वार्षिक प्रतिवेदन
Annual Report 2022

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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ANNUAL REPORT
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NBPGR

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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

हमें वर्ष 2022 की वार्षिक रिपोर्ट प्रस्तुत करते हुए खुशी हो रही है, जिसके दौरान आईसीएआर–एनबीपीजीआर दुनिया भर में प्रजनकों और अन्य हितधारकों के लिए पादप आनुवंशिक संसाधन अनुसंधान में महत्वपूर्ण भूमिका निभा रहा है। इस परिप्रेक्ष्य में, हमने 2022 में पादप आनुवंशिक संसाधनों पर केंद्रित और कार्यनीतिक अनुसंधान के लिए राष्ट्रीय साझेदारों को शामिल करते हुए संस्थागत और बाह्य रूप से वित्त पोषित कार्यक्रमों और नेटवर्क परियोजनाओं के तहत कार्य किया है।

आईसीएआर–एनबीपीजीआर एक अग्रणी पादप आनुवंशिक संसाधन संस्थान है जो पादप आनुवंशिक संसाधनों की खोज, संरक्षण, विनिमय, संगरोध और लक्षण वर्णन के लिए कटिबद्ध है। एनबीपीजीआर में पीजीआर प्रबंधन और अनुसंधान देश की समकालीन आवश्यकताओं पर केंद्रित है और इसमें फसल प्रजनकों और कृषक समुदायों के लिए व्यापक पीजीआर लाभ हैं। पीजीआर सबसे शक्तिशाली संसाधन है जो पर्यावरणीय परिवर्तन, मानव स्वास्थ्य, जैविक, अजैविक स्ट्रेस और भोजन की कमी जैसी चिंताओं का स्थायी समाधान प्रदान करने में सक्षम है।

इस दिशा में, एनबीपीजीआर ने फसल जननद्रव्य आपूर्ति, विनिमय और संगरोध के क्षेत्रों में राष्ट्रीय और अंतर्राष्ट्रीय सेवा प्रदान करना जारी रखा और साथ ही पीजीआर अनुसंधान का लक्षण वर्णन करने और दस्तावेजीकरण करने का कार्य भी किया।

मैं युवा शोधकर्ताओं– वैज्ञानिकों, तकनीकी कार्मिकों, परियोजना और संविदा कर्मचारियों और अनुभवी कार्मिकों/ प्रभागाध्यक्षों और प्रभारी अधिकारियों, प्रशासनिक और सहायक कर्मचारियों के अलावा उनकी टीम वर्क, दक्षता और प्रतिबद्धता की हार्दिक सराहना करना चाहता हूं।

हमें भारतीय कृषि अनुसंधान परिषद् का अटूट समर्थन मिला और मैं डॉ. हिमांशु पाठक, सचिव, डेयर और महानिदेशक, भाकृअप और डॉ. टी महापात्र, पूर्व सचिव, डेयर और महानिदेशक, भाकृअनुप; डॉ. टी आर शर्मा, उप महानिदेशक (फसल विज्ञान) और डॉ. डी के यादव, सहायक महानिदेशक (बीज) को आईसीएआर–एनबीपीजीआर के आवश्यक अधिदेश की सराहना के लिए उनके नेतृत्व को कृतज्ञतापूर्वक धन्यवाद देता हूं।

मैं आपको इस वार्षिक रिपोर्ट का अध्ययन करने और 2022 के दौरान एनबीपीजीआर में हुई उत्कृष्ट प्रगति की सराहना करने हेतु अनुरोध करता हूं।

ज्ञानेंद्र प्रताप सिंह
निदेशक

PREFACE

I am pleased to put forth Annual Report 2022 during which ICAR-NBPGR has been in the significant role of plant genetic resources research with substantial consequence to breeders and other stakeholders worldwide. In this perspective, we have implemented a range of institutional and externally funded programmes and network projects involving national partners for focused and strategic research on plant genetic resources in 2022.

ICAR-NBPGR is the leading plant genetic resources institute dedicated to the exploration, conservation, exchange, quarantine and characterization of plant genetic resources. PGR management and research in NBPGR focuses on the contemporary requisite of the country and has broad based PGR benefits to crop breeders and farming communities. PGR is the most powerful resource capable of providing sustainable solutions to concerns like environmental changes, human health, biotic, abiotic stresses and food shortages.

In this direction, NBPGR continued to provide national and international service in the areas of crop germplasm supply, exchange and quarantine as well as undertook to characterize and document the PGR research.

I take the opportunity to place on record my sincere appreciation to the young researchers— scientists, technicals, project & contractual staff; and seasoned personnel — HoDs & OICs; in addition to the administrative and supporting staff for their teamwork, proficiency and commitment.

We received unwavering support of ICAR and I gratefully acknowledge the leadership of Dr Himanshu Pathak, the Hon'ble Secretary, DARE and Director General, ICAR and Dr T Mohapatra, Former Secretary, DARE and Director General, ICAR; Dr TR Sharma, DDG (Crop Science), ICAR; and Dr DK Yadava, ADG (Seeds), for rewarding the essential mandate of ICAR-NBPGR.

I persuade you to read this Annual Report and appreciate the outstanding progress that was made at NBPGR during 2022.

Gyanendra Pratap Singh
Director

कार्यकारी सारांश

आईसीएआर–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो (आईसीएआर–एनबीपीजीआर) द्वारा 2022 के दौरान विभिन्न पादप आनुवंशिक संसाधन प्रबंधन पहलुओं जैसे पौधों की खोज और जननद्रव्य का संग्रह पर महत्वपूर्ण उपलब्धियां, जननद्रव्य विनिमय, पादप जननद्रव्य संगरोध, जननद्रव्य लक्षण वर्णन और मूल्यांकन, जननद्रव्य का एक्स–सीटू, इन–सीटू और इन–विट्रो संरक्षणय डीएनए फिंगरप्रिंटिंग, जीनोमिक संसाधनों का सृजन और जीएम का पता लगाना, संस्थागत रूप से वित्त पोषित 21 कार्यक्रमों और बाह्य रूप से वित्त पोषित 42 परियोजनाओं का सारांश यहां दिया गया है:

पौधों की खोज और जननद्रव्य का संग्रह

वर्ष 2022 में, देश भर में कुल 29 अन्वेषण किए गए और 18 राज्यों और दो संघ राज्य क्षेत्र में स्थित 81 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों की वन्य प्रजातियों और अन्य आर्थिक प्रजातियों के 1,803 एक्सेशन एकत्र किए गए। इनमें से 660 एक्सेशन आईसीएआर–एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा 13 अन्वेषणों के माध्यम से एकत्र किए गए।

कुल 542 हर्बेरियम नमूनों को संसाधित किया गया और नेशनल हर्बेरियम ऑफ कल्टीवेटेड प्लांट्स (एनएचसीपी), नई दिल्ली में जोड़ा गया। राजमा की 6,845 देसी एक्सेशन, मोथ बीन (*विग्ना एकोनिटिफोलिया*) की 1,556 एक्सेशन और चावल की फलियों (*विग्ना उम्बेलाटा*) की 2,327 एक्सेशन का भू–संदर्भ और मानचित्रण किया गया।

अकोला क्षेत्रीय केंद्र ने वर्ष के दौरान एक अन्वेषण और संग्रह कार्यक्रम चलाया और छत्तीसगढ़ से कुल 50 एक्सेशन एकत्र किए गए। क्षेत्रीय केंद्र भोवाली ने एक राष्ट्रीय अन्वेषण योजना में 26 अलग–अलग संग्रह बनाए। बेस सेंटर कटक में, तीन अन्वेषण मिशन शुरू किए गए और पांच राज्यों से 227 एकड़ वन्य चावल, वन्य फसल प्रजातियाँ, कद्दू और मूल्यवान एम एंड एपी एकत्र किए गए। क्षेत्रीय केंद्र जोधपुर ने दो अन्वेषण किए और 174 जननद्रव्य एक्सेशन एकत्र किए। क्षेत्रीय केंद्र रांची ने शिमला में एक अन्वेषण कार्यक्रम आयोजित किया। शिलांग केंद्र ने साइट्रस जननद्रव्य की एक खोज की। शिमला क्षेत्रीय केंद्र ने अरुणाचल प्रदेश, हिमाचल प्रदेश से विभिन्न कृषि–बागवानी फसलों की खोज की और कुल 34 फसलें एकत्र की गईं। श्रीनगर क्षेत्रीय केंद्र ने दो अन्वेषण और जननद्रव्य संग्रह कार्यक्रम चलाए और जम्मू और कश्मीर के विभिन्न क्षेत्रों से कृषि–बागवानी फसलों और फसल वन्य प्रजातियों (सीडब्ल्यूआर) की कुल 183 एक्सेशन एकत्र की गईं। त्रिशूर केंद्र पर, लक्षद्वीप, मध्य प्रदेश, मणिपुर और मिजोरम जिलों को कवर करते हुए तीन अन्वेषण मिशनों में जननद्रव्य के 227 नमूने एकत्र किए गए।

