-355

Suma AA, John JK, Bhat KV, Latha M, Lakshmi CJ, Pitchaimuthu M, Muhammed Nissar VA, Thirumalaisamy PP, Pandey CD, Pandey S, Kumar A, Gautam RK and Singh GP (2023). Genetic enhancement of okra [*Abelmoschus esculentus* (L.) Moench] germplasm through wide hybridization. *Frontiers in Plant Science* 14: 1284070

Tacconi F, Waha K, Ojeda JJ, Leith P, Mohammed C, Venables WN, Rana JC, Bhardwaj R, Yadav R, Ahlawat SP, Hammond J and Wijk MV (2023). Farm diversification

strategies, dietary diversity and farm size: Results from a cross-country sample in South and Southeast Asia. *Global Food Security* 38: 100706

Talang H, Yanthan A, Rathi RS, Pradheep K, Longkumer S, Imsong B, Singh LH, Assumi RS, Devi MB, Kumar A, Ahlawat SP, Bhatt KC and Bhardwaj R (2023). Nutritional evaluation of some potential wild edible plants of North Eastern region of India. *Frontiers in Nutrition* 10: 1052086.

Thakur G, Paul S, Gautam RK and Langyan S (2023). Revelation of Genotype×Environment Interaction in Linseed (*Linum usitatissimum* L.) Under Conventional and Natural Farming Production Systems in the North-Western Himalayas. *Journal of Food Quality* 4: 1-16.

Thirumalaisamy PP, Parameswari B, Karthikaiselvi L, Amal TC, Pradheep K, Chalam VC, Suma A, Latha M, Senthilraja G, Anitha K, Manivannan A and Mahalingam A (2023). Phytoplasma association with phyllody of Sesamum species in India. *Trop. Plant Pathol.* 48: 594-603

Tiwari SK, Pandey CD, Bhardwaj R, Kumar R, Chaubey T, Binod K Singh, Pradip Karmakar, Suresh Reddy Y, Devi Jyoti, Pandey Sushil and Behera TK (2023). Unique germplasm of vegetable crops in India. *Indian Horticulture* 68(2): 45-55

Tomar A, Pandey A, Bhatt KC, Panwar NS and Ahlawat SP (2023). NBPGR-PDS: A precision tool for plant germplasm collecting. *Indian Journal of Plant Genetic Resources* 36(2): 250-255

Tripathi A, Akhtar J, Kalaiponmani K, Dubey SC and Chalam VC (2023). Quadruplex and q-PCR based diagnostic assay to delineate the major quarantine and other seed-borne fungal pathogens of soybean. *World Journal of Microbiology and Biotechnology* 39: 233

Tripathi A, Akhtar J, Kumar P, Kalaiponmani K, Chalam VC (2023). Diagnostic assay for molecular detection of *Bipolaris maudis* and *Stenocarpella maudis* for safe exchange long-term conservation of maize germplasm. *PhysiolMol Plant Pathol* 128: 102165

Tripathi A, Dubey SC, Akhtar J and Kumar P (2023). Development of PCR-based assays to diagnose the major fungal pathogens infecting pulse crops, potential for germplasm health certification and quarantine processing. *World Journal of Microbiology and Biotechnology* 39: 74

Tripathi K, Bhardwaj R, Gore Padmavati G, Pandey A, Sharma P, Pamarthi RK and Pandey R (2023). (IC0259504; INGR21055), a Wild Bean (*Vigna vexillata*) germplasm high protein content (9.5%) in tuber. Bold seededness. Fodder type. *Indian Journal of Plant Genetic Resources* 36(01): 167

Tripathi K, Pamarthi RK, Gore Padmavati G, Nagaraju S, Singh PK, Latha M, Ramya KR, Pratap A, Gautam RK, Rana JC and Singh GP (2023). Development and standardization of key descriptors for agro-morphological characterization in *Vigna stipulacea* (Lam.) Kuntze.: a potential legume for India. *Genet Resour Crop Evol* 71: 929-945

Tripathi K, Pamarthi RK, Semwal DP, Tyagi V, Brahmi P and Pandey A (2023). Efforts for the Revival of *Vigna subterranea* (L.) Verdc. (Bambara groundnut) through Germplasm Introduction in India. *Indian Journal of Plant Genetic Resources* 36(1): 116-121

Tyagi R, Bhardwaj R, Suneja P, Sureja AK, Munshi AD, Arya L, Riar A and Verma M (2023). Harnessing sponge gourd: an alternative source of oil and protein for nutritional security. *Frontiers in Nutrition* 10: 1158424

Upadhyay D, Budhlakoti N, Mishra DC, Kumari J, Gahlaut V, Chaudhary N, Padaria JC, Sareen S and Kumar S (2023). Characterization of stress-induced changes in morphological, physiological and biochemical properties of Indian bread wheat (*Triticum aestivum* L.) under deficit irrigation. *Genet. Resour. Crop Evol.* 70(8): 2353-66

Varalakshmi S, Smrutishree S, Singh NK, Pareek Navneet, Garkoti Priyanka, Senthilkumar V, Kashyap Shruti, Jaiswal JP, Jacob Sherry Rachel and Nankar AN (2023). Market-Trait Association for Protein Content among Maize Wild Accessions and Coix using SSR Markers. *Agronomy* 13(8): 2138

Vats G, Das D, Gupta R, Singh A, Maurya A, Rajkumar S, Singh AK, Bhardwaj R, Kumar S, Kaushik SK, Gupta V, Singh K and Singh R (2023). Validation of Genome-wide SSR markers developed for genetic diversity and population structure study in Grain Amaranth (*Amaranthus hypochondriacus*). *Agriculture* 13(2): 431

Wan C, Langyan S, Echeverría J, Devkota HP, Tewari D, Moosavi MA, Ezzat SM, Perez-Vazquez A, Fraga-Corral M, Cravotto G and Prieto MA (2023). Edible fruits and berries as a source of functional polyphenols: current scene and future perspectives. *Phytochemistry Reviews* 1-29

Yadav AK, Singh CK, Kalia RK, Mittal S, Wankhede DP, Kakani RK, Ujjainwal S, Aakash, Saroha A, Nathawat NS, Rani R, Panchariya P, Choudhary M, Solanki K, Chaturvedi KK, Archak S, Singh K, Singh GP and Singh AK (2023). Genetic diversity, population structure, and genome-wide association study for the flowering trait in a diverse panel of 428 moth bean (*Vigna aconitifolia*) accessions using genotyping by sequencing. *BMC Plant Biol.* 23(1): 228

Yerasu SR, Tiwari SK, Pandey CD and Pandey S (2023). Characterization of exotic tomato germplasm from ICAR-NBPGR genebank. *Indian Journal of Plant Genetic Resources* 36(2): 301-308

20.10.2. Books

Agrawal A, Singh M, Tripathi K, Srivastava V, Pamarthi RK, Negi N (2023). Book of abstracts of the national seminar on plant biodiversity for food, nutrition and health security in north-west Himalayas (PBFSNWH), Shoolini University, Solan, Nov. 27-28, 2023. *Indian Society of Plant Genetic Resources*, New Delhi, New Delhi, p 51.

Akhtar J, Gupta K, Singh MC, Khan Z and Chalam VC (eds.) *Potential Quarantine Pests for India in Cucurbitaceous and Solanaceous Vegetable Crops*. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India. x+181 p.ISBN: 978-81-958250-4-2 (Hardcopy), ISBN: 978-81-958250-6-6 (e-book).

Anitha K, Chitra Shanker P, Padmaja G, Parameswari B, Holajjer P, Somasekhar N, Katti G, Singh TVK and Sarath Babu B (2023). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability, 15-18 November 2023, 308 pp. Plant Protection Association of India, NBPGR Regional Station, Rajendranagar, Hyderabad, India.

Chalam VC, Gupta K, Singh MC, Khan Z, Akhtar J, Gawade B, Kumar PP, Kumari P, Meena BR, Maurya AK, Meena DS and Sadhana (2023). *75 Quarantine Pests Intercepted Ensuring Crop Biosecurity*. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, xv+76p. ISBN: 978-81-958250-5-9 (Hard copy), ISBN: 978-81-958250-3-5 (e-Book)

Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (2023). Plant Genetic Resources Management-Theory and Practice. ebook. *ICAR-National Bureau of Plant Genetic Resources*, New Delhi, India, 408p.ISBN: 978-81958250-2-8.

Katti G, Anitha K, Prasanna H, Bhaskar B, Parameswari B and Singh TVK (2023). Souvenir, International Conference on Plant Health Management, ICPHM 2023: Innovation and Sustainability, Hyderabad, 15-18, November 2023. Published by Plant Protection Association of India. 52 Pp.

Langyan S, Belwal T, Wan C, Yadava P, Kaul T (2023). Agro-morphological and nutritional profiling of crops. Lausanne: *Frontiers Media SA*.

Pandravada SR, Sivaraj N, Kamala V and Sarath Babu B (2022). Agrobiodiversity of Telangana: A treatise on genetic resources of agri-horticultural crops. ICAR-National Bureau of Plant Genetic Resources, Regional Station, Hyderabad, Telangana x+382 pp. (ISBN 978-93-5407-286-4) (released in 2023).

Singh GP, Singh R, Rajkumar S and Wankhede DP (Eds). Genome tools in Plant Genetic Resource Management. Practical Manual. ICAR-NBPGR, New Delhi.

Sivaraj N, Pandravada SR, Kamala V, Anitha K, Saravanan L, Parameswari B, Nivedhitha S, Pranusha P, Holajjer P, Bhaskar B and Babu Abraham (2023). Agri-horticultural crop genetic resources of Andhra Pradesh: A checklist. ICAR-NBPGR Regional Station, Hyderabad 62 p. (ISBN 978-81-963685-0-0).

Tripathi K, Kumari J, Singh M, Pragya, Gangopadhyay KK, Gautam RK, Kumar A, and Singh GP, (2023). 75 unique accessions utilized in plant variety development. *ICAR-National Bureau of Plant Genetic Resources*, New Delhi, India, i-iv+ 75p.

20.10.3. Chapters in books, review articles, proceedings, bulletin, manuals, etc

Agrawal A, Gowthami R, Srivastava V and Chander S (2023). Trans-situ Conservation of PGR. In: Gautam RK, Kumari J, Tripathi K, Parmarti RK, Chander S, Singh M, Hooda KS and Singh GP (eds) Plant Genetic Resources Management-Theory and Practice. ICAR- NBPGR, New Delhi, India. pp 48-52

Agrawal A, Singh M, Tripathi K, Srivastava V, Pamarthi RK and Negi N (2023). Book of Abstracts of the National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Solan, Nov. 27-28, 2023. Indian Society of Plant Genetic Resources, New Delhi, New Delhi, p 51.

Ahlawat SP, Bhatt KC, Semwal DP, Malav PK, Pamarthi RK and Panwar NS (2023). Exploration and Collection of PGR: Principals and Priorities. In: Gautam et al, Plant Genetic Resources Management - Theory and Practice. ICAR-National Bureau of Plant Genetic Resources. New Delhi, India, 1-393

Akhtar J, Kumar A, Thirumalaisamy PP, Meena BR, Jaiswal P and Gupta AK (2023). Detection techniques of bunt and smut pathogens in cereal seeds. In: Manual, National Training on '*Seed Health Testing*' (eds) Ekta Kumari et al, organized by National Seed Research & Training Centre, Varanasi (U.P.) Feb 06-10, 2023. pp 125-132

Akhtar J, Kumar P, Meena BR, Maurya Tripathi AK, Mauryaand S and Tiwari R (2023). Detection and identification of plant pathogenic fungi and bacteria in exotic plant genetic resources. *In:* 3rdTraining Manual of *'Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues'* (eds) Chalam VC et al, organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi, (ISBN: 978-81-9387111-9-4) pp 60-67.

Akhtar J, Meena BR, Kumar P, Tripathi A, Sadhana and Chalam VC (2023). Detection and management of seed-borne viruses. In: Manual, National Training on '*Seed Health Testing*' (eds) Ekta Kumari et al, organized by National Seed Research & Training Centre, Varanasi (U.P.) Feb 06-10, 2023. pp 110-118

Akhtar J, Tripathi A, Meena BR, Kumar P, Kiran R, Maurya S and Jaiswal PK (2023). Techniques for detection and identification of plant pathogenic fungi and bacteria. *In:* 3rdTraining Manual of *'Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues'* (eds) Chalam VC et al, organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi (ISBN: 978-81-9387111-9-4), pp 218-226.

Bansal S, Malhotra EV and Joshi P (2023). Bioactive compounds and biological activities of black cumin (*Elwendia persica* (Boiss.) Pimenov & Kljuykov). In: Murthy HN, Paek KY, Park SY (eds) Bioactive Compounds in the Storage Organs of Plants. Reference Series in Phytochemistry. Springer, Cham. https://doi.org/10.1007/978-3-031-29006-0_51-1

Bhalla S, Chimata MC, Gupta K and Chalam VC (2023). Cartagena Protocol on Biosafety: Overview and Compliance In: *3rdTraining Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 37-44

Bhatt KC, Pamarthi RK, Pandey A, Pradheep K and Gupta R (2023). National Herbarium of Cultivated Plants: A National Repository. In: RK Gautam, Jyoti Kumari, Kuldeep Tripathi, RK Pamarthi, Subhash Chander, Mamta Singh, KS Hooda and GP Singh (2023) Plant Genetic Resources Management – Theory and Practice. ICAR-NBPGR, New Delhi-110012. 27-34p

Boopathi T, Gupta K, Singh SP and Meena DS (2022). Insects Pests of Quarantine Significance in Cucurbitaceous and Solenaceous Vegetables. In: *Pests of Quarantine Significance in Cucurbitaceous and Solenaceous Vegetables* (eds. Akhtar J, Gupta K, Singh MC, Khan Z and Chalam VC), National Bureau of Plant Genetic Resources, New Delhi, India. 1-24pp

Chalam VC and Ahuja V (2023). Biosafety clearing house: Information exchange on living modified organisms. In: *3rdTraining Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 176-182.

Chalam VC, Gupta K, Akhtar J, Khan Z, Singh MC, Gawade BH, Kumari P, Kumar P, Meena BR, Maurya AK, Meena DS, Kalaiponmani K, Tripathi A and Yadav P (2023). National plant quarantine system. In: *Training Manual of Plant Genetic Resources Management: Theory and Practice* (eds) Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP, February 1-21, 2023, ICAR-NBPGR, New Delhi. pp 189-199.

Chalam VC, Gupta K, Khan Z, Akhtar J, Singh MC, Gawade BH, Kumari P, Kumar P, Maurya AK, Meena DS,

Kalaiponmani K and Tripathi A (2023). Biosecurity and Biosafety: Concepts, International Scenario and Safe Transboundary Movement of Germplasm In: *3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 13-22.

Chalam VC, Gupta K, Singh MC, Khan Z, Akhtar J, Gawade BH, Kumar P, Kumari P, Maurya AK, Meena DS, Maurya S, Lenka S, Kalaiponmani K and Tripathi A (2023). National Plant Quarantine System. In: Training Programme on Management of Plant Genetic Resources, November 2-8 2023, ICAR-NBPGR, New Delhi.

Chalam VC, Kumari P, Deepika DD, Yadav P, Kalaiponmani K and Maurya AK (2023). Cross boundary movement of phytoplasma in Asia and status of plant quarantine. pp 85-96 In: Phytoplasma Diseases in Asian Countries Volume 3 *Characterization, Epidemiology and Management*. Tiwari AK, Oshima K, Yadav A, Hosseini SAE, Hanboonsong Y and Lakhanpaul S (ed.) Elsevier Inc. https://doi.org/10.1016/B978-0-323-91671-4.00016-2

Chalam VC, Kumari P, Kalaiponmani K and Maurya AK (2023). Plant quarantine processing: Virology. In: Training Programme on Management of Plant Genetic Resources, November 2-8 2023, ICAR-NBPGR, New Delhi.

Chalam VC, Kumari P, Kalaiponmani K, Yadav P and Maurya AK (2023). Plant quarantine processing: Virology. In: *Training Manual of Plant Genetic Resources Management: Theory and Practice* (eds) Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP, February 1-21, 2023, ICAR-NBPGR, New Delhi. pp 351-358.

Chalam VC, Kumari P, Kalaiponmani K, Yadav P, Parameswari B and Maurya AK (2022). Detection and identification of plant viruses in quarantine In: *3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 74-82.

Deshpande SK, Kavyashree NM, Singh K, Ramya KR, Sharma N, Tripathi K (2023). Diseases in cowpea (*Vigna unguiculata* (L.) Walp.): next generation breeding techniques for developing disease-resistant cowpea. In: Jha UC, H Nayyar, KD Sharma, EJB von Wettberg, P Singh, KH Siddique (eds) *Diseases in Legume Crops*. Springer, Singapore

Dubey SC and Gupta K (2023). Plant Biosecurity in India: Emerging Issues and Challenges. In: Training manual of Virtual Training Program on Management and Utilization of Plant Genetic Resources, Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and GP Singh GP (Eds), at ICAR-NBPGR, New Delhi from Feb 1-21, 2023,pp 200-207.

Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (2023). Plant Genetic Resources Management – Theory and Practice. ICAR-NBPGR, New Delhi-110012. 1-393p

Gawade BH and Khan Z (2023). Nematodes of quarantine significance for India in cucurbitaceous and solanaceous vegetable crops. In: *Pests of Quarantine Significance in Cucurbitaceous and Solenaceous Vegetables* (eds. Akhtar J, Gupta K, Singh MC, Khan Z and Chalam VC), National Bureau of Plant Genetic Resources, New Delhi, India 121-142 pp.

Gawade BH and Khan Z (2023). Techniques for detection and identification of plant parasitic nematodes germplasm under exchange. *In:* Training manual of 'Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues' Chalam VC et al (eds) ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012, 227-232pp.

Gawade BH, Chalam VC, Gupta K, Singh MC, Khan Z, Akhtar J, Kumar P, Meena BR, Kiran R, Kumari P, Maurya AK, Meena DS and Maurya S (2023). Phytosanitary Treatments for Disinfestation and Disinfection of Seed and other Planting Material in Quarantine. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Yadav P and Kumar A organized under DBT-sponsored project "National Programme for Quarantine and GM

Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 152-163.

Gawade BH, Chalam VC, Gupta K, Singh MC, Khan Z, Akhtar J, Kumar P, Meena BR, Raj Kiran, Pooja Kumari, Maurya AK, Meena DS and Sadhana Maurya (2023). Quarantine treatments for disinfestation and disinfection of seed and other planting material under exchange. *In:* Training manual of 'Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues' Chalam VC et al (eds) ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012, 152-163pp.

Gupta K and Chalam VC (2023). Pest Risk Analysis: Concepts and Methodology In: *3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 115-124.

Gupta K and Chalam VC (2023). Pest Risk Analysis: Concepts and Methodology. In: Manual, National Training on '*Seed Health Testing*'(eds) Kumari Ekta et al, organized by National Seed Research & Training Centre, Varanasi (U.P.) Feb 06-10, 2023. pp 44-52.

Gupta K, Chalam VC, Khan Z, Akhtar J, Singh MC, Gawade BH, Kumar P, Meena BR, Kumari P, Meena DS, Maurya AK and Sadhana (2023). Plant Quarantine and its role under the International Agreements. In: Manual, National Training on '*Seed Health Testing*'(eds) Kumari Ekta et al, organized by National Seed Research & Training Centre, Varanasi (U.P.) Feb 06-10, 2023. pp 93-108.

Gupta K, Meena DS and Tahseen S (2023). Detection and Identification of Insects and Mites in Quarantine In: Training manual of Virtual Training Program on Management and Utilization of Plant Genetic Resources, Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (Eds) at ICAR-NBPGR, New Delhi from Feb 1-21, 2023,pp 359-363.

Gupta S and Malhotra EV (2023). Application of tissue culture in PGR management. In: Plant Genetic Resources Theory and Practice. (Gautam RK, Kumari J, Tripathi K, Parmarthi RK, Chander S, Singh M, Hooda KS snd Singh GP (Eds) ICAR-NBPGR, New Delhi, pp. 232-236. E-Book ISBN 978-81958250-2-8.

Gupta S, Bansal S, Malik SK, Srivastava V, Chander S, Malhotra EV, Gowthami R, Chandra R and Mali S (2023). *In vitro* and Cryo-preservation of Plant Genetic Resources. in the Training Programme on "Management of Plant Genetic Resources", during November 2, to November 8, 2023 for the students of B.Sc. Agriculture (final year), College of Agriculture, Bawal, CCS HAU, Hisar, Haryana.

Gupta S, Srivastava V and Singh GP (2023). Conservation of Horticultural Diversity at ICAR-NBPGR. In Srivastav RK et al. Progressive Horticulture Conclave: Transforming Horticulture Science into Technology. GB pant Univ of Agriculture and Horticulture, Pantnagar, Uttarakhand (in press).

Hajong S, Biate DL, Sharma B, Uchoi J, Ahlawat SP and KC Bhatt (2023). Rice germplasm: History of rice germplasm collection and conservation in North Eastern India. Publisher: AAU-Assam Rice Research Institute, Assam Agricultural Univeristry, Titabar-785630. 66-73p

Jacob SR and Harish GD (2023). Seed Viability Assessment-In. Training Manual on Plant Genetic Resource management- Theory & Practice, pp 291-294

Jacob SR and Kumar Arun MB (2023). Seed Technological interventions for climate change mitigation. In: Stress-Fee Horticulture- Empowering crop resilience against abiotic challenges (Eds: Bhagat KP, Poonam Kashyap, Roy SS, Meena AL and Thirugnanavel A). Today & Tomorrow's Printers and Publishers, New Delhi, India. pp 261-272

Khan Z and Gawade BH (2023). Detection and identification of plant parasitic nematodes germplasm under exchange. *In:* Training manual of 'Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues' Chalam VC et al (eds) ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012, 83-88pp.

Kumar P, Akhtar J, Kiran R, Meena BR, Tripathi A, Maurya S and Tiwari R (2023). Molecular detection and identification of plant pathogens in quarantine.*In:* 3rd Training Manual of *'Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues'* (eds) Chalam VC et al, organized under DBT-sponsored project "National Programme for Quarantine

and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi (ISBN: 978-81-9387111-9-4), pp 68-73.

Kumar S and Kaushik SK (2023). Bio-fortification potential of potential crops for Nutritional and Livelihood Security. In: "Igniting the Millet Renaissance: Advancing the Millet year with Post-Harvest Engineering& Technology for Nutritional Security, Loss Minimization and Enhanced Profitability", (Eds: Bala Manju, Sethi Swati and Kumar Pankaj). ICAR-CIPHEET, Ludhiana, pp 327-334.

Kumar S, Pradhan AK, Sharma D, Mir ZA, Budhlakoti N, Mishra DC, Kumar U, Vikas VK, Singh A, Kumari J, Singh K and Singh GP (2023). Application of Genome-Wide Association Studies (GWAS) in the Management of Wheat Genetic Resource at National and International Level. In Gautam et al. (Eds.) *Plant Genetic Resources Management:* Theory and Practices. ebook NBPGR, New Delhi pp. 180-188.