जननद्रव्य विनिमय

रिपोर्ट के तहत अवधि के दौरान 68,770 एक्सेशन (2,01,655 नमूने) आयात किए गए, जिनमें जननद्रव्य के 52,072 एक्सेशन (53,942 नमूने) और सीजीआईएआर नर्सरी/परीक्षणों की 16698 एक्सेशन (1,47,713) नमूने शामिल थे। सीआरपी परियोजना के तहत कुल 1747 नमूने और उज्बेकिस्तान के शीतोष्ण फलों के 1047 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 10,573 नमूने प्रदान किए गए थे। इसके अलावा, 66,475 नमूनों को पुनर्जनन/गुणन/रूपात्मक लक्षण वर्णन/प्रारंभिक मूल्यांकन/वर्गीकरण पहचान/डीएनए फिंगरप्रिंटिंग/व्यवहार्यता परीक्षण के लिए आपूर्ति की गई। 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।

जैसा कि खाद्य और पोषण संबंधी जरूरतों को पूरा करने के लिए दिल्ली घोषणा में प्रतिबद्धता व्यक्त की गई थी, भारत ने समान पहुंच और लाभ साझा करने के अवसरों को सुनिश्चित करते हुए आनुवंशिक संसाधनों के आदान–प्रदान की सुविधा के लिए बहुपक्षीय और द्विपक्षीय दोनों उपकरणों को अपनाया (आइची लक्ष्य – रणनीतिक लक्ष्य डी, लक्ष्य 17, एसडीजी 2.5)।

पादप जननद्रव्य संगरोध

विभिन्न फसलों और उनकी वन्य प्रजातियों की परीक्षण एक्सेशन सहित आयातित जननद्रव्य एक्सेशन के कुल

1,33,170 नमूनों को संगरोध मंजूरी के लिए संसाधित किया गया। इन नमूनों में असली बीज, जड़ वाले पौधे, कलम, प्रकंद, सकर्स, बल्ब, नट और टिशू कल्चर पौधे शामिल थे। पर्याक्रांत/संक्रमित नमूनों (2,939) में कई विदेशी कीटों सहित कीड़े (337), नेमाटोड (398), कवक (1,737), वायरस (420), और खरपतवार (27) शामिल थे। 2,939 पर्याक्रांत/संक्रमित/दूषित नमूनों में से 2,671 को भौतिक–रासायनिक तरीकों जैसे धूमन, एक्स–रे रेडियोग्राफी, कीटनाशक उपचार, यांत्रिक सफाई और बढ़ते परीक्षण के माध्यम से बचाया गया, जबकि 268 संक्रमित नमूनों को बचाया नहीं जा सका, इसलिए खारिज कर दिया गया। विभिन्न देशों/स्रोतों से आयातित विभिन्न फलियां फसलों के विदेशी जननद्रव्य के कुल 1232 नमूने पोस्ट–एंट्री संगरोध (पीईक्यू) ग्रीनहाउस में उगाए गए और वायरस से मुक्त पौधों की फसल मांगकर्ताओं को जारी की गई। इस अवधि के दौरान विभिन्न इंडेंटर साइटों पर कुल 45 पोस्ट–एंट्री संगरोध निरीक्षण किए गए। निर्यात के लिए विभिन्न फसलों के कुल 1ए855 नमूनों को संसाधित किया गया, जिनमें से 18 संक्रमित नमूनों को बचा लिया गया और 6 फाइटोसैनिटरी प्रमाणपत्र जारी किए गए। आयातित ट्रांसजेनिक रोपण सामग्री के 10 नमूनों का संगरोध प्रसंस्करण किया गया। बीज स्वास्थ्य परीक्षण के अंतर्गत राष्ट्रीय जीनबैंक में कीट–मुक्त संरक्षण हेतु जननद्रव्य संरक्षण प्रभाग से कुल 6,577 नमूने प्राप्त हुए।

हैदराबाद में, रिपोर्ट के तहत अवधि के दौरान, कुल 97,104 नमूने (34,208 आयात, 62,896 निर्यात) को संगरोध मंजूरी के लिए संसाधित किया गया। 34 पादप स्वच्छता प्रमाणपत्र जारी किए गए। कीटों/रोगजनकों से संक्रमित आयातित फसल जननद्रव्य नमूने (11,691) बचाए गए और जारी किए गए। विभिन्न केंद्रों पर उगाई गई विभिन्न फसलों की 10,920 एक्सेशन पर संगरोध निरीक्षण किया गया।

जननद्रव्य लक्षण वर्णन और मूल्यांकन

वर्ष 2022 के दौरान, विभिन्न कृषि–बागवानी फसलों के कुल 29,706 एक्सेशन को गुण–विशिष्ट मूल्यांकन के संबंध में गुणात्मक रूप से लखन वर्णन/मूल्यांकन/रिजेनेरेशन किया गया, फसल विशिष्ट जैविक स्ट्रेस के लिए विभिन्न फसलों के कुल 5,583 एक्सेशन का मूल्यांकन किया गया, जैविक स्ट्रेस और विभिन्न फसलों से संबंधित कुल 4,281 एक्सेशन का मूल्यांकन अजैविक स्ट्रेस के तहत किया गया। इसके अलावा, विभिन्न गुणवत्ता लक्षणों के लिए विभिन्न क्षेत्र की फसलों के कुल 9,376 जननद्रव्य एक्सेशन का विश्लेषण किया गया। इसके अलावा, कृषि–जैव विविधता–पीजीआर घटक–II पर सीआरपी के तहत, जैविक दबाव के लिए गेहूं (662 एकड़) और भिंडी (60 एकड़) सहित कुल 581 एक्सेशन का मूल्यांकन किया गया। फसल सुधार कार्यक्रमों में उपयोग के लिए विभिन्न फसलों की कुल 6293 एक्सेशन मांगकर्ताओं को आपूर्ति की गईं।

अकोला क्षेत्रीय केंद्र ने 4,793 एक्सेशनों (रबी 2021–22 में 3,339 और खरीफ 2022 में 1,454) की पहचान और मूल्यांकन किया। क्षेत्रीय केंद्र ने भारत के भीतर उपयोगकर्ता एजेंसियों को अनुसंधान उद्देश्यों के लिए विभिन्न फसलों की 10,459 आपूर्ति भी की। समीक्षाधीन अवधि के दौरान विभिन्न फसलों के 7,279 जननद्रव्य एक्सेशन का गुणन और पुनर्जीवित किया गया। क्षेत्रीय केंद्र भोवाली में एमटीएस बीज प्रतिस्थापन के लिए विभिन्न क्षेत्रों, बागवानी, डब्ल्यूईयूपी फसलों की कुल 1,687 एक्सेशनयों को चिह्नित किया गया, गुणन किया गया और पुनर्जीवित किया गया। क्षेत्रीय केंद्र भोवाली में एमटीए के समक्ष देश भर के शोधकर्ताओं के साथ विभिन्न फसल जननद्रव्य के 1517 एक्सेस साझा किए गए। कटक में, विभिन्न फसलों और वन्य प्रजातियों के 1,884 एकड़ के एक सेट का गुणन/पुनर्जीवित किया गया और 385 एक्सेशन को विभिन्न रूपात्मक–कृषि संबंधी लक्षणों के लिए चिह्नित किया गया। आईसीएआर–संस्थानों को 68 एकड़ चावल का एक सेट आपूर्ति किया गया और चावल जननद्रव्य (105) एनबीपीजीआर, नई दिल्ली से प्राप्त किए गए। हैदराबाद में, लक्षण वर्णन, मूल्यांकन, स्क्रीनिंग, कायाकल्प और गुणन के लिए विभिन्न कृषि–बागवानी फसलों की 1,468 फसलें उगाई गईं। दालों, बाजरा और धान की अड़तालीस किस्मों को बढ़ाया गया और लंबी अवधि के भंडारण के लिए एनजीबी को भेजा गया। केंद्र पर एमटीएस में मूल्यांकित और बहुगुणित स्वदेशी जननद्रव्य की 240 एक्सेशन जोड़ी गईं। 34 एसएयूध्आईसीएआर संस्थानों को विभिन्न कृषि–बागवानी फसलों के कुल 955 जननद्रव्य एक्सेशन प्रदान किए गए।

विभिन्न फसल समूहों के कुल 2,643 जननद्रव्य एक्सेशन, जिसमें रबी 2021–22 के दौरान 458 एक्सेसेशन और खरीफ 2022 के दौरान 2185 एक्सेसेशन शामिल थे, का जोधपुर केंद्र पर लक्षण वर्णन और मूल्यांकन किया गया। एमटीएस और एफजीबी से 19 मांगकर्ताओं को विभिन्न कृषि–बागवानी फसल प्रजातियों के कुल 1959 जननद्रव्य एक्सेशन की आपूर्ति की गई थी। समीक्षाधीन अवधि के दौरान विभिन्न बागवानी फसलों की 45 कटाईयों को

प्रवर्धित और पुनर्जीवित किया गया। रांची में, उपज विशेषताओं और रूपात्मक लक्षणों के लिए कुलथी के कुल सेट, कटहल के एक्सेशन और इमली के 38 एक्सेशन का मूल्यांकन/लक्षण वर्णन किया गया। शिलांग में, मक्के की 400 एक्सेशन, धान की फलियों की 125 एक्सेशन और सोहफ्लांग की 132 एक्सेशन का मूल्यांकन किया गया और बेहतर जननद्रव्य की पहचान की गई। शिलांग केंद्र ने विभिन्न फसलों के 2235 जननद्रव्य एक्सेशन को पुनर्जीवित किया।

शिमला केंद्र ने महत्वपूर्ण कृषि–रूपात्मक लक्षणों के लिए विभिन्न क्षेत्रीय फसलों के 989 जननद्रव्य एक्सेशन की विशेषता और मूल्यांकन किया और अनाज ऐमारैंथ, बकव्हीट, एडजुकी बीन, फ्रेंच बीन और मटर में आशाजनक परिवर्धन की पहचान की गई। देश भर के विभिन्न मांगकर्ताओं को कुल 5279 नमूने आपूर्ति किए गए। श्रीनगर क्षेत्रीय केंद्र पर 124 जननद्रव्य एक्सेशन को कृषि–रूपात्मक लक्षणों के लिए चिन्हित किया गया। त्रिशूर में, 400 हरे चने, 300 कुलथी चने और 43 कटहल सहित कुल 743 संग्रह प्रस्तुत किए गए। विभिन्न फसलों और उनके फसल की वन्य प्रजातियों/औषधीय पौधों सहित 289 नमूनों के जननद्रव्य को एनजीबी में एलटीएस के लिए भेजा गया। एमटीए के तहत 28 मांगकर्ताओं को विभिन्न प्रजातियों/वर्गों में कुल 820 एक्सेशन की आपूर्ति की गई।

जननद्रव्य का पूर्व–स्थाने संरक्षण

राष्ट्रीय जीनबैंक में दीर्घकालिक संरक्षण के लिए पुनर्जीवित जननद्रव्य, अधिसूचित की जाने वाली किस्मों, जारी किस्मों और विभिन्न फसलों के लक्षण–विशिष्ट पंजीकृत जननद्रव्य सहित कुल 6,561 जननद्रव्य प्राप्त हुए। इन्हें जीनबैंक मानकों का पालन करते हुए संसाधित किया गया, आधार संग्रह में विभिन्न कृषि–बागवानी फसलों की 5,932 एक्सेशन जोड़ी गईं, जिससे कुल जननद्रव्य होल्डिंग 4,63,130 तक बढ़ गई। संरक्षित एक्सेशन में से 4,176 नए थे और 1,756 एक्सेशन पुनर्जनन के बाद प्राप्त हुए थे। संरक्षित जननद्रव्य (6,367 एक्सेशन) में व्यवहार्यता और बीज की मात्रा की निगरानी और लक्षण वर्णन/मूल्यांकन/पुनर्जनन/अनुसंधान के लिए वितरण (47,859) अन्य प्राथमिकता वाली गतिविधियाँ थीं।

जननद्रव्य का इन–विट्रो और क्रायो संरक्षण

इन विट्रो में, विभिन्न पौधों की प्रजातियों के 1,962 एक्सेशन की संस्कृतियों को इन विट्रो जीनबैंक (आईवीएजी) में 8–25 डिग्री सेल्सियस के भंडारण तापमान पर संरक्षित किया गया, जिसमें उप संवर्धन अवधि 1–24 महीने तक थी। क्रायोजीनबैंक में बीज, भ्रूणीय अक्ष, पराग और 2,194 जीनोमिक संसाधनों के रूप में कृषि–बागवानी प्रजातियों की कुल 12,615 एक्सेशन संरक्षित की गईं। आईवीएजी में कुल 28 नए एक्सेशन जोड़े गए और इन विट्रो बेस जीनबैंक (आईवीबीजी) में 13 एक्सेशन जोड़े गए। इन विट्रो स्थापना और गुणन में, कई फसल प्रजातियों में प्रोटोकॉल विकसित किए गए और विट्रिफिकेशन, ड्रॉपलेट–विट्रिफिकेशन, इनकैप्सुलेशन–डिहाइड्रेशन और वी– और डी–क्रायोप्लेट तकनीकों का उपयोग करके क्रायोप्रिजर्वेशन प्रयोगों में अलग–अलग डिग्री की सफलता प्राप्त की गई। फलों, औद्योगिक फसलों, फलियां, बाजरा, चारा, सब्जियों और वन्य प्रजातियों से संबंधित कुल 478 एक्सेशन को बीज, भ्रूणीय अक्षों और पराग के रूप में क्रायो–संग्रहित किया गया था। 14 प्रजातियों में हिमीकरण और शुष्कन अध्ययन किया गया। क्रायो संरक्षित पौधों की आनुवंशिक अखंडता के रखरखाव की पुष्टि पाइपर नाइग्रम (48 आईएसएसआर मार्करों का उपयोग करके), इपोमिया बॅटस (48 आईएसएसआर मार्करों), और जैंथोसोमा सैगिटिफोलियम (40 आईएसएसआर मार्करों) में की गई और उच्च समानता का पता चला।

एमटीएस और एफजीबी में जननद्रव्य

तिलहन (10452), दलहन (4687), सब्जियाँ (2034), संभावित फसलें (1399), बाजरा (1536) और फसल पौधों के वन्य प्रजातिया (730) सहित विभिन्न फसलों/प्रजातियों के जननद्रव्य की कुल 20,838 एक्सेशनों का रखरखाव किया जा रहा है। अकोला में क्षेत्रीय केंद्र के मध्यम अवधि के भंडारण में नियंत्रित स्थितियाँ। क्षेत्रीय केंद्र भवाली में एमटीएस में कुल 11,786 एक्सेसेशन और फील्ड जीन बैंकों में 1017 एक्सेसेशन का भी रखरखाव किया जा रहा है। कटक में, एम एंड एपी, बागवानी फसलें, कंद फसलें और सीडब्ल्यूआर सहित कुल 595 एक्सेशन एफजीबी में बनाए रखे जा रहे हैं और कुल 1480 हर्बेरियम नमूने संरक्षित किए जा रहे हैं।

क्षेत्रीय केंद्र जोधपुर के फील्ड जीन बैंक में बारहमासी फसलों के कुल 453 जननद्रव्य एक्सेशन को जीवित पौधों के रूप में बनाए रखा जा रहा है। केंद्र पर मध्यम अवधि भंडारण इकाई में नियंत्रित परिस्थितियों में विभिन्न फसलों/प्रजातियों के कुल 43,264 जननद्रव्य को संरक्षित किया जा रहा है। शिमला में, विभिन्न फसलों की 12,565 फसलें एमटीएस में संरक्षित हैं और 1023 फसलें एफजीबी

में संरक्षित हैं। रांची के फील्ड जीन बैंक में कुल 609 बागवानी पादप एक्सेशन और 300 औषधीय पादप एक्सेशन को संरक्षित किया जा रहा है। क्षेत्रीय केंद्र शिलांग ने विभिन्न कृषि–बागवानी फसल जननद्रव्य के 1235 एक्सेशन को बनाए रखा और पुनर्जीवित किया। त्रिशूर में विभिन्न फसलों/बारहमासी बागवानी पौधों और उनके वन्य प्रजातियों की 12,711 प्रजातियों का जननद्रव्य है, जिनमें से 10,392 एमटीएस में और 2,319 एफजीबी में हैं।