Kumar S, Yadav SK and Kaushik SK (2023). Underutilized crop genetic resources and their utilization. *In*: Management of Plant Genetic Resources (Authors: Kumari J, Gore Padmavati G, Pragya, Jacob Sherry R, Kaushik SK and Singh GP). ICAR-NBPGR, New Delhi. pp 66-72.

Kumari J and Tripathi K (2023). Strategies for Efficient Utilization of PGR. In Gautam (Eds.) *Plant Genetic Resources Management*: Theory and Practices. ebook NBPGR, New Delhi pp.73-78.

Kumari P, Maurya AK, Kalaiponmani K, Yadav P and Chalam VC (2023). Practicals on Detection and Identification of Viruses in Quarantine In: *3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z. Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" from 4-14 September, 2023 at ICAR-NBPGR, New Delhi. pp 233-238.

Kumari P, Yadav P, Kalaiponmani K, Maurya AK and Chalam VC (2023). Viruses of quarantine significance for India infecting cucurbitaceous and solanaceous vegetable crops. pp 86-120 In: *Potential Quarantine Pests for India in Cucurbitaceous and Solanaceous Vegetable Crops*. Akhtar J, Gupta K, Singh MC, Khan Z and Chalam VC (ed.) ICAR-National Bureau of Plant Genetic Resources, New Delhi, India.

Lone JK, Mushtaq M, Gupta OP and Gayacharan (2023). Future prospective of small RNA molecules: food crop improvement and agricultural sustainability. In *Plant Small RNA in Food Crops* (pp. 571-600). Academic Press.

Malhotra EV and Bansal S (2023). In vitro conservation and cryopreservation. In: Plant Genetic Resources Management: Theory and Practice (Eds. Gautam RK et al) ISBN 978-81-958250-2-8. ICAR-NBPGR, New Delhi. pp. 320-324.

Malik SK, Bansal S and Chaudhury R (2023). Cryopreservation of Non-orthodox Seed Species: Practical Considerations. In: Plant Genetic Resources Management: Theory and Practice (Eds. Gautam RK et al) ISBN 978-81-958250-2-8. ICAR-NBPGR, New Delhi. pp. 237-246.

Pandey CD and Jacob Sherry R (2023). Procedures for Long Term Conservation of Orthodox Seeds. In the Training manualon "Management of Plant Genetic Resources", during November 2 to November 8, 2023for the students of B.Sc. Agriculture (final year), College of Agriculture, Bawal, CCS HAU, Hisar, Haryana.

Pandey CD and Pandey S (2023). Processing and Conservation of Vegetable Genetic Resources. In the Training manual on"Learning Genomic tools and techniques for improvement of Vegetable crops" organized in the Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi, during 10th to 20th November, 2023

Pandey S and Pandey CD (2023). Seed quality enhancement - principles and procedures. In the Training Manual of International Training Programme on "Seed Production and Quality Evaluation" for the officials of AARDO member countries conducted by Division of Seed Science and Technology, ICAR-IARI during February 12 -23, 2023.

Pathania P, Aravind J and Rajkumar S (2023). 'Methods in core development using molecular markers', Singh GP, Singh R, Rajkumar S, and Wankhede DP (eds.) In: *Genomic Tools in Plant Genetic Resource Management - A Practical Manual*. ICAR - National Bureau of Plant Genetic Resources, New Delhi, India, pp 75–86.

Raina PA (2023). *Phytochemical Evaluation of Medicinal Plants*. *In:* Training Manual on *Plant Genetic Resources Management* – Theory and Practice. *eds*. Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (2023) Proceedings of virtual training organized by ICAR-NBPGR, New Delhi from 1st Feb – 23rd Feb, 2023, pp. 139-144.

Raina PA (2023). *Potential Medicinal and Aromatic Plants of ZingiberaceaeFamily*. *In:* Proceedings of *3rd International Conference and Buyers Sellers Meet on Medicinal Plants used in Lifestyle Products* organized by Jadavpur University, Kolkata in association with RCFC Eastern Region, National Medicinal Plants Board (NMPB), Ministry of Ayush, Government of India from December 06-08, 2023 held at Jadavpur University, Kolkata (Virtual Mode); In Compilation of Abstracts book at Abstract No.3 at p.16.

Sahu TK, Singh M, Kalia S and Singh AK (2023). Genome-wide association study (GWAS): Concept and methodology for gene mapping in plants. In: Raina A, Wani MR, Laskar RA, Tomlekova N, Khan S (eds) *Advanced Crop Improvement*, Vol 2. Springer, Cham. https://doi.org/10.1007/978-3-031-26669-0_17

Saidaiah P, Geetha A, Pandravada SR, Khan S, Thuraga VK, Sivaraj N and Kattula Nagaraju (2023). Conservation Strategies for Indian Medicinal Plants. In: Mathe A, Khan IA (eds) Medicinal and Aromatic Plants of the World. Vol. 9. Springer, cham.https://doi.org/10.1007/978-3-031-44914-7_14

Semwal DP, Malav PK and Soyimchiten (2023). Geographic Information Systems (GIS) Applications in PGR Management. In: Gautam et al, Plant Genetic Resources Management - Theory and Practice. ICAR-National Bureau of Plant Genetic Resources. New Delhi, India, 1-393

Sharma L and Singh R (2023). Development of EST-SSR and g-SSR Markers in Plants. In: Singh GP, Singh R, Rajkumar S, and Wankhede DP (Eds.) Genomic Tools in Plant Genetic Resource Management- A Practical Manual. ICAR - National Bureau of Plant Genetic Resources, New Delhi-110012, India. pp 30-49.

Singh GP and Gupta K (2023). Role of ICAR-NBPGR in PGR Management In: Training manual of Virtual Training Program on Management and Utilization of Plant Genetic Resources, Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (Eds) at ICAR-NBPGR, New Delhi from Feb 1-21, 2023, pp 1-11.

Singh M and Singh AK (2023). Molecular approaches and techniques for the detection of genetically modified plants. In: Singh GP, Singh R, Rajkumar S, and Wankhede DP (Eds.) *Genomic Tools in Plant Genetic Resource Management- A Practical Manual* (eds Singh GP, R Singh, Rajkumar S and Wankhede DP), ICAR - NBPGR, New Delhi, pp. 108-120.

Singh M, Aminedi R and Singh A (2023). Detection of GMOs and visit to GM detection research facility. In: 3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues (eds) (Chalam et al., 2023), ICAR-NBPGR, New Delhi, pp. 239-248.

Singh M, Aminedi R and Singh A (2023). DNA-based techniques for detection of genetically modified organisms. In: 3rd Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues (eds) (Chalam et al., 2023), ICAR-NBPGR, New Delhi, pp. 99-108.

Singh R, Darjee S, Rohtagi B, Khandelwal A, Langyan S, Singh AK, Shrivastava M, Bharti A, Singh HM and Kundan S (2023). Biobutanol Production Using Nanotechnology: A Way Forward. *In Sustainable Butanol Biofuels* (pp. 241-257). CRC Press.

Singh SP, Gupta K, Boopathi T and Meena DS (2022). Mite Pests of Quarantine Significance in Cucurbitaceous and Solenaceous Vegetables. In: *Pests of Quarantine Significance in Cucurbitaceous and Solenaceous Vegetables* (eds. Akhtar J, Gupta K, MC Singh MC, Khan Z and Chalam VC), National Bureau of Plant Genetic Resources, New Delhi, India. 25-34pp.

Singh, MC (2023). Detection and Identification of Weeds in Plant Quarantine. *In:* Training manual of 'Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues' Chalam VC et al (eds) ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012, 89-91pp.

Sivaraj N, Pandravada SR, Kamala V, Anitha K, Elangovan M and Rajasekaran C (2023). Are landraces Sorghum

climate resilient? A case study from Telangana, India. In: Dutta SK, Deka J, Das R, Sarma AK, Rajasekaran C (Eds) Climate Change: Conservation, Biodiversity & Sustainability. College of Agriculture, Jorhat, Assam Agricultural University, Jorhat-785 013, Assam, India. PP. 160-178.

Srivastava V, Gowthami R, Shirbhate KD, Singh M, Charan G, Sagore B and Singh K (2023). Embryo Rescue Technique in Wide Hybridization. In: Gautam RK, Kumari J, Tripathi K, Parmarti RK, Chander S, Singh Mamta, Hooda KS and Singh GP (eds) Plant Genetic Resources Management-Theory and Practice. ICAR- NBPGR, New Delhi, India. Pp 325-331

Viswanathan R, Geetha N, Anna Durai A, Prathima PT, Appunu C, Parameswari B, Nithya K, Ramasubramanian T and Selvi A (2022). Genomic Designing for Biotic Stress Resistance in Sugarcane. In: Kole C (eds) Genomic Designing for Biotic Stress Resistant Technical Crops. Springer, Cham. https://doi.org/10.1007/978-3-031-09293-0_9

20.10.4. Oral Presentation/Invited lectures

Anju Mahendru Singh deliveredthe lecture "Ex-situ Conservation of Plant Geetic Resources in the National Genebank, India"to the students of College of Agriculture, Bawal, CCS HAU, Hisar in the Training Course on "Management of Plant Genetic Resources" at ICAR-NBPGR, New Delhi during November 2-8, 2023.

Aravind J (2023). Core collection for efficient management and enhanced utilization of PGR. presented at the Training Program on Genomic Tools in Plant Genetic Resource Management, September 18-29, 2023, ICAR-National Bureau of Plant Genetic Resources, New Delhi, September 22.

Aravind J and S Rajkumar (2023). Methods in core development using molecular markers. presented at the Training Program on Genomic Tools in Plant Genetic Resource Management, September 18-29, 2023, ICAR-National Bureau of Plant Genetic Resources, New Delhi, September 22.

Aravind J and Singh B (2023). Virtual visit to NBPGR genebank. presented at the Virtual Training Programme on "Management and Utilization of Plant Genetic Resources", February 1-21, 2023, ICAR-National Bureau of Plant Genetic Resources, New Delhi, February 1.

Gowthami R was an invited keynote speaker in International Conference on Innovative Approaches in crop Improvement for Sustainable Agriculture (Virtual) and delivered a talk on *In vitro* conservation and cryopreservation of agri-horticulture Plant diversity organized by JSA College of Agriculture and Technology, TNAU, India, February 23, 2023.

K Pradheep attended and delivered anoral presentation on "A note on the occurance, taxonomy, and genetic resource potential of *Sesamum laciniatum*, an endemic wild relative of sesame from Peninsular India' in the International Seminar on Advances in Plant Systematics, Biogeography and Biodiversity Conservation (APSBBC-2023) held at Dept. of Botany, Botanical Survey of India, Kolkotta on November 25-27, 2023.

K Pradheep delivered an invited talk on "Crop Wild Relatives of Spices, Medicinal and Aromatic plants: What can they offer? during the National Conference on Spices, Aromatic and Medicinal Plants for Economic Prosperity and Ecological Sustainability-2023 organized by ICAR-CIARI, Port Blair, A&N Islands from October 5-6, 2023.

K Pradheep delivered a talk on "PGR Collection and its Conservation" to the staff of ICRISAT and Agricultural Officers of Odisha State Govt. at ICRISAT, Hyderabad on June 26, 2023.

K Pradheep, participated and delivered an oral presentation on the topic "A note on ecology, taxonomy and genetic resource potential of *Oryza meyeriana* var. *indandamanica*, a rare wild relative of rice from Andaman & Nicobar Islands" during the II Rice Congress held at NRRI, Cuttack on February 11-14, 2023.