डीएनए फिंगरप्रिंटिंग, जीनोमिक संसाधन निर्माण, और जीएम का पता लगाना

कुल 16 कृषि–बागवानी फसलों के 51 नमूनों के लिए डीएनए फिंगरप्रिंटिंग सेवा प्रदान की गई। कुसुम, डोलिचोस बीन, तिल आदि फसलों में नवीन जीनोमिक संसाधन विकसित किए गए। एसएसआर मार्करों का उपयोग करके तिल, ब्राउनटॉप बाजरा, छोटा बाजरा, कोदो बाजरा, चावल, गेहूं और ऐमारैंथ जैसी फसलों में आनुवंशिक विविधता का अध्ययन किया गया। एसएनपी जीनोटाइपिंग डेटा का उपयोग करके डुप्लिकेट जननद्रव्य की पहचान के लिए एक वेब सर्वर विकसित किया गया और कई प्रजातियों में मान्य किया गया। सुगंधित धान की लैंडरेसेस के विविधता विश्लेषण से उच्च स्तर की बहुरूपता का पता चला। अगली पीढ़ी के अनुक्रमण–आधारित जीनोटाइपिंग प्रोटोकॉल को तिल और कुसुम में मानकीकृत किया गया। कैप्सूल विकास के विभिन्न चरणों के दौरान निम्न और उच्च तेल वाले जीनोटाइप पर ट्रांसक्रिप्टोमिक विश्लेषण किया गया, जिसने उच्च तेल संचय प्राप्त करने के लिए बीज विकास के दौरान तेल जैवसंश्लेषण की लंबी अवधि के महत्व को रेखांकित किया। जीनोम–वाइड एसोसिएशन अध्ययनों से चावल में पौधे की ऊंचाई और अलसी में बीज के वजन के लिए जीनोमिक क्षेत्रों का पता चला। ड्राफ्ट–स्तरीय क्लोरोप्लास्ट और संपूर्ण जीनोम असेंबली का गठन ओरिजा अल्टा में किया गया। गर्मी सहनशीलता के लिए गेहूं की बाइपेरेंटल और एमएजीआईसी आबादी वाले संकर को अगली पीढ़ियों के लिए उन्नत किया गया। भारत की वन्य और खेती की गई मूसा प्रजाति की विशेषता प्लोइडी और परमाणु डीएनए सामग्री के लिए प्रवाह साइटोमेट्रिक विश्लेषण के आधार पर की गई थी। खेत और सब्जी फसलों के जननद्रव्य में चीनी और स्टार्च सामग्री के आकलन के लिए एनआईआर–आधारित भविष्यवाणी मॉडल विकसित किए गए थे। विभिन्न वांछनीय लक्षणों के लिए गेहूं के तीन आनुवंशिक स्टॉक पंजीकृत किए गए थे। पीसीआर/रियल टाईम पीसीआर परख को नियोजित करने वाले विशिष्ट आनुवंशिक तत्वों के लिए *अरबिडोप्सिस थालियाना* (3 नमूने) और मेडिकैगो ट्रंकुलाटा (7 नमूने) सहित आयातित ट्रांसजेनिक खेप के दस नमूनों का परीक्षण किया गया। इसके अतिरिक्त, ISO/IEC17025:2017 मान्यता प्राप्त GM डिटेक्शन रिसर्च फैसिलिटी द्वारा कपास, पपीता, अरहर और सोयाबीन की 23 खेपों के 54 नमूनों के लिए GMO परीक्षण सेवाएँ प्रदान की गईं। रियल टाईम लूप–मध्यस्थ आईसो थर्मल एम्प्लीफिकेशन (एलएएमपी)–आधारित जीएम डायग्नोस्टिक्स को पिनII टर्मिनेटर अनुक्रम के तेजी से ऑन–साइट पता लगाने के लिए विकसित और मान्य किया गया है।

अन्य गतिविधियों

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 तक आसान पहुंच की सुविधा प्रदान करना है। पीजीआर पोर्टल, एनबीपीजीआर का प्रमुख वेब–आधारित सूचना संसाधन, कई देशों के शोधकर्ताओं द्वारा एक्सेस किया गया। नए एप्लिकेशन विकसित किए गए और कुछ को सार्वजनिक उपयोग के लिए जारी किया गया। ट्विटर के माध्यम से पीजीआर गतिविधियों पर जानकारी प्रसारित करने के एकेएमयू के प्रयास ने एनबीपीजीआर द्वारा निभाई गई भूमिका को लोकप्रिय बनाने वाले कई उपयोगकर्ताओं को आकर्षित किया है।

वर्ष 2022 में, संस्थान द्वारा मुख्यालय और क्षेत्रीय स्टेशनों में 11 प्रशिक्षण/कार्यशाला/जागरूकता कार्यक्रम आयोजित किया गया। विभिन्न वैज्ञानिक कार्मिकों ने 17 प्रशिक्षण कार्यक्रमों में भाग लिया। तकनीकी और कुशल सहायक कार्मिकों ने क्रमशः 6 और 4 प्रशिक्षणों में भाग लिया।

EXECUTIVE SUMMARY

The significant achievements during 2022 by ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) on various plant genetic resources management aspects *viz.*, plant exploration and collection of germplasm; germplasm exchange; plant germplasm quarantine; germplasm characterization and evaluation; *ex-situ*, *in-situ* and *in-vitro* conservation of germplasm; DNA fingerprinting, genomic resources' generation and GM detection; under 21 institutionally funded programs and 42 externally funded projects are summarized hereunder:

Plant exploration and collection of germplasm

In 2022, **a total of 29 explorations** were undertaken across the country and **1,803 accessions of various agri-horticultural crops, wild relatives** of crops and other economic species were collected from 81 districts located in 18 states and two union territories. Of these, 660 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 13 explorations.

A total of **542 herbarium specimens** were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Geo-referencing and mapping of 6,845 indigenous accessions of kidney bean, 1,556 accessions of moth bean (*Vigna aconitifolia*) and 2,327 accessions of rice bean (*Vigna umbellata*) were done.

Akola regional station undertook one exploration and collection programme during the year and a total of 50 accessions were collected from Chattisgarh. **RS Bhowali** made 26 different collections in one national exploration plan. At Base Centre **Cuttack**, three exploration missions were undertaken and 227 acc comprising wild rice, wild crop relatives, cucurbits and valuable M&AP were collected from five states. **RS Jodhpur** conducted two explorations and collected 174 germplasm accns. RS **Ranchi** conducted one exploration programme in **Shimla**. **Shillong** station undertook one exploration Citrus germplasm. **Shimla** regional station conducted one exploration for various agri- horticultural crops from Arunachal, Himachal Pradesh and a total of 34 accessions were collected. **Srinagar** regional station undertook two exploration and germplasm collection programmes and a total of 183 accessions of agri-horticultural crops and crop wild relatives (CWR) were collected from various areas of Jammu & Kashmir. At **Thrissur** station, 227 samples of germplasm were collected in three exploration missions, covering districts of Lakshadweep, Madhya Pradesh, Manipur and Mizoram.

Germplasm exchange

During the period under report **68,770 accessions (2,01,655 samples) were imported** including 52,072 accessions (53,942 samples) of germplasm and 16,698 entries (1,47,713) samples of CGIAR nurseries/trials. A total of **1,747 samples were exported** under CRP Project and 1,047 samples of temperate fruits of Uzbekistan. A total of **10,573 samples of different crops were supplied to 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, **66,475 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.

As committed in Delhi Declaration, to meet the food and nutritional needs, India adopted both multi-lateral and bilateral instruments to facilitate the exchange of genetic resources, while ensuring equitable access and benefit sharing opportunities (Aichi Target -Strategic Goal D, Target 17; SDG 2.5)

Plant quarantine

A total of **1,33,170 samples** of imported germplasm accessions including trial entries 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 (2,939)** comprised insects (337), nematodes (398), fungi (1,737), viruses (420) and weeds (27) including several exotic pests. Of the 2,939 infested/ infected/ contaminated samples, **2,671 were salvaged** through physico- chemical methods *viz.*, fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test while 268 infected samples could not be salvaged, hence rejected. A total of 1,232 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 **45 post-entry quarantine inspections** were carried out at various indenter's sites during this period. A total of **1,855 samples of various crops were processed for export** of which 18 infested samples were salvaged and 6 Phytosanitary Certificates were issued. Quarantine processing of 10 samples of imported transgenic planting material was undertaken. Under **seed health testing, a total of 6,577 samples** were received from Division of Germplasm Conservation for pest free conservation in National Genebank.

At **Hyderabad**, during the period under report a total of **97,104** samples (**34,208** imports; **62,896** exports) were processed for quarantine clearance. **34** Phytosanitary certificates were issued. Import crop germplasm samples (**11,691**), infested/ infected with pests/pathogens, were salvaged and released. **Post-entry quarantine inspection was conducted on 10,920 accessions of different crops grown at different centres.**

Germplasm characterization and evaluation

During 2022, a total of **29,706 accessions of various agro-horticultural crops were characterised/evaluated/regenerated/ multiplied** regarding trait specific **evaluation, a total of 5,583 accessions** of different crops were evaluated for crop specific biotic stresses and a total of 4,281 accessions belonging to different crops were evaluated under abiotic stresses. In addition, a total of **9,376 germplasm accessions of different field crops were analyzed for various quality traits**. In addition, under CRP on Agro-biodiversity-PGR Component- II, a total of **581 accessions comprising wheat (662 acc.) and okra (60 acc.) were evaluated** for biotic stresses. A total of **6,293 accessions of various crops were supplied** to indenters for use in crop improvement programmes.

Akola regional station characterized and evaluated 4,793 accessions (3,339 in *Rabi* 2021-22 and 1,454 in *Kharif* 2022). The regional station also supplied 10,459 accessions of various crops for research purpose to user agencies within India. Multiplied and regenerated 7,279 germplasm accessions of different crops during the reporting period. At **RS Bhowali** total 1,687 accessions of various field, horticultural, WEUP crops were characterized, multiplied and rejuvenated for MTS seed replacement. At **RS Bhowali** 1,517 accessions of various crop germplasms were shared with researchers across the country against MTA. At **Cuttack a** set of 1,884 acc of different crops and wild relatives was multiplied/ regenerated and 385 accessions were characterized for different morpho- agronomic traits. A set of 68 acc of rice were supplied to ICAR- institutes and rice germplasm (105) were received from NBPGR, New Delhi. At **Hyderabad**, **1,468** accessions of different agri-horticultural crops were raised for characterisation, evaluation, screening, rejuvenation and multiplication. **Forty-eight** accessions of pulses, millets and paddy were multiplied and sent to NGB for long term storage. **240** accessions of evaluated and multiplied indigenous germplasm were added to the MTS at the station. A total of **955** germplasm accessions of different agri-horticultural crops was provided to 34 SAUs/ ICAR institutes.

A total 2,643 germplasm accessions of various crop groups comprising 458 accessions during *Rabi* 2021-22 and 2,185 accessions during *Kharif* 2022 were characterized and evaluated at **Jodhpur** station. A total of 1,959 germplasm accessions of various agri- horticultural crop species were supplied from MTS and FGB to 19 indenters. Multiplied and regenerated 45 cuttings of various horticultural crops during the period under reporting. At **Ranchi, a** total of core set of horsegram, accessions of jackfruit and 38 accessions of Tamarind were evaluated/ characterized for yield attributes and morphological traits. At **Shillong,** evaluation of 400 accessions of maize, 125 accessions of rice bean 132 accessions of sohphlang and identification of superior germplasm was done. Shillong station regenerated 2,235 germplasm accessions of various crops.

Shimla station characterized and evaluated 989 germplasm accessions of various field crops for important agro-morphological trait sand promising accessions were identified in grain amaranth, buckwheat, adzuki bean, french bean and fieldpea. A total of 5,279 samples were supplied to various indentors across country. At **Srinagar** regional station 124 germplasm accessions were characterized for agro-morphological traits. At **Thrissur**, a total of 743 collections comprising 400 of greengram, 300 of horsegram and 43 of jackfruit were characterized. Germplasm of 289 samples comprising various crops and their crop wild relatives/ medicinal plants were sent for LTS in NGB. A total of 820 accessions in various species/ taxa were supplied to 28 Indenters under MTA.

Ex-situ conservation of germplasm

A total of 6,561 accessions of germplasm, including regenerated germplasm, varieties to be notified, released cultivars and trait-specific registered germplasm of various crops were received for long-term conservation in the National Genebank. These were processed following the genebank standards, adding 5,932 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 4,63,130. Of the conserved accessions, 4,176 were new and 1,756 accessions were received after regeneration. Monitoring of viability and seed quantity in conserved germplasm (6,367 accessions) and distribution (47,859) for characterization/ evaluation/ regeneration/research were the other priority activities.

In-vitro and cryo conservation of germplasm

In vitro cultures of 1,962 accessions of various plant species were conserved in the *In Vitro* Genebank (IVAG) at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months. A total of 12,615 accessions of agri-horticultural species in the form of seeds, embryonic axes, pollen and 2,194 genomic resources were conserved in the Cryogenebank. A total of 28 new accessions were added to the IVAG and 13 accessions were added to *In Vitro* Base Genebank (IVBG). *In vitro* establishment and multiplication protocols were developed in several crop species and varying degrees of success was achieved in cryopresevation experiments using vitrification, droplet-vitrification, encapsulation- dehydration and V- and D-cryoplate techniques. A total of 478 accessions belonging to fruits, industrial crops, legumes, millets, forages, vegetables and wild species were cryostored in the form of seeds, embryonic axes and pollen. Freezing and desiccation studies were carried out in 14 species. Maintenance of genetic integrity of cryopreserved plants was confirmed in *Piper nigrum* (using 48 ISSR), *Ipomea batatas* (48 ISSR markers) and *Xanthosoma sagittifolium* (40 ISSR markers) and revealed high similarity.

Germplasm in MTS & FGB

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 wild relatives of crop plants (730) are being maintained under controlled conditions in the medium term storage of the Regional Station at **Akola**. At **RS Bhowali** a total of 11,786 accessions in MTS and 1017 accessions in field gene banks are also being maintained. At **Cuttack**, a total of 595 accessions comprising M&AP, horticultural crops, tuber crops and CWR are being maintained in the FGB and a total 1,480 herbarium specimens are being preserved.

Total 453 germplasm accessions of perennial crops are being maintained as live plants in the field gene bank of Regional Station **Jodhpur**. A total of 43,264 accessions of various crops/species germplasm are being conserved at the station under controlled conditions in the medium term storage unit. At **Shimla,** 12,565 accessions of various crops are conserved in MTS and 1023 accessions are maintained in FGB. A total of 609 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank of **Ranchi**. **RS Shillong** maintained and regenerated 1,235 accessions of various agri-horticultural crop germplasm. **Thrissur** has a germplasm holding of 12,711 accessions of various crops/ perennial horticultural plants and their wild relatives of which 10,392 are in the MTS and 2,319 in the FGB.

DNA fingerprinting, genomic resources generation and GM detection

DNA fingerprinting service was provided for 51 samples of 16 agri-horticultural crops. Novel genomic resources were developed in crops such as safflower, dolichos bean, sesamum, etc. Genetic diversity studies were undertaken in crops such as sesamum, browntop millet, little millet, kodo millet, rice, wheat and amaranth using SSR markers. DNA fingerprinting service was provided for fifty-one (51) samples of 16 agri-horticulral crops. A web server for the identification of duplicate germplasm using SNP genotyping data was developed and validated in multiple species. Diversity analysis of aromatic rice landraces revealed a high level of polymorphism. Transcriptomic analysis was performed on the low and high oil-content genotypes during the different stages of capsule development which underscored the importance of the longer duration of oil biosynthesis during seed development to obtain higher oil accumulation. Genome-wide association studies revealed genomic regions for plant height in rice and seed weight in linseed. Draft-level chloroplast and the whole genome assemblies were constituted in *Oryza alta*. The biparental and MAGIC populations crosses of wheat for heat tolerance were advanced to the next generations. Wild and cultivated *Musa* species of India were characterized based on flow cytometric analysis for ploidy and nuclear DNA content. NIR based prediction models were developed for the estimation of sugar and starch contents in field and vegetable crops germplasm. Three genetic stocks of wheat were registered for various desirable traits. Ten samples of imported transgenics consignments including *Arabidopsis thaliana* (3 samples) and *Medicago trunculata* (7 samples) were tested for specific genetic elements employing PCR/ real-time PCR assays. Additionally, GMO testing services were provided for 54 samples of 23 consignments of cotton, papaya, pigeon pea and soybean by ISO/ IEC17025:2017 accredited GM Detection Research Facility. Real-time Loop-mediated isothermal amplification (LAMP)-based GM diagnostics developed and validated for rapid on-site detection of *pinII* terminator sequence.

Other Activities

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 Twitter has attracted many users popularizing the role played by NBPGR.

In 2022, the institute was involved in organizing 11 trainings / workshops / awareness programs in the headquarters and regional stations. Various scientific staff attended 17 training programs. The technical and Skilled Supporting staff attended 6 and 4 trainings, respectively.

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, अर्थात् i) पादप अन्वेषण और जननद्रव्य संग्रह, ii) पादप संगरोध, iii) जननद्रव्य मूल्यांकन, iv) जननद्रव्य संरक्षण और v) जीनोमिक संसाधन और इकाइयों में, जननद्रव्य एक्सचेंज (जेक्स), टिशू कल्चर और क्रायोप्रिजर्वेशन (टी.सी.सी.यू.), पीजीआर नीति (पी.पी.यू.), कृषि ज्ञान प्रबंधन (एकेएमयू) और संस्थान प्रौद्योगिकी प्रबंधन (आईटीएमयू)।

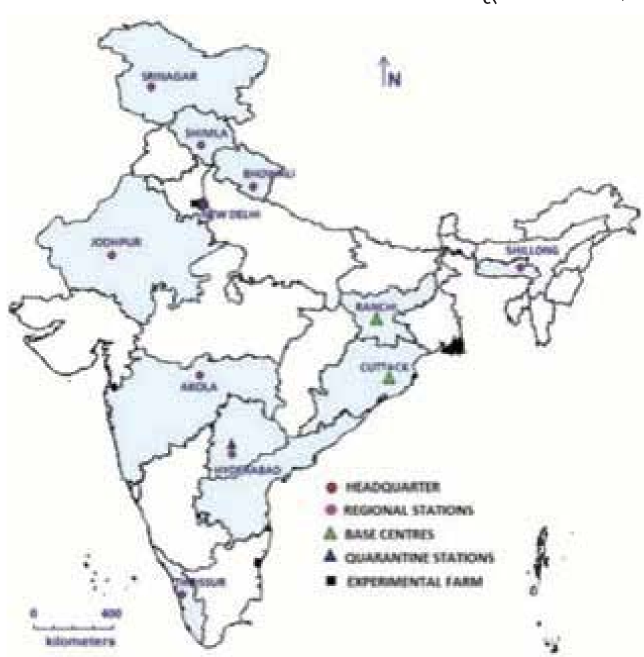
देश की विभिन्न कृषि–पारिस्थितिकी स्थितियों में पीजीआर प्रबंधन के अधिदेश को पूरा करने के लिए ब्यूरो के पास 10 आरएस/बीसी का नेटवर्क है। इसके अतिरिक्त, 40 हेक्टे. इस्सापुर गांव (दिल्ली से लगभग 45 किमी पश्चिम) में प्रायोगिक फार्म मुख्यालय में अनुसंधान आवश्यकताओं को पूरा करता है। ब्यूरो का प्रमुख फसल–आधारित 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/बेस सेंटर 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/