Padmavati G Gore, Gayacharan C, Tripathi K and Wankhede DP (2023). Genotypic variation for tolerance to preharvest sprouting in mungbean germplasm. International Conference on, "Pulses: Smart Crops for Agricultural Sustainability and Nutritional Security", Feb. 10-12, 2023 at NASC, New Delhi, pp-168. Organized by Indian Society of Pulses Research & Development

Pandey Chithra Devi delivered lecture on "Management of PGR in the Indian National Genebank (2023). "at Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany, June 15, 2023.

PP Thirumalaisamy attended and presented a paper on Resistance to bacterial wilt (*Ralstonia solanacearum*) in

eggplant and its wild relatives atNational Symposium on "Crop Health Management: Safeguarding Crop through Diagnostics and Innovations" (September 29-30, 2023) held at VPKAS, Almora via virtual mode.

Sandhya Gupta and Sangita Bansal conducted practical on In vitro and Cryo-preservation of Plant Genetic Resources on November 3, 2023 from 4.00-5.30 PM Tave an invited talk raining Programme on "Management of Plant Genetic Resources", organized by CAR-NBPGR during November 2-8, 2023.

Sandhya Gupta delivered an invited talk on 'Application of tissue culture in PGR management' on 10th Feb 2023, in 'Virtual training Programme on management & Utilization of PGRs at ICAR-NBPGR during February 1-21, 2023.

Sandhya Gupta delivered Lead presentation on 'Conservation of Horticultural Diversity at ICAR-NBPGR' on 3rd Feb 2023, in 'Progressive Horticulture Conclave: Transforming Horticulture Science into Technology', at GB Pant Univ of Agriculture & Technology organized by ISHRD and GBPUA&T, Pantnagar in Pantnagar during February 3-5, 2023.

Subhash Chander presented a lead lecture on the topic of Conservation of seeds using cryopreservation techniques in International Conference on Innovative Approaches in crop Improvement for Sustainable Agriculture held on February 23, 2023 in Online mode.

Suma A delivered an invited lecture on "Potential under-exploited vegetables of Western Ghats" during "National Conference on Ethnic Vegetables" held on 27th and 28th May 2023 at Dr. YSRHU-College of Horticulture, Anantharajupeta, Andhra Pradesh on virtual mode.

Vartika and Gowthami conducted Practical on "Embryo Rescue Technique in Wide Hybridization" in virtual training programme on "Management and utilization of Plant Genetic Resource Management" at ICAR NBPGR during February 1-21, 2023.

Vartika delivered invited lecture in National Workshop on Plant Tissue Culture/Molecular Marker Technology in Fruit Crops. On the topic "*In vitro* germplasm conservation of fruit crops' on November 3, 2023 via online mode in the NAHEP funded National Workshop on Plant Tissue Culture/Molecular Marker Technology in Fruit Crops at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, 224 229 (U.P.), India

20.10.5. Poster presentation/Abstracts

Bhaskar B, Anitha K, Parameswari B, Holajjer P, Saravanan L and Sivaraj N (2023). Identification and Characterization of *Colletotrichum* Species Associated with Stem Anthracnose Disease of Dragon Fruit (OP-15- Page No.058). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability held at Hyderabad, India, from November 15-18.

Gore PG, Gayacharan C, Tripathi K and Wankhede DP (2023). Genotypic variation for tolerance to preharvest sprouting in mungbean germplasm. International Conference on, "Pulses: Smart Crops for Agricultural Sustainability and Nutritional Security", Feb. 10-12, 2023 at NASC, New Delhi, pp-168. Organized by Indian Society of Pulses Research & Development

Hajong S, Bhardwaj R, Pheirim R, Pradhan S, Jain A, Singh S, Kondal V, Aochen C, Punatemjen T and Uchoi J (2023). Agro-morphological characterization and nutritional diversity of *Coix lacryma-jobi* L.: A potential crop under changing climate regime. In: 5th International Conference on "Global Insights in Research and Development in Agriculture, Horticulture and Allied Sciences" organised by GH Raisoni University, Saikheda (MP); Just Agriculture Education Group and AEEFWS Punjab in hybrid mode, October 5-7, 2023. 100p

Hajong S, Pheirim R, Pradhan S, Aochen C, Punatemjen T and Uchoi J (2023). Agro-morphological characterization of *Coix lacryma-jobi* L.: An important potential crop from North-east India. In: National Conference on "Rebooting the hill farming for future sustainability and livelihood" organized by Indian Association of Hill Farming, ICAR RC for NEH Region, Umiam, June 08-09,2023.131p

Holajjer P, Pandravada SR, Ahammed Shabeer TP, Mahatma MK, Khan Z, Sivaraj N, Anitha K and Pardeshi A (2023). Metabolomic Profiling of Root-Knot Nematode, *Meloidogyne incognita* Resistant and Susceptible Accessions of Chilli (OP-84 – Page No.113). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability held at Hyderabad, India, from November 15-18.

Humayun P, Anitha K, Sarath Babu B, Saravanan L, Parameswari B, Holajjer P, Bhaskar, B and Sharma R (2023). Phytosanitary measures for the safe global germplasm exchange of ICRISAT mandate crops. (PP-72-Page No.206). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability held at Hyderabad, India, from November 15-18.

Kunal, Malhotra EV, Malik SK, Sharma MK, Pant P, Kumari J and Bansal S (2023). Effect of Phytohormone meta-Topolin on in vitro Propagation of *Rubia cordifolia* L. In: Abstract Book of National Conference onSpices, Aromatic and Medicinal Plants for EconomicProsperity and Ecological Sustainability-2023, organized by ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands, Oct 5-6, 2023. p. 25.

Malhotra EV, Johnson A, Bansal S and Sharma S (2023). *In vitro* propagation and conservation of *Zingiber wightianm* Thwaites: an important and endangered wild relative of Zingiber species. In: Abstractbook of National Conference on Spice, medicinal and aromatic plants for economic prosperity and ecological sustainability held on October 05-06, 2023 at ICAR-CIARI, Port Blair (A&N). pp. 24.

Malhotra EV, Johnson A, Bansal S and Sharma S (2023). In Vitro Propagation and Conservation of *Zingiber wightianum* Thwaites: an Important and Endangered Wild Relative of Zingiber Species. In: Abstract Book of National Conference onSpices, Aromatic and Medicinal Plants for EconomicProsperity and Ecological Sustainability-2023, organized by ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands, October 05-06, 2023. p. 24.

Panda RR and Gupta S (2023). Sustaining Wild Edible Fruit Treasures: Ex Situ Conservation of *Artocarpus lacucha* Buch.-Ham. In: Agrawal A, Singh M, Tripathi K, Srivastava V, Pamarthi RK, Negi N (eds) (2023). Book of Abstracts of the National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Solan, November 27-28, 2023. Indian Society of Plant Genetic Resources, New Delhi, New Delhi, pp. 34.

Parameswari B, Bhaskar B, Karthikaiselvi L, Mangrauthia SK, Anbazahagan P, Sivaraj N, Celia Chalam V and Anitha K. Complete Genome Sequence of an Isolate of *Cactus virus X* Infecting Dragon Fruit in India: First Record (OP-77-Page No.107). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability held at Hyderabad, India, from November 15-18.

Purwar S, Singh CM, Kumar M, Singh AK, Pratap A, Gore PG and Singh NP (2023). Genome-wide identification and analysis of NBS-LRR encoding genes in mungbean (Vigna radiata L. Wilczek) and their expression in two wild non-progenitors reveal their role in MYMIV resistance. J. Plant Growth Reg. 42:6667–6680https://doi.org/10.1007/s00344-023-10948-7.

Rangappa K, Kumar A, Moirangthem P, Rajkhowa D, Mishra VK, Layek J, Hajong S, Harish GD, Bhattacharjee B and Saikia US (2023). Buckwheat (*Fagopyrum* spp.)- Potential stress resilient crop for mountainous ecosystems of Meghalaya (India) under changing climate. In: International Seminar and Workshop on "CRISPR/CAS-based Plant Functional Genomics and Computational Modeling" organised by and held at North East Institute of Science and Technology, Jorhat, Assam, January 17-21, 2023. 117p

Roy Debajyoti, Chakraborti Mridul, Kar Meera Kumari, Sahoo Pritiranjan, Behera Motilal, Samal Pankajini, Pani Dipti Ranjan and Dasgupta Tapash (2023). Combining biotic stress resistance alongwith herbicide and abiotic tolerance in rice mega variety 'Swarna' through minimal use of molecular markers. Poster presented at*: 2nd Indian Rice Congress* on February 11, 2023; ICAR-NRRI Cuttack Odisha.

Saha S, Jacob SR, Abhijith KP, Arun Kumar MB, Mishra A, Aravind J, Kumar S, Kumari J, Navathe S and Kumar Y (2023). Exploring the Genetic Basis of Seed Longevity in Wheat (*Triticum aestivum* L.) – a Genebank Perspective, in the "International Conference on Biochemical and Biotechnological Approaches for Crop Improvement" held during October 30 to November 01, 2023" at NASC, New Delhi.

Saikrishna K, Saravanan L, Sunitha Devi R, Aruna Kumari J, Tripathi K, Anitha K, Nivedhitha S and Sivaraj N (2023). Morphological and biochemical traits imparting resistance in cowpea genotypes against cowpea aphid, Aphis craccivora (OP-95 – Page No.122). ABSTRACTS. International Conference on Plant Health Management-Innovation and Sustainability held at Hyderabad, India, from November 15-18.

Shashank HG, Jacob SR, Abhijith KP, Arun Kumar MB, Mishra A, Kumar S, Kumari J, Navathe S, Kumar Y and Sharma A (2023). Genetic dissection of Seedling Establishment Traits in Indian Wheat Germplasm Conserved in National Genebank (Triticum aestivum L.) in the "International Conference on Biochemical and Biotechnological Approaches for Crop Improvement" held during October 30 to November 01, 2023" at NASC, New Delhi.

Uchoi J, Thakuria D, Hajong S, Reang E, Murasing KK, Dey A and Markhap O (2023). Exploration and germplasm collection of citrus spceies in Meghalaya: Future conservation and utilization. In: International conference on "Agriculture in Hilly and Mountain Landscape: An Interdisciplinary perspecetive" organized by CAU, Imphal, November 22-24, 2023

Yadav T, Gupta S, Malik SK, Pal A and Topno SE (2023). Desiccation and freezing study on seeds of Dragon Fruit (*Hylocereus costaricensis*) In Srivastav RK et al (ed.) Souvenir cum compendium of abstract. Progressive Horticulture Conclave: Transforming Horticulture Science into Technology. Pantnagar, Uttarakhand, February 3-5, 2023, pp 6. (ab). (Poster)

20.10.6. Review articles

Chandra T, Jaiswal S, Iquebal MA, Singh R, Gautam RK, Rai A and Kumar D (2023). Revitalizing miRNAs mediated agronomical advantageous traits improvement in rice. *Plant Physiology and Biochemistry*, p.107933.

Gowthami R and Chander S (2023). Book review: Anjula Pandey, Pavan Kumar Malav, KM Rai and SP Ahlawat (2022). Genus *Allium* L. of the Indian Region: A Field Guide for Germplasm Collection and Identification, ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, 109p + i-vi.. Indian J. Plant Genet. Resour. 36(02), 317–318.

Langyan S, Khan FN and Kumar A (2023). Advancement in Nutritional Value, Processing Methods and Potential Applications of Pseudocereals in Dietary Food: A Review. *Food Bioprocess Technol*.