चित्र 1.1 क्षेत्रीय केन्द्रों और आदहरभूत केन्द्रों का एनबीपीजीआर नेटवर्क

कोशिका संवर्धन, भ्रूण, युग्मक आदि के रूप में जननद्रव्य संग्रह की राष्ट्रीय विरासत को संरक्षित करने के लिए की गई थी। कोल्ड स्टोरेज 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 इकाइयाँ और 176 मी^{3} क्षमता की दो इकाइयां) 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 जोड़ते हुए विभिन्न फसलों के लिए जिम्मेदार 59 राष्ट्रीय सक्रिय जननद्रव्य साइटों के साथ संग्रह जहां जननद्रव्य संग्रह का मूल्यांकन किया जाता है और मध्यम अवधि के भंडारण सुविधाओं द्वारा समर्थित, क्षेत्र की स्थितियों के तहत इसमें वृद्धि की जाती 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 हैः

i. भोजन, चारा, ईंधन, फाइबर, ऊर्जा और औद्योगिक उपयोग के नए पौधों के स्रोतों का पता लगाना और उन्हें डोमेस्टिकेट करना

ii. उपलब्ध 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) जोड़ा 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 गईं। रिपोर्ट के तहत वर्ष के दौरान, पीजीआर प्रबंधन और कृषि के विभिन्न पहलुओं से संबंधित 75 पुस्तकें खरीद और विनिमय के आधार पर पुस्तकालय संग्रह में जोड़ी गईं। पुस्तकालय ने मुख्यालय और विभिन्न क्षेत्रीय स्टेशन पर उपयोग के लिए सदस्यता के माध्यम से 37 पत्रिकाएँ खरीदीं जिनमें 21 अंतर्राष्ट्रीय पत्रिकाएँ और 16 भारतीय शामिल हैं। कुल 21 अंतर्राष्ट्रीय पत्रिकाओं में से केवल दस ऑनलाइन हैं और छह पत्रिकाएँ ऑनलाइन और मुद्रित दोनों में हैं जो वैज्ञानिकों और तकनीकी कार्मिकों के लिए सुलभ हैं और उनके डेस्कटॉप पर भी उपलब्ध हैं। मुख्यालय और क्षेत्रीय स्टेशनों पर पाठकों को नए आगमन की एक मासिक सूची भी प्रसारित की गई। ब्यूरो के प्रकाशन भारत में 298 से अधिक विभिन्न संगठनों को प्रदान किए गए और बदले में, पुस्तकालय को विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय संगठनों से 410 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 61वें दीक्षांत समारोह में पांच एम.एससी. और चार पीएच.डी. के विद्यार्थियों को डिग्री प्रदान की गई। वर्तमान में, 13 एम.एससी. सहित कुल 44 छात्र हैं और इकतीस पीएच.डी. रोल पर 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 बीज/रोपण 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 headquarters 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 (GEx), Tissue Culture and Cryopreservation (TCCU), PGR Policy (PPU), Agricultural Knowledge Management (AKMU) and Institute Technology Management (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 ha0 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 workplans 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. 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