20.11. Manuals/research bulletin/information bulletin/brochure

20.11.1. Training Manual edited

Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP (eds) (2023). Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues. Organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material from 4-14 September, 2023 at ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012. 248p + xivp. ISBN No: 078-81937111-9-4.

Gautam RK, Kumari J, Tripathi K, Singh M, Chander S, Pamarthi RK, Hooda KS (2023). Plant Genetic Resources Management – Theory and Practice. ICAR-National Bureau of Plant Genetic Resources, 393.

20.12. Technical bulletins

20.12.1. Technical Article

Archak S, Tyagi V, Pragya and Chand P (2023). Exchange Procedures for Germplasm including transgenics. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 45-50.

Bhalla S, Chimata M Krishna, Gupta K and Chalam VC (2023). Cartagena Protocol on Biosafety: Overview and Compliance. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 37-44.

Brahmi P and Tyagi V (2023). Policies and guidelines related to plant genetic resources management in e-manual on Training Program on management and utilization of plant genetic resources, February 1-12, 2023, ICAR-NBPGR Publication. 227-231pp

Chalam V C, Gupta K, Khan Z, Akhtar J, Singh MC, Gawade BH, Kumari P, Kumar P, Meena BR, Kiran R, Maurya AK, Meena DS, Kalaiponmani K, Tripathi A and Yadav P (2023). Biosecurity and Biosafety: Concepts, International Scenario and Safe Transboundary

Movement of Germplasm In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Kavita Gupta, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 13-22.

Chalam VC and Ahuja V (2023). Biosafety Clearing House: Information Exchange on LMOs. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta Kavita, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 176-182.

Elangovan M, Hariprasanna K, Pandey S, Pradheep K, Vetriventhan M, Alercia A, Cerutti AL and Lopez F (2023). Key descriptors for fonio millets. ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India; ICAR-National Bureau of Plant Genetic Resources, New Delhi, India; International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Telangana, India and FAO on behalf of the International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy. https://doi.org/10.4060/cc8563en

Elangovan M, Hariprasanna K, Pandey S, Pradheep K, Vetriventhan M, Alercia A, Cerutti AL and Lopez F (2023). Key descriptors for foxtail millet. ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India; ICAR-National Bureau of Plant Genetic Resources, New Delhi, India; International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Telangana, India and FAO on behalf of the International Treaty on Plant Genetic Resources for Food and Agriculture, Rome, Italy. https://doi.org/10.4060/cc7531en

Gupta K and Chalam VC (2023). Pest Risk Analysis: Concepts and Methodology. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 128-135.

Rai KM, Arya M and Sharma A (2023). Raashtreey Padaap Anuvanshikeey Sansadhan Bureau kshetriye Kendr Bhowali me Sanrakshit Baagavaanee Phasaloka Sankshipt Parichay, NBPGR, R/S Bhowali.

Rai KM, Arya M and Sharma A (2023). Raashtreey Padaap Anuvanshikeey Sansadhan Bureau kshetriye Kendra Bhowali me Sanrakshit AushadiytathaSugandhiy Phasalo ka Sankshipt Parichay, NBPGR, R/S Bhowali.

Singh GP and Gupta K (2023). Overview of PGR Activities at ICAR-NBPGR. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Gupta K, Akhtar J, Khan Z, Kalaiponmani K, Tripathi A, Bhaskar DK and Singh GP organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 2-12.

Tyagi V, Brahmi P, Yadav SK, Pragya and Chandra P (2023). Introduction and Exchange of plant genetic resources in e-manual on Training Program on management and utilization of plant genetic resources, February 1-12, 2023, ICAR-NBPGR Publication. 224-226 pp

Yadav SK, Pragya and Tyagi V (2023). Procedures for exchange of germpplasmIntroduction and Exchange of plant genetic resources in e-manual on Training Program on management and utilization of plant genetic resources, February 1-12, 2023, ICAR-NBPGR Publication. 278-283 pp

20.12.2. Popular Articles/ Publication in Conference (Abstract/ Extended summaries)

Gowthami R, Padmavati GG, Tripathi K, Pamarthi RK and Chander S (2022). Foldscope- a cost effective pocket microscope and its utilization in plant genetic resources management. Kerala Karshakan. 10 (11):29-37

Hajong S, Uchoi J, Pradhan S and David LB (2023). Ricebean (*Vigna umbellata*) An important Potential crop of NE India. Published by ICAR-NBPGR RS Shillong.

Jain A, Kondal V, Singh M, Yadav R, Jeyaseelan C, Rana JC and Bhradwaj R, (2023). Nutrient profiling of Indian buckwheat germplasm-identification of eite lines for

nutritional security. In. Abstracts book of "15th International Symposium on Buckwheat for Health" 2-8th July, 2023, held at Pulawy, Poland.

Kaur V, Gomashe SV, Shashank K, Yadav, *et al* (2023). Understanding genetic variability for morphological and nutritional traits in the linseed germplasm collection at National Genebank of India. Oral presentation under the theme "Trait discovery and genomics in plants of NWH" in National Seminar on 'Plant Biodiversity for food, nutrition and health security in Noth-West Himalayas' on 27-28 November 2023 at Shoolini University, Solan, Himachal Pradesh.

Kumari J, Sharma S, Jacob SR, Gupta A, Basandrai A, Sivasamy M, Vikas VK, Kant L, Mishra KK, Jakhar P, Kumar G, Jadon V, Kumar S, Kumar A, Gauta RK, and Singh GP (2023). Search of novel donor germplasm for powdery mildew resistance in wheat minicore.pp. 9. In Agrawal *et al*. (eds) (2023) Book of Abstracts of the National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH), Shoolini University, Solan, Nov. 27-28, 2023. Indian Society of Plant Genetic Resources, New Delhi, New Delhi.

Malhotra EV, Bansal S (2023). Indian long pepper (Pippali): a wonder plant. Scientific India 11(4): 22-23https://scind.org/article/Indian-long-pepper-Pippali-a-wonder-plant

Pamarthi RK, Semwal DP, Soyimchiten and Singh PK (2023). Expedition of PGR diversity in North Western Himalaya of India" National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH)" at Shoolini University, Solan held on November 27-28, 2023.

Roy D, Chakraborti M, Kar M, Sahoo P, Behera M, Samal P, Pani D and Dasgupta T (2023). Combining biotic stress resistance alongwith herbicide and abiotic tolerance in rice mega variety 'Swarna' through minimal use of molecular markers. *In:* 2nd Indian Rice Congress Transforming Rice Research: Recent Scientific Developments and Global Food Crisis: Extended summary Book (eds. Kumar et al.), pp. 125-126.

Saravanan M, Sirsam A, Mohan P, Misra RC, Waghmare N, Kranthi KR and Prasad YG (2023). Genetic diversity analysis of perennials and landraces of *desi* cotton collected from different eco-geographical regions of India. In: 9th ACRDN International Conference at ICAR-CIRCOT, Mumbai: Book of Abstract (eds. Shukla et al.) p. 23.

Sharma BB, Banerjee J and Sharma VK (2023). Nutritional and health importance of snow peas e-published in Krishisewa, pp 6pages.

Singh M, Shiwani, Srivastava V, Kaur K and Singh AK (2023). Genetically modified and genome-edited fruit crops. Scientific India. 11 (3), 12-17pp.

Singh RP, Kumar V, Kaur V, Wankhede DP, and Singh M (2023). Alsi: Bahuayamifasalavamunnatkheti ki taqnique. *Anuvanshiki Pravah*. PP. 2-5.

Srivastava V, kumari A, Hajong S and Gowthami R (2023). Blood Fruit (*Haematocarpus validus*): An Underutilized species with potential health benefits in Thyroid and Anemia conditions. Kerala Karshakan english journal. Published by Department of Agriculture Development & Farmers' Welfare, Farm Information Bureau, Government of Kerela. 11(06): 38-43.

Srivastava V, Kumari A, Hajong S, Gowthami R (2023). Blood fruit (*Haematocarpus validus*) an underutilized species with potential health benefits in Thyroid and Anemia conditions. Kerala Karshakan e-journal, 11 (6): 38-43. https://www.fibkerala.gov.in/sites/default/files/inlinefiles/KKE%20%202023%20DECEMBER.pdf

Suma A, Joseph John K, Latha M, Pradheep K, Thirumalaisamy PP and Venkatesan K (2022). *Cheerayile jaivaividhyam* (English: Genetic diversity in *Amaranthus tricolor*). *Krishianganam* (In Malayalam), 5 (5). October-2022.

Thirumalaisamy PP and Pradheep K (2023). Millet cultivation: Current status in the Eastern Ghats section of Tamil Nadu. *Agritech Today*, 1(5): 44-46.

Thirumalaisamy PP, Sane Anuradha, Suma A, Pradheep K, Latha M and Venkatesan K (2023). Wood apple: A fruit rich in nutritional and medicinal value. *AgriTech Today*. Special Issue Nov.2023.

वर्तिका श्रीवास्तव, अनुराधा अग्रवाल, जीबी पाटिल, सादुयशवंत एवं एस के कौशिक (2023). उत्तक संवर्धित कंकोडा फसल से अधिक लाभ। फल–फूल (सितम्बर–अक्टूबर, 2023), 44–46.

मोनिका सिंह, ललित आर्य, मंजूषा वर्मा, सुनील श्रीराम गोमाशे, ममता सिंह, आकांशा बाजपेयी एवं सुशील पांडे (2023). कुटकी (लिटिल मिलेट): खाद्य सुरक्षा के लिए उपयोगिता। आनुवंशिकी प्रवाह, 2(1): 101–103.

त्यागी वन्दना एंव प्रतिभा ब्रह्मी (2023). अनुसंधान प्रयोजनों के लिए पादप आनुवंशिक संसाधनो के आदान प्रदान की प्रक्रिया, आनुवंशिकी प्रवाह, प्रथम अंक 45–48.

प्रज्ञा, वर्तिका श्रीवास्तव, वन्दना त्यागी एवं ज्ञानेन्द्र प्रताप सिंह (2023). जी–देशों के बीच फल आनुवंशिक संसाधनों के लिए परस्पर आत्मनिर्भरता: भारत में स्थिती और चुनोतियाँ, आनुवंशिकी प्रवाह अंक 2(1): 13–19 पृ.

संध्या गुप्ता (2023). भारत में जी 20 (G-20) शिखर सम्मेलन का भारत के कृषि क्षेत्र में प्रभाव। आनुवंशिकी प्रवाह 2(1): 38–41 पृ.

20.12.3. E-publications

Baliyan V, Singh D, Verma RK and Kaur V (2023). Agronomic Practices in Linseed. *AgriGate* 3(7): 177-181.

Gautam RK, Kumari J, Tripathi K, Pamarthi RK, Chander S, Singh M, Hooda KS and Singh GP (2023). Plant Genetic Resources Management – Theory and Practice. ICAR-NBPGR, New Delhi-110012. 1-393p

Singh M, Aminedi R and AK Singh (2023). Exploring the potential of next generation sequencing in detection of unauthorized genetically modified events in India. AgriGate - An e-Magazine, 3 (7): 19-23.

Singh M, Shiwani, Srivastava V, Kaur K and Singh AK (2023). Genetically modified and genome-edited fruit crops. Scientific India, 11 (3): 12-17.

Thirumalaisamy PP, Suma A, Latha M and Venkatesan K (2023). Thai nightshade (*Solanum trilobatum* L.): Boon to various ailments. *Kerala Karshakan e-journal*. 10(12): 30-32.

Thirumalaisamy PP, Suma A, Pradheep K and Latha M (2023). *Epilachna*beetle: A threat to cultivation of bitter gourd and its related species. *Kerala Karshakan e-journal*. 10(9): 31-35.

20.12.4. Plant germplasm reporter / brochure

Bhatt KC, Semwal DP, Ahlawat SP, Rathi RS, Pandey A, Chandra P, Kannaujia PK, Malav PK, Pamarthi RK, Soyimchiten, Panwar NS, Dhariwal OP, Tomar A and Singh PK (2023). *Plant Germplasm Reporter-2022* (*Indigenous Collections*). ICAR-National Bureau of Plant Genetic Resources, New Delhi. Pp 112.

20.12.5. Registration of Genetic Stocks

Gayacharan et al (2023). Chickpea (*Cicer arietinum*) germplasm IC275447 (INGR23046) was registered for Ascochyta blight resistance.

Jyoti et al (2023). Registered wheat germplasm IC112049 (INGR23019) for Terminal heat tolerance.

Kaur V, Aravind J, Manju, Jacob SR, Kumari J, Panwar BS, Pal N, Rana JC, Pandey A, and Kumar A (2023). Barley accession IC0650741 (tested as IC0138110-Sel) registered as genetic stock (INGR23087) for early heading and early maturity in six-rowed genetic background.

Kaur V, Manju, Yadav SK, Wankhede DP, Saroha A, Jacob SR, Pandey R, Sharma AD, Sheela and Kumar M, (2023). Barley accession IC0650742 (tested as IC0113045-Sel) registered as genetic stock (INGR23088) for drought tolerance at seedling and adult plant stage.

Lal C, Kumar D, Kaur V, Singh J, Kumar L, Ram Pal, Malik R, Bishnoi SK, Singh C, Jasrotia P, Kumar R, Singh OV and Singh GP (2023). Germplasm DWRBG15 (tested as HLR-136, selection from IC0313162) hulless six-row landrace of barley (IC0650738) with high protein (14.6%) and â-glucan (6.0%) contents registered as genetic stock INGR23084.

Lal C, Kumar D, Kaur V, Singh J, Kumar L, Ram Pal, Malik R, Bishnoi SK, Singh C, Jasrotia P, Kumar R, Singh OV and Singh GP (2023). Germplasm DWRBG16 (tested as HLR-240, selection from the landrace IC82717) of barley IC0650739 registered as genetic stock (INGR23085) for high ß-glucan (6.1%).

Tripathi K et al (2023). registered Lentil germplasm IC650748 (INGR23093) for Seed-coat colour anomalies due to altered anthocyanin pathway.

Tripathi K et al (2023). Registered Mungbean germplasm IC650749 (INGR23096) for resistance to MYMIV infection under North Indian conditions.

20.12.6. NCBI GenBank Submissions

Abhishek GJ, Kalaiponmani K, Deepika DD, Tripathi K and Chalam VC (2023). Mungbean yellow mosaic India virus isolate CPH23AV13 coat protein (AV1) and AC5 protein (AC5) genes, partial cds. (Accession No. OQ929494)

Biradar VK, Nair B, Kumar S, Ayanur G, Shah M, Tekale N, Parbat J, Kaur V, Rathnakumar AL and Bhoopathi T (2023). Linseed bud fly isolates (*mitochondrial cytochrome c oxidase subunit I (COX1)* gene), CDS. Accession number: OQ613414 & OQ613415)

Biradar VK, Nair B, Kumar S, Ayanur G, Shah M, Tekale N, Parbat J, Kaur V, Rathna Kumar AL, and Boopathi T (2023). Cecidomyiidae sp. isolate Nagpur01 cytochrome c oxidase subunit I (COX1) gene, partial cds; mitochondrial. GenBank ID: OQ613414.

Biradar VK, Nair B, Kumar S, Ayanur G, Shah M, Tekale N, Parbat J, Kaur V, Rathnakumar AL and Boopathi T (2023). Cecidomyiidae sp. isolate Nagpur02 cytochrome c oxidase subunit I (COX1) gene, partial cds; mitochondrial. GenBank ID: OQ613415.

Kalaiponmani K, Khan Z, Gawade BH and Chalam VC (2023). *Meloidogyne enterolobii* isolate Sataparai, Tamil Nadu small subunit ribosomal RNA gene and internal transcribed spacer 1, partial sequence (Accession No. OQ826656)

Tripathi A, Akhtar J and Chalam VC (2023). *Xanthomonas campestris*pv. *vesicatoria* strain XCV 16S ribosomal RNA gene, partial sequence (Accession no. OQ457621).

Tripathi A, Akhtar J and Chalam VC (2023). *Diaporthephaseolorum* isolate Dp1 actin gene, partial CDS (Accession No. OQ186631).

Tripathi A, Gupta K and Chalam VC (2023). *Callosobruchus chinensis* isolate Cc cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OR294175).

Tripathi A, Gupta K and Chalam VC (2023). *Rhyzoperthadominica* isolate Rd cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OQ569541).

Tripathi A, Gupta K and Chalam VC (2023). *Sitophilus oryzae* isolate So cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OQ996824).

Tripathi A, Gupta K and Chalam VC (2023). *Triboliumcastaneum* isolate Tb cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OQ509919).

Tripathi A, Gupta K. and Chalam VC (2023). *Callosobruchus maculatus* isolate Cm cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OQ509809).

Tripathi A, K Gupta K and Chalam VC (2023). *Bruchuslentis* isolate Bl cytochrome c oxidase subunit I (COX1) gene, partial cds mitochondrial (Accession No. OQ572315).

Yadav SK, Kaur V, Singh D, Jat B, Prasad L and Sagar S (2023). "Candidatus Phytoplasma australasiaticum" clone LuPHY_IC0498748 16S ribosomal RNA gene, partial sequence. GenBank ID: OR178439.

Yadav SK, Kaur V, Singh D, Jat B, Prasad L and Sagar S (2023). "Candidatus Phytoplasma australasiaticum" clone LuPHY-EC1074585 16S ribosomal RNA gene, partial sequence. GenBank ID: OR178021.

Yadav SK, Sonia, Arya SS and Kaur V (2023). Hordeum sp. accessions Hordeum vulgare root abundant factor (HvRAF) gene. GenBank ID: OR077393 - OR0773404.

20.12.7. Barcodes submitted

Tripathi A, Gupta K and Chalam VC (2023). *Callosobruchus maculatus* isolate Cm cytochrome c oxidase subunit I (COX1) gene, Barcode ID: NCP001-23, Barcode index Number (BIN) - BOLD: ACX1369 (Genbank Accession: OQ685800).

Tripathi A, Gupta K and Chalam VC (2023). *Tribolium castaneum* isolate Tb cytochrome c oxidase subunit I (COX1) gene, Barcode ID: NCP002-23, BIN-BOLD: AAH8019, Genbank Accession:OQ685802.

Tripathi A, Gupta K, and Chalam VC (2023). *Callosobruchus chinensis* isolate Cc cytochrome c oxidase subunit I (COX1) gene, Barcode ID: NCP006-23 Barcode index Number (BIN) - BOLD: AAF8476

Tripathi A, Gupta K, and Chalam VC (2023). *Sitophilus oryzea* isolate So cytochrome c oxidase subunit I (COX1) gene, Barcode ID: NCP005-23 Barcode index Number (BIN) - BOLD: AAJ6841

Tripathi A, Gupta K, and Chalam VC (2023). *Bruchuslentis* isolate Bl cytochrome c oxidase subunit I (COX1) gene Barcode ID: NCP003-23 Barcode index Number (BIN) - BOLD: AFC9077, (Genbank Accession: OQ685799).

Tripathi A, Gupta K, and Chalam VC (2023). *Rhyzopertha dominica* isolate Rd cytochrome c oxidase subunit I (COX1) gene, Barcode ID: NCP004-23 Barcode index Number (BIN) - BOLD: ACB4329 (Genbank Accession: OQ685799).

Table 20.1: Various PGR awareness programmes organized by ICAR-NBPGR in 2023

Sn.	Programme	Organised by	Date	Venue
1.	Sorghum Germplasm Field Day	ICAR-NBPGR Regional Station,, Akola	March 13, 2023	Agriculture Research Station, Washim, Maharashtra
2.	Barnyard millet field day	ICAR-NBPGR, New Delhi	October 16, 2023	ICAR-NBPGR, Farm Issapur, New Delhi
3.	PGR Awareness cum cleanliness drive organised on the occasion of "Kisan Diwas"	ICAR-NBPGR, New Delhi	December 23, 2023 Issapur, New Delhi	ICAR-NBPGR, Farm
4.	Germplasm Diversity Day - 2023	ICAR-NBPGR, New Delhi	October 13, 2023	ICAR-NBPGR, Pusa Farm, New Delhi
5.	Germplasm Diversity Day - 2023	ICAR-NBPGR, New Delhi	March 15, 2023	ICAR-NBPGR Farm, Issapur, New Delhi
6.	Mango Germplasm Diversity Day	ICAR-NBPGR Regional Station, Thrissur	May 10, 2023	ICAR-NBPGR Regional Station, Thrissur
7.	Promoting Teasel gourd cultivation in Kerala	ICAR-NBPGR Regional Station, Thrissur	May 19, 2023	ICAR-NBPGR Regional Station, Thrissur
8.	Malabar Tamarind Germplasm Diversity Day	ICAR-NBPGR Regional Station, Thrissur	August 10, 2023	ICAR-NBPGR Regional Station, Thrissur
9.	Germplasm Diversity Day on *Abelmoschus* and *Solanum*	ICAR-NBPGR Regional Station, Thrissur	November 20, 2023	ICAR-NBPGR Regional Station, Thrissur
10.	Kisan Gosthi on the occasion of World Soil Day	ICAR-NBPGR, New Delhi	December 05, 2023	ICAR-NBPGR Farm, Issapur, New Delhi
11.	Vigilance Awareness Week	ICAR-NBPGR, New Delhi	October 30 to March 5, 2023	ICAR-NBPGR, New Delhi
12.	Kisan Gosthi on Waste to Wealth' and 'Swachhata Programme'	ICAR-NBPGR, New Delhi	October 12, 2023	ICAR-NBPGR Farm, Issapur, New Delhi
13.	Gram Sabha for awareness Building about Public Interest Disclosure and Protection of Informers (PIDPI) resolution	ICAR-NBPGR, New Delhi	November 10, 2023	ICAR-NBPGR Farm, Issapur, New Delhi
14.	Vigilance Awareness Week	ICAR-NBPGR, New Delhi	October 30 to March 5, 2023	ICAR-NBPGR, New Delhi
15.	9th International Day of Yoga - 2023	ICAR-NBPGR, New Delhi	June 21, 2023.	Harbhajan Enclave NBPGR, New Delhi
16.	"PGR Awareness camp/Biodiversity Fair"	ICAR-NBPGR Regional Station, Srinagar	March 25, 2023	KVK SKUST- Poonch, Jammu, Qazi Morah, Poonch Jammu & Kashmir
17.	A workshop cum awareness programme on "Conservation of Plant Genetic Resources for Health and Nutritional Security" under Schedule Caste Sub-Plan	ICAR-NBPGR Regional Station, Akola	March 23, 2023	Krishi Vigyan Kendra, Selsura, District Wardha of Maharashtra
18.	PGR Awareness-Cum-Training Programme on Plant Genetic Resources Conservation under SCSP programme	ICAR-NBPGR Regional Station, Cuttack	March 14, 2023 and March 17, 2023	Polasara, and Bhanjanagar, Ganjam, Odisha
19.	Exhibition stall depicting activities of Base Centre emphasizing M&AP, vegetable crops, cotton & other crop diversity of Odisha	ICAR-NBPGR Regional Station, Cuttack	11-12 May 2023	"Regional Workshop on PPV &FRA Act and Exhibition Agro-biodiversity" at ICAR-NRRI, Cuttack

20.13. Participation in radio/TV programmes

Dr. Rashmi Yadav delivered a Radio talk on "Til ke germplasm main vividhta" broadcasted by All India Radio on May 21, 2023.