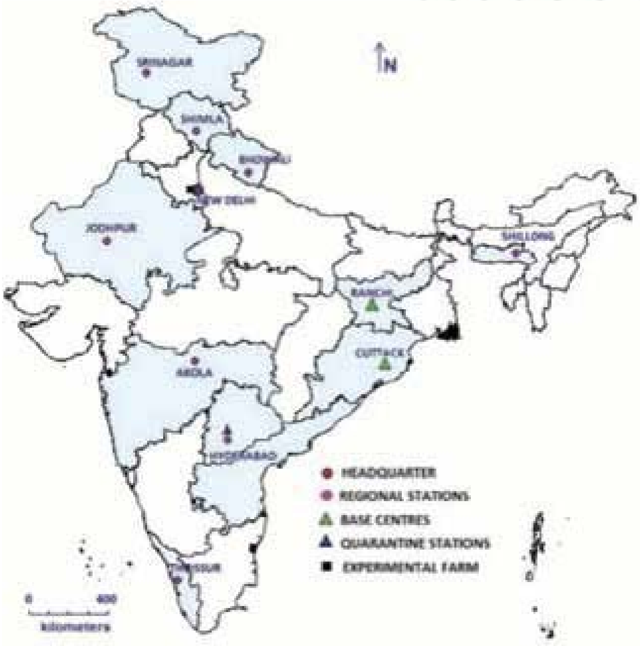


Fig. 1.1. NBPGR network of regional stations and base centres

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

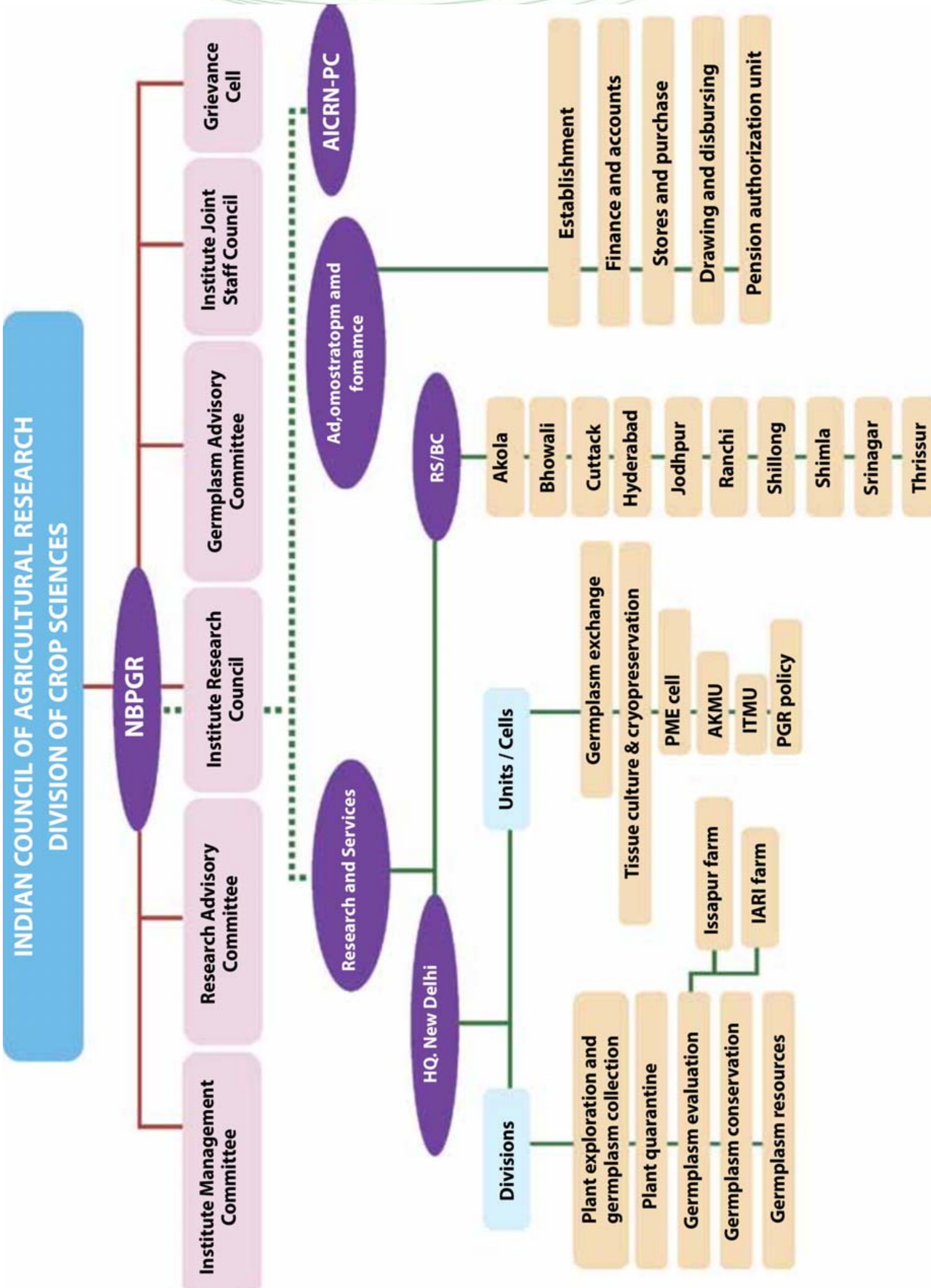


Fig. 1.2. Organogram of ICAR-NBPGR

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 regional stations as well. Newspaper clipping services on PGR and its related subjects were provided to readers regularly. During the year under report, 75 books related to various aspects of PGR management and agriculture were added to the library collections through purchase and exchange basis. Library procured 37 journals including 21 international journals and 16 Indian through subscription for the use at the Headquarter and different regional stations. Out of 21 International journals, ten are online only and six online as well as printed journals, which are accessible to scientists and technical personnel at their desktop. A monthly list of new arrivals were also circulated to readers at the headquarters and regional stations. Bureau's publications were provided to over 298 different organizations in India and in return, library has received 410 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. Five M.Sc. and four Ph.D. students were awarded degree in 61st Convocation of P G School IARI. Currently, a total of 44 students including 13 M.Sc. and thirty one 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 grassroot 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 glasshouses/ 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 2022 में, देश भर में कुल 29 अन्वेषण किए गए जिनमें से विभिन्न कृषि–बागवानी फसलें, फसलों की वन्य प्रजातियां और अन्य आर्थिक प्रजातियों के 1803 एक्सेशनों को 18 राज्यों और भारत के दो केंद्र शासित प्रदेशों में स्थित 81 जिलों से एकत्र किया गया। इनमें से, 660 एक्सेशन 13 अन्वेषण के माध्यम से आईसीएआर– एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा एकत्र की गई थीं। ये अन्वेषण अरुणाचल प्रदेश, असम, बिहार, छत्तीसगढ़, गुजरात, हिमाचल प्रदेश, झारखंड, जम्मू और कश्मीर, लक्षद्वीप, मणिपुर, मध्य प्रदेश, महाराष्ट्र, मेघालय, मिजोरम, ओडिशा, राजस्थान, सिक्किम, तेलंगाना, उत्तराखंड और पश्चिम बंगाल के कुछ हिस्सों में आयोजित किए गए थे। कुल 542 हर्बेरियम नमूने, 54 बीज नमूने/आर्थिक उत्पादों को राष्ट्रीय कृषि पादप हर्बेरियम (एनएचसीपी) में शामिल किया गया। किडनीबीन (फासिओलस वल्गारिस) के 6,845 एक्सेशनों, अश्वग्राम (मैक्रोटिलोमा यूनिफ्लोरम) के 3,770 और मसूर (लेंस कुलीनारिस) के 5,202 एक्सेशनों का जियो–रेफरेंसिंग और मैपिंग किया गया। जनजातीय कृषक समुदायों की आजीविका सुरक्षा के लिए पादप आनुवांशिक संसाधन संरक्षण जागरूकता और पोषण और जैव विविधता मेले पर एनईएच और टीएसपी उप–योजना के तहत पांच कार्यक्रमों का आयोजन किया गया।

Summary: : In 2022, a total of 29 explorations were undertaken across the country wherein 1803 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 81 districts located in 18 states and two union territories of India. Of these, 660 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 13 explorations conducted in parts of Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jharkhand, Jammu & Kashmir, Lakshadweep, Manipur, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Odisha, Rajasthan, Sikkim, Telangana, Uttarakhand and West Bengal. A total of 542 herbarium specimens, 54 seed samples/economic products were added to the National Herbarium of Cultivated Plants (NHCP). Geo-referencing and mapping of 6,845 accessions of kidney bean (*Phaseolus vulgaris*), 3,770 of horsegram (*Macrotyloma uniflorum*) and 5,202 of lentil (*Lens culinaris*) was done. Five programmes on Plant Genetic Resources Conservation Awareness and Biodiversity Fair for nutritional and livelihood security of tribal farming communities were organized under NEH and TSP Sub-Plan.

1.1 Plant exploration and germplasm collection

During the year 2022, a total of 29 explorations (involving 27 collaborators) were undertaken and 1,803 accessions of different agri-horticultural crops comprising 1,000 accessions of cultivated and 803 accessions of wild species were collected from 81 districts covering 18 states and two union territories of India. The states include Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jharkhand, Jammu & Kashmir, Lakshadweep, Manipur, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Odisha, Rajasthan, Sikkim,

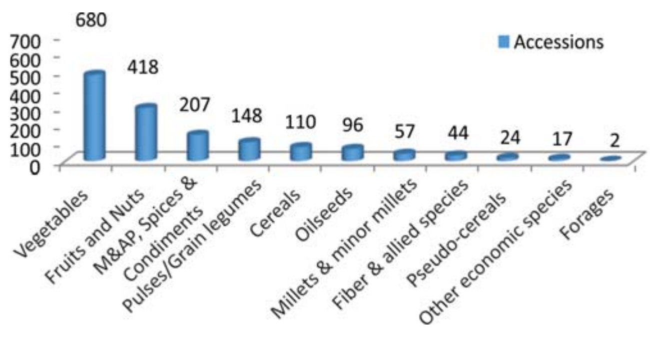


Fig. 1.1a. Germplasm collected during 2022 across different crop groups

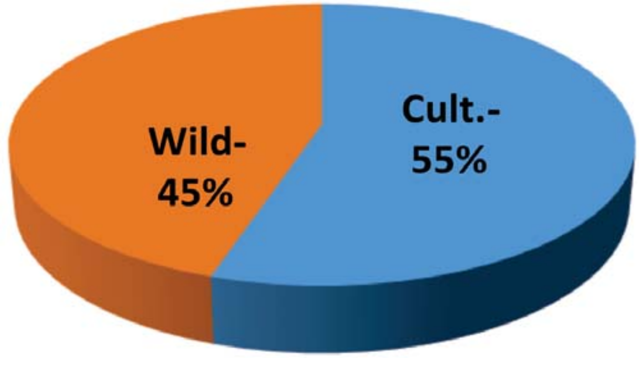


Fig. 1.1b. Share of cultivated and wild accessions among germplasm collected during 2022

Telangana, Uttarakhand and West Bengal. These collections captured diversity in 427 species; cultivated (1000 acc.; 55%) and crop wild relatives (803 acc.; 45%) in various crop-groups (Table. 1.1 & Fig. 1.1). Emphasis was given on collecting germplasm in landraces, crop wild relatives, minor fruits, wild edibles, unattended species from various diversity-rich, remote/ tribal inhabited, disturbed and under-explored areas mainly in Assam, Arunachal Pradesh, Jammu & Kashmir, Manipur, Mizoram, Rajasthan, Sikkim and Uttarakhand. A total of 1178 collected accessions were sent to Germplasm Handling Unit (GHU) for conservation, while the remaining accessions were sent for multiplication and maintence in National Active Germplasm Sites (NAGS). Status of germplasm collected in explorations conducted by ICAR-NBPGR and its regional stations/base centres is given below (Table 1.1 & 1.2).

Table 1.1: Explorations undertaken and germplasm collected in year 2022

Headquarters/Station/Centre	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	1	5	45	50
Bhowali	1	-	26	26
Cuttack	3	28	189	217
Hyderabad	1	138	12	150
Jodhpur	2	156	18	174
New Delhi (HQ)	13	382	278	660
Ranchi	1	4	4	8
Shimla	1	-	34	34
Shillong	1	29	4	33
Srinagar	2	158	25	183
Thrissur	3	100	168	268
Total	**29**	**1000**	**803**	**1803**

Table 1.2: Details of germplasm collected in different crop groups during the year 2022