Dr. Ishwar Singh delivered a Radio talk on "वसंत कालीन गन्ने में सहफसली एवं खरपतवार नियंत्रण" broadcasted by Prasar Bharati, Akashwani/Doordarshan on March 21, 2023.

Dr. Ishwar Singh delivered a Radio talk on "गन्ने की पेड़ी (Ratoon) में समसामयिक कार्य एवं उर्वरक प्रबंधन" broadcasted by Prasar Bharati, Akashwani/Doordarshan on May 02, 2023.

Dr. Ishwar Singh delivered a Radio talk on "शरद कालीन गन्ने की उन्नतशील किस्में एवं बुवाई" broadcasted by Prasar Bharati, Akashwani/Doordarshan on September 15, 2023.

20.14. Organization of germplasm field days

20.14.1. Sorghum Germplasm Field Day (13 March 2023)

A Mega event of Sorghum Germplasm Field Day was organized on March 13, 2023 at Agriculture Research Station, Washim. It was organized in collaboration with Dr. PDKV, Akola and ICAR-IIMR, Hyderabad. The total germplasm of sorghum conserved in NBPGR National Genebank (~25,000 accessions) was at display in the field. More than 600 participants which included farmers, researchers and students got the opportunity to see one of the largest Characterization programme.

20.14.2. Barnyard Millet diversity showcased on the occasion of World Food Day 2023 at ICAR-NBPGR, Farm Issapur on Oct.16, 2023

Barnyard millet field day was organized at ICAR-NBPGR, Farm Issapur on October 16, 2023. The entire set of 1888 diverse accessions of Barnyard millet from the National Genebankwas grown and showcased for the first time at ICAR-NBPGR for their agro-morphological characterization. The occasion was celebrated to realize the goals of promoting "*Shree Ann*" as nutri-rich crops envisioned by Hon'ble Prime Minister, Shri Narendra Modi for achieving food, nutritional and environmental security. A total of 50 millet researchers, scientists from various institutions, farmers and KVK personnel joined this event to have firsthand view of the genetic variability for future utilization.

20.14.3. One day "PGR Awareness cum cleanliness drive" organised on the occasion of "Kisan Diwas" on December 23, 2023 at Issapur Farm, New Delhi

On the auspicious occasion of "National Farmers Day" on December 23, 2023, one day PGR awareness cum

cleanliness drive was organized at ICAR-NBPGR, Issapur Farm, New Delhi. Around 50 farmers participated in this event. Dr. Rakesh Singh, Head, DGR addressed the farmers about importance of Plant Genetic Resources. He emphasized on strategic use of plant genetic resources with efficient soil health management for food, nutrition and income security of farmers under emerging climate change situation.

20.14.4. "Germplasm Diversity Day - 2023" at ICAR-NBPGR, Pusa Farm, New Delhi on October 13, 2023

In his inaugural address, Dr. GP Singh, Director, ICAR-NBPGR, New Delhi stressed on utilizing the Crop Wild Relatives (CWRs) and landraces in Indian breeding programme and establishing collaborative linkages with crop-based Institutes for better utilization of the germplasm. During his interaction with the concerned scientists and participants, Dr. AK Vishwakarma, PC, Sesame and Niger appreciated the Bureau's efforts for large-scale germplasm characterization and developing the core sets in sesame, cowpea, black gram, etc. Earlier, in his welcome address, Dr. RK Gautam, Head (Division of Germplasm Evaluation), ICAR-NBPGR, New Delhi outlined the germplasm activities being carried out at the Pusa Farm. He also outlined the large-scale characterization of germplasm through different projects. Dr. Kuldeep Tripathi, OIC, ICAR-NBPGR, Pusa Farm showed crop wild relatives of pulses established at the CWR garden. He urged breeders to use targeted species in their respective crop improvement programs. Dr PK Singh, Head, DPEGC facilitated the visit of Yardlong bean grown in controlled condition with trailing support. Around 4,800 germplasm accessions of different field crops were shown to the crop experts belonging to the ICAR-IARI, ICAR-IIPR, ICAR-IGFRI, ICAR-CSSRI, JNKVV, PAU, DBT-NIPGR, RPCAU, UAS-Bengaluru and ICAR-NBPGR during the occasion.

20.14.5. ICAR-National Bureau of Plant Genetic Resources, New Delhi organized the "Germplasm Diversity Day - 2023" at ICAR-NBPGR Farm, Issapur, New Delhi on March 15, 2023

The Germplasm Diversity Day was organized at ICAR-NBPGR Experimental Farm, Issapur, New Delhi on March 15, 2023. It was attended by around 60 participants from 13 organizations namely ICAR-IIWBR, Karnal; ICAR- IARI, New Delhi; PAU, Ludhiana; ICAR-VPKAS, Almora; ICAR-NBPGR, New Delhi; ICAR-IIPR, Kanpur; SHUATS, Prayagraj; CSKHPV, Palampur; ICARDA-India; KVK, Ujwa; Nuziveedu seeds; ZARS, Kalaburgi and GBPUAT, Pantanagar including five farmers of nearby villages. At the outset, Dr. R K Gautam, Head, Division of Germplasm Evaluation ICAR-NBPGR apprised about the germplasm of different crops being grown at NBPGR, Issapur farm. Dr. GP Singh, Director, ICAR-NBPGR welcomed all the participants and highlighted the importance of genetic resources and field days for their effective utilization. He also expressed his interest in effective collaboration for trait specific evaluation by NARS collaborators. He emphasized about the development of donor for utilization in crop improvement. Dr. Kuldeep Tripathi, OIC, Issapur Experimental Farm facilitated field visit. The participants visited the Issapur farm where 4,180 germplasm accessions comprising grass pea (3,000) and triticale (1,180) are being grown for characterization and preliminary evaluation. Similarly, 3,571 germplasm accessions comprising wheat (1831), chickpea (1040) and barley (700) are being grown for evaluation against abiotic stresses. In addition, the trait-specific germplasm of faba bean nurseries are also on display. The participants selected germplasm of their interest according to their breeding objectives. During interaction, the participants appreciated the efforts of ICAR-NBPGR in showcasing the utilizable crop genetic resources i.e., trait specific germplasm, and crop diversity in landraces. The farmers were very excited to see the material and evinced keen interest in wheat material with high sweetness, bold seeds and thick stem and early maturing chick pea germplasm. The program was concluded with the vote of thanks by Dr. Jyoti Kumari, Principal Scientist, DGE.

20.14.6. Mango Germplasm Diversity Day

A germplasm diversity day for mango was organized on May 10, 2023 to showcase the diversity of 66 mango landraces maintained in the field genebank of ICAR-NBPGR Regional Station, Thrissur and 22 collections maintained by various farmer conservators.

20.14.7. Promoting Teasel gourd cultivation in Kerala

A teasel gourd distribution day was organized by ICAR-NBPGR Regional Station, Thrissur on May 19, 2023 wherein more than 25 farmers were supplied with twosets of male and female plants. Dr. Joseph John, K., Ex-Principal Scientist, NBPGR delivered a lecture on cultivation practices of teasel gourd in Kerala. Training on the cultivation practices, demonstration ofartificial pollination and propagation method using terminal stem cuttings were also made.

20.14.8. Malabar Tamarind Germplasm Diversity Day

Malabar tamarind diversity day was organized by ICAR-NBPGR Regional Station, Thrissur on August 10, 2023 which was attended by 25 participants comprising farmers, students and researchers from different parts of the state. Fruits of more than 30 diverse Malabar tamarind germplasm were displayed.

20.14.9. Germplasm Diversity Day on *Abelmoschus* and *Solanum*

A germplasm diversity day on *Abelmoschus* and *Solanum* was conducted by ICAR-NBPGR Regional Station, Thrissur on November 20, 2023 to showcase the germplasm and species diversity, which was attended by 43 participants comprising researchers/ faculties and scholars from Kerala Agricultural University and Tamil Nadu Agricultural University.

20.15. PGR awareness, MGMG and TSP

Organized a Kisan Gosthi on the occasion of World Soil Day and delivered lecture on Soil health to the participating farmers on December 05, 2023 at NBPGR, Issapur Farm.

Celebrated Vigilance Awareness Week from October 30 to March 05, 2023 and conducted different activities viz.; Integrity pledge, Poster making, Slogan writing, Essay writing and Debate competition during the week at ICAR-NBPGR, New Delhi.

Organized a **Kisan Gosthi** on Waste to Wealth' and **'Swachhata Programme'** on the occasion of observance of Special Campaign 3.0 and delivered lecture on Management

of Domestic and Field waste on October 12, 2023 at NBPGR Issapur Farm.

Conducted a Gram Sabha at Issapur Village on November 10, 2023 for awareness Building about Public Interest Disclosure and Protection of Informers (PIDPI) resolution' to inculcate the true spirit of participative vigilance among the public.

Celebrated Vigilance Awareness Week from October 30 to March 05, 2023 and conducted different activities viz.; Integrity pledge, Poster making, Slogan writing, Essay writing and Debate competition during the week at ICAR-NBPGR, New Delhi

Celebrated 9th International Day of Yoga - 2023 at Harbhajan Enclave NBPGR, New Delhi on June 21, 2023.

20.15.1. "PGR Awareness camp/Biodiversity Fair" at Regional Station Srinagar under TSP

"PGR Awareness camp/Biodiversity Fair" was organized by ICAR-NBPGR Regional Station Srinagar under TSP at Qazi Morah, Poonch Jammu & Kashmir in collaboration with KVK SKUST- Poonch, Jammu on March 25th, 2023. One hundred and fifty (150) farmers including women farmers from the villages of Nangali, Bhaincah, Chandak, Khanetar, Kojra, Jhullas, Mangnar and others Panchayats participated in the programme. During the event farmers displayed crop diversity maintained in their fields and cash prizes were awarded to the best displays for encouragement.


20.16. FGB Status of RS, NBPGR (2023)

Table 20.2: Genetic Resources added to the Field Genebank of the Regional Stations of NBPGR during 2023

S No	Regional Station Name	No. of germplasm/spp. added in 2023
1.	ICAR-NBPGR RS, Akola, Maharashtra	NIL
2.	ICAR-NBPGR RS, Bhowali, Uttarakhand	53 (Wild Allium, Bramble, Garlic, Stone Bramble, Raspberry, Black berry, Lemon, Indian Magnolia)
3.	ICAR-NBPGR RS, Cuttack, Odisha	33 (*Costus pictus, Abelmoschus crinitus, Abelmoschus odishae, Abelmoschus manihot, Andrographis paniculata*, *Ocimum basilicum var. pilosum, Ocimum gratissimum, Hibiscus sabdariffa* (2), *Luffa aegyptiaca, Thespesia lampas, Cissus quadrangularis, Dioscorea alata* (3), *Dioscorea oppositifolia* (1), *Oryza nivara* and *Oryza rufipogon*)
4.	ICAR-NBPGR RS, Hyderabad, Telangana	01 (Wild Banana -*Ensete glaucum*)
5.	ICAR-NBPGR RS, Jodhpur, Rajasthan	05 (*Ficus carica)*
6.	ICAR-NBPGR RS, Ranchi, Jharkhand	10 (*Artocarpus heterophyllus,Aegle marmelos*)
7.	ICAR-NBPGR RS, Shillong, Meghalaya	09 (Sweet Orange, Rough lemon, Indian wild orange, Lemon, Satkara, Sour Orange, Khasi Papeda, Hill Lemon and Khasi Mandarin)
8.	ICAR-NBPGR RS, Shimla, Himachal Pradesh	43 (Apricot, Walnut, Peach, Almond, Plum, Cherry Plum, Cherry and Kiwi fruit)
9.	ICAR-NBPGR RS, Srinagar, Jammu & Kashmir	24 (Blackberry)
10.	ICAR-NBPGR RS, Thrissur, Kerala	96 (Medicinal plants, *Musa* spp., *Artocarpus* spp., turmeric, economically important plants from A&N Islands)

Photographs of some of the accessions established in Field Genebanks of NBPGR during 2023

20.17. Extension and awareness programme

A workshop cum awareness programme on "Conservation of Plant Genetic Resources for Health and Nutritional Security" under Schedule Caste Sub-Plan was organized at Krishi Vigyan Kendra, Selsura, District Wardha of Maharashtra State on March 23, 2023. It was organized with local support from from KVK, Selsura. A total of 130 participants comprising farmers and organizers were part of

Akola organized Workshop cum awareness programme organized under Scheduled Caste Sub-Plan at KVK, Shelsura, District Wardha, Maharashtra

the programme. Women farmers also participated proactively in the event.

20.17.1. Participated in State level Agriculture Exhibition (AGROTECH- 2023) during December 27-29, 2023 at Dr. PDKV, Akola, Maharashtra

ICAR-NBPGR, Regional Station, Akola participated in Agriculture Exhibition organized by Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on the occasion of 125th birth anniversary of late Dr. Panjabrao Deshmukh during December 27-29, 2023. ICAR-NBPGR Akola exhibited seed variability conserved in MTS at Akola of Millets, Oilseeds, Pulses, Amaranth and specimens of Vegetable crops and Crop Wild Relatives (CWRs). Farmers were apprised on the need to conserve our traditional seeds and diversify the cropping system by inclusion of minor pulses, millets and potential crops to attain nutritional and health security. More than nine lakh (5.5 lakh) farmers/students/industry people visited the exhibition during December 27-29, 2023. The farmers appreciated the efforts carried out by NBPGR specifically for small millets and oil seeds.

RS, Akola Participated in State level Agriculture Exhibition (AGROTECH- 2023) during December 27-29, 2023 at Dr. PDKV, Akola, Maharashtra

Co-organized two PGR Awareness-Cum-Training Programme by RS Cuttack on Plant Genetic Resources Conservation at Polasara, and Bhanjanagar, Ganjam, Odisha under SCSP programme on March 14, 2023 and March 17, 2023 respectively. About 210 farmers from SC community were imparted on seed treatment, line sowing, bio-fertilizer preparation by scientists of KVK, Bhanjanagar-I. They have also received seeds, planting materials of different vegetable crops and small farm implements during the programme.

RS Cuttack organized exhibition stall depicting activities of Base Centre emphasizing M&AP, vegetable crops, cotton & other crop diversity of Odisha in the "Regional Workshop on PPV&FRA Act and Exhibition Agro-biodiversity" at ICAR-NRRI, Cuttack during May 11-12, 2023. Organised field demonstration for B.Sc. (Agril.) students of IGKV, CARS, Mahasmund, Chhatisgarh on May 19, 2023.

In 2023, the Hyderabad station facilitated various educational initiatives and study tours. An Awareness Programme and study tour for over 75 students from Government Unanai College, Charminar, Hyderabad took place on February 26, 2022, focusing on medicinal plants. Lecture topics included "Medicinal plants diversity and their Conservation in India with special reference to Eastern Ghats." Visits continued with 80 B.Sc (Agriculture) students from USHA Martin University on February 20, 2023, 95 B.Sc. (Agriculture) students from TNAU-Agricultural College & Research Institute on March 01, 2023, 46 B.Sc (Ag) students from PJTSAU on March 15, 2023 & March 17, 2023, and 103 students of B.Sc (Hons) agriculture from College of Agriculture, Dhule, Maharashtra in July 2023. Additionally,

Two groups of thirty seven (37) progressive farmers from UT of Ladakh visited RS Srinagar on August 23, 2023 and September 11, 2023 and interacted with the scientists regarding mandate and activities of the station

educational tours included 34 students of III year B.Sc. (Botany) from Government Arts College, Krishnagiri, Tamil Nadu on September 22, 2023, and 95 students of III year B.Sc.(Ag) from Loyola Academy, Secunderabad on September 26, 2023. An Orientation programme for IARI-Mega Hub-Hyderabad students took place on November 21, 2023.

PGR Awareness programme for students and farmers:109 students from different colleges [St. Joseph College, Devagiri, Kozhikode (23), NEHU, Tura Campus, Meghalaya (24), Sree Krishna College, Guruvayur (32), SN College, Alathur (30)] and 17 farmers from Wayanad district visited the ICAR-NBPGR Regional Station, Thrissur for understanding the PGR activities.

20.18. Distinguished visitors of NBPGR and its stations

20.18.1. Visits to the Division/ NGB/Regional station

Dr Himanshu Pathak Hon'ble Secretary, DARE and Director General, (ICAR)visited the Bureau on August 14, 2023 (foundation day of the Bureau). He assessed the progress and maintenance of the NGB and the in vitro genebank of DGC.

Dr. G.P. Singh, Director and Dr. Anju Mahendru Singh, Head, DGC, ICAR-NBPGR inaugurated two new facilities *i.e.*new tube well in office premises and drip irrigation system at ICAR-NBPGR Regional Station, Jodhpur on September 5-6, 2023.

Dr. P. L. Gautam, Chairman, 25th RAC visited the National Genebank on October 31, 2023

Visit of Dr. Venu Ramaiah,Incharge, IRRI Genebank to DGC on November 06, 2023 was organized and he delivered a talk on "Use of Artificial Intelligence in upgradation of National Genebank."

NBPGR organized 50th and 51st Meeting of the Plant Germplasm Registration Committee (PGRC) on June 12, 2023 and November 22, 2023 in virtual mode under the Chairmanship of Dr TR Sharma (DDG), Crop Science, ICAR.

Visit of renowned international Citrus scientists, (Prof. Mikeal L Roose, Dr. David Karp, Dr. Georgios Vidalakis and Dr. Chandrika Ramadagu) from University of California (Riverside) and Prof Fredrick Gimmter from University of Florida, USA and Dr. Franck Curk from French National Research Institute for Agriculture, Food and the Environment (INRAE) to National Genebank and Cryogenebank was organized on December 01, 2023.

A Webinar on **Citrus: Genetic Resources to Genomics** was also held.

Following presentations were made by the visiting scientists.

- The California Citrus Clonal Protection Program: A Model System For Citrus Germplasm Disease Protection by **Georgios Vidalakis, UC, Riverside, USA**
- Comparative Genomic Analysis Illuminates the Evolution and Domestication of Citrus: The Next Chapter? by **Fred Gmitter Jr., University of Florida, USA**
- Conservation of Germplasm of Clonally Propagated Crops: The US System and Global Context by **Mikeal Roose, UC, Riverside, USA**

Webinar was attended by the scientists, researchers, students of ICAR-NBPGR, ICAR- IARI and other institutes.

Visit of Dr. B.S. Dhillon, former Director, ICAR-NBPGR to National Genebank was organized on December 05, 2023

20.18.2. RS Cuttaack

1. Dr T Mohapatra, Chairperson, PPVFRA, New Delhi visited on dated May 11, 2023.
2. Dr P C Chaurasiya,Asst Prof. PBG,IGKVV, Raipur and 14 UG students visited on May 18, 2023
3. Dr S K Pradhan, ADG, FFC and Dr S K Dash, Principal Scientist, ICAR-NRRI, Cuttack visited on September 06, 2023
4. Prof. Ruma Pal, Retired Prof. Botany, Calcutta University visited on October 04, 2023.
5. Dr. Yutaka Sato and Dr. Takanori Yushikawa from National Institute of Genetics, Mishima, Shizuok, Japan visited on November 06, 2023.

20.18.3. Regional Station, Hyderabad

In 2023, notable visits to the station included Dr. P L Gautam, Former Director, NBPGR, who discussed networking capabilities with local ICAR institutes. Dr. PK Singh, Head of Germplasm Exploration at ICAR-NBPGR, inspected facilities in Hyderabad in June. On July 12th, Dr. G.P. Singh, Director, Dr. PK Singh, Dr. Kavita Gupta, and Dr. Sushil Pandey visited. Dr. D K Yadava, ADG (Seeds), toured the station on November 7th, conducting an interactive meeting. Lastly, on November 17th, Dr. V Celia Chalam, Dr. Kavita Gupta, and Dr. Zakaullah Khan from the Division of Plant Quarantine visited and engaged with the station's staff.

Parliamentary Committee inspection on Hindi Implementation during August 21-23, 2023, Vijayawada

20.19. Other programmes

The station marked the 74th Republic Day, 77th Independence Day, Hindi Diwas on September 14, 2023, and Vigilance Awareness Week on October 26, 2023. Dr. Seema Verma highlighted Hindi's significance, conducted competitions, and emphasized integrity. Constitution Day, observed on November 26, 2023, involved a pledge ceremony led by Dr. N Sivaraj, underscoring the importance of transparency and accountability for growth. All staff actively participated in these patriotic and awareness events at the Regional Station, Hyderabad.

20.19.1. Regional Station, Shimla

1. Dr. Tej Pratap former Vice Chancellor, GBPUAT, Pantnagar visited ICAR-NBPGR RS Shimla on dated February 06, 2023.
2. Dr G.P. Singh, Director ICAR-NBPGR visited ICAR-NBPGR RS Shimla on dated October 09, 2023

20.19.2. Regional Station, Thrissur

Dr. Sanjay Kumar Singh, Director, ICAR-IIHR, Bengaluru visited the station on 11th Oct, 2023 and Dr. K Pradheep, Officer Incharge explained him with the various research activities being undertaken at the station (Fig. 11). Mr VS Sunil Kumar, Ex Minister for Agriculture, Govt. of Kerala visited the station on December 22, 2023.

Visit of Dr. Sanjay Kumar Singh, Director, ICAR-IIHR, Bengaluru

20.20. Report of ICAR Sports Meet(Central Zone), 2023

The ICAR Sports Meet (Central Zone), 2023 was held at ICAR-CIAE, Bhopal, Madhya Pradesh from December 18-21, 2023. The ICAR-NBPGR Sports Contingent took part in Badminton (Men &Women), Badminton (mixed double), Volley ball (Shooting), Carom and Chess (Men) and Athletics

Sports contingent in March-past

Sports contingent with Trophies

Felicitated players who would be participating in the tournament for the last time before their superannuation

Winners with medals

Badminton Zonal Champions

Runners up trophy in Volleyball (Shooting)

event as 100m and 200 m race (Men &Women), 1500m (Men), Relay Race 100m x 4 (Men), Cycle Race, Long jump, with a total of 20 participants. The ICAR-NBPGR Won Gold Medal in Badminton (Men), Runners Up in Badminton (Women doubles), Badminton (mixed doubles), silver medal in 200m (Men and Women) and Bronze Medal in High Jump (Men).

Arial view of CWR garden at ICAR-NBPGR experimental farm, Pusa campus, New Delhi

Field day of finger millet germplasm (around 12000 accessions)

MoU signed between ICAR-Indian Institute of Agricultural Biotechnology, Ranchi and ICAR-NBPGR on 12 May 2023 for undertaking collaborative research

NBPGR exhibition stall at ICAR convention centre, NASC to have glimpse of plant genetic resources diversity conservation efforts

Large scale germplasm characterization and evaluation at RS, Akola

"Van Mahotsav" organized at ICAR-NBPGR, Issapur farm

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