Crop-group (accs.)	Crop/wild species (accessions)
Cereals (110)	*Avena sativa* (1), *Coix aquatica* (3), *C. lacryma-jobi* (13), *C. lacryma-jobi* var. *ma-yuen* (2), *Hordeum vulgare* (2), *Oryza nivara* (16), *O. rufipogon* (5), *O. sativa* (33), *O. sativa* var. *spontanea* (18), *Triticum aestivum* (2), *T. durum* (2) and *Zea mays* (13)
Pseudo-cereals (24)	*Amaranthus blitum* (1), *A. cruentus* (2), *A. dubius* (3), *A. spinosus* (2), *A. tricolor* (1), *A. tristis* (1), *A. viridis* (4), *Chenopodium album* (3), *C. foliosum* (1), *Fagopyrum esculentum* (4) and *F. tataricum* (2)
Millets	*Brachiaria ramosa* (1), *Echinochloa colona* (2), *E. crus-galli* (4), *Eleusine coracana* (7), *E. indica* (4), *Panicum miliaceum* (2), *P. sumatrense* (5), *Paspalum conjugatum* (1), *P. scrobiculatum* (2), *Pennisetum hohenackeri* (1), *P. orientale* (1), *P. glaucum* (5), *Setaria italica* (13), *S. pumila* (1), *Sorghum arundinaceum* (1) and *S. bicolor* (7)
Pulses (148)	*Cajanus cajan* (13), *C. scarabaeoides* (13), *Cicer arietinum* (1), *Dunbaria podocarpa* (1),), *Lathyrus oleraceus* (3), *Lathyrus sativus* (4), *Lens culinaris* (2), *Macrotyloma uniflorum* (12), *Phaseolus vulgaris* (13 *Rhynchosia minima* (2), *Vigna aconitifolia* (3), *V. angularis* (2), *V. angularis* var. *nipponensis* (1), *V. mungo* (15), *V. radiata* (14), *V. radiata* var. *setulosa* (4), *V. stipulacea* (4), *V. trilobata* (1), *V. umbellata* (13), *V. unguiculata* (23) and *V. unguiculata* subsp. *sesquipedalis* (4)
Oilseeds (96)	*Arachis hypogaea* (1), *Brassica campestris* (2), *B. juncea* (3), *B. napus* (15), *B. oleracea* var. *acephala* (6), *B. rapa* var. *brown sarson* (3), *B. rapa* var. *yellow sarson* (1), *Glycine max* (11), *Helianthus annuus* (1), *Linum usitatissimum* (4), *Perilla frutescens* (14), *Sesamum indicum* (22) and *S. malabaricum* (13)
Fiber and allied species (44)	*Corchorus aestuans* (9), *C. capsularis* (5), *C. olitorius* (7), *C. trilocularis* (1), *Crotalaria juncea* (1), *C. medicaginea* (1), *C. pallida* (2), *C. assamica* (1), *C. tetragona* (1), *Gossypium arboreum* (1), *G. barbadense* (1), *Hibiscus cannabinus* (4), *H. sabdariffa* (4), *H. tiliaceus* (1), *Sesbania bispinosa* (2), *S. cannabina* (1) and *S. sesban* (2)

Crop-group (accs.)	Crop/wild species (accessions)
Fruits and nuts (418)	*Actinidia callosa* (4), *Aegle marmelos* (39), *Annona reticulata* (6), *Berberis lycium* (1), *Buchanania lanzan* (30), *Carissa carandas* (2), *Citrus aurantifolia* (7), *C. aurantium* (3), *C. grandis* (1), *C. indica* (1), *C. jambhiri* (14), *C. latipes* (2), *C. limetta* (1), *C. limon* (3), *C. limonia* (1), *C. macroptera* (4), *C. medica* (9), *C. megaloxycarpa* (3), *C. paradisi* (1), *C. pseudolimon* (5), *C. reticulata* (5), *C. sinensis* (1), *Cordia myxa* (3), *C. subcordata* (1), *Corylus jacquemontii* (1), *Cotoneaster microphyllus* (2), *Crataegus songarica* (3), *Dillenia indica* (2), *Diospyros glandulosa* (1), *D. melanoxylon* (5), *Docynia indica* (2), *Elaeocarpus serratus* (1), *Ensete glaucum* (1), *E. superbum* (2), *Euryale ferox* (102), *Ficus carica* (1), *F. palmata* (1), *Garcinia acuminata* (3), *G. assamica* (6), *G. dulcis* (2), *G. lanceifolia* (2), *G. morella* (1), *G. pedunculata* (6), *G. sibeswarii* (2), *G. succifolia* (1), *G. xanthochymus* (2), *Hippophae rhamnoides* (1), *H. salicifolia (1), Limonia acidissima (1), Manilkara hexandra (2), Meyna spinosa* (1), *Morus alba* (17), *M. indica* (17), *M. laevigata* (1), *M. macroura* (8), *Muntingia calabura* (3), *Musa balbisiana* (5), *M. ochracea* (1), *M. sikkimensis* var. *simmondsii* (2), *M. thomsonii* (1), *Phoenix sylvestris* (1), *Phyllanthus emblica* (1), *Physalis angulata* (2), *P. lagascae* (1), *Pithecellobium dulce* (5), *Prunus cerasus* (3), *P. cornuta* (3), *P. mira* (1), *P. persica* (2), *P. rufa* (1), *Pyrus pashia* (2), *Ribes alpestre* (1), *R. himalense* (1), *R. orientale* (1), *Rosa macrophylla* (2), *R. moschata* (1), *R. sericea* (1), *Rubus acuminatus* (1), *R. calycinus* (1), *R. ellipticus* (2), *R. fruticosus* (2), *R. hypargyrus* (2), *R. idaeus* (1), *R. lineatus* (1), *R. niveus* (1), *R. paniculatus* (1), *R. rosaifolius* (1), *R. rugosus* (1), *R. saxatilis* (1), *R. sumatranus* (1), *Semecarpus anacardium* (1), *Saurauia punduana* (1), *Scaevola taccada* (1), *Sorbus koehneana* (1), *Stauntonia elliptica* (1), *Tamarindus indica* (1), *Vaccinium sikkimense* (2), *Viburnum cotinifolium* (2), *Vitis vinifera* (1), *Ziziphus mauritiana* (1), *Z. nummularia* (2), *Z. oenoplia* (1) and *Z. rugosa* (1)
Vegetables (680)	*Abelmoschus caillei* (2), *A. crinitus* (1), *A. esculentus* (10), *A. ficulneus* (6), *A. manihot* var. *pungens* (3), *A. moschatus* (3), *A. pungens* var. *mizoramensis* (1), *A. tetraphyllus* (9), *A. tuberculatus* (7), *A. tuberculatus* var. *deltoidefolius* (4), *Aerva lanata* (1), *Allium carolinianum* (1), *A. cepa* (3), *A. cepa* var. *aggregatum* (1), *A. fasciculatum* (3), *A. hookeri* (2), *A. proliferum* (1), *A. sativum* (4), *A. stracheyi* (3), *A. victoriallis* (1), *A. wallichii* (2), *Amorphophallus konkanensis* (2), *Atriplex hortensis* (4), *Basella alba* (1), *Benincasa hispida* (15), *Brassica juncea* var. *rugosa* (13), *Canavalia ensiformis* (1), *C. gladiata* (2), *Capsicum annuum* (30), *C. chinense* (5), *C. frutescens* (1), *Celosia argentea* (2), *Citrullus lanatus* (1), *Coccinia grandis* (5), *Colocasia esculenta* (1), *Cucumis hystrix* (4), *C. maderaspatanus* (2), *C. melo* (4), *C. melo* var. *alwarensis* (1), *C. callosus* (46), *C. melo* var. *conomon (8), C. melo* var. *momordica* (5), *C. prophetarum* (3), *C. sativus* (36), *C. sativus* var. *hardwickii* (3), *C. setosus* (1), *Cucurbita maxima* (1), *C. moschata* (7), *C. pepo* (36), *Cyamopsis tetragonoloba* (2), *Cyclanthera pedata* (2), *Daucus carota* (2), *Dioscorea alata* (1), *D. arachidna* (1), *D. belophylla* (1), *D. bulbifera* (1), *D. oppositifolia* (2), *Gymnopetalum chinense* (1), *Houttuynia cordata* (1), *Lablab purpureus* (5), *L. purpureus* subsp. *bengalensis* (2), *Lagenaria siceraria* (39), *Luffa acutangula* (25), *L. acutangula* var. *amara* (10), *L. aegyptiaca* (51), *L. echinata* (2), *Solanum lycopersicum* (5), *Malva sylvestris* (1), *Momordica balsamina* (2), *M. charantia* (10), *M. charantia* var. *muricata* (4), *M. dioica* (1), *M. subangulata* (1), *Moringa concanensis* (54), *M. oleifera* (39), *Nelumbo nucifera* (1), *Parkia timoriana* (1), *Plukenetia volubilis* (1),8 *Raphanus sativus* (1), *Smallanthus sonchifolius* (1), *Solanum aethiopicum* (6), *S. anguivi* (1), *S. coagulans* (3), *S. erianthum* (1), *S. incanum* (8), *S. lycopersicum* var. *cerasiforme* (1), *S. macrocarpon* (1), *S. melongena* (7), *S. sisymbriifolium* (6), *S. torvum* (2), *S. viarum* (5), *S. villosum* (2), *S. violaceum* (6), *S. virginianum* (5), *Spinacia oleracea* (1), *Suaeda fruticosa* (3), *Thladiantha cordifolia* (1), *Trichosanthes anamalaiensis* (3), *T. anguina* (2), *T. bracteata* (3), *T. cordata* (1), *T. cucumerina* (16), *T. cucumerina* var. *sublobata* (5), *T. dunniana* (1), *T. khasiana* (1), *T. majuscula* (4), *T. tricuspidata* (2), *T. wallichiana* (1), *Tubocapsicum anomalum* (2) and *Tupistra clarkei* (1)
Medicinal and aromatic plants, spices and condiments (207)	*Abroma augusta* (1), *Abrus precatorius* (3), *Abutilon indicum* (3), *Alangium salviifolium* (2), *Andrographis paniculata* (1), *Aristolochia acuminata* (1), *Arivela viscosa* (3), *Atropa belladonna* (1), *Bacopa monnieri* (1), *Balanites roxburghii* (2), *Bauhinia purpurea* (1), *Bixa orellana* (2), *Boerhavia diffusa* (1), *B. erecta* (1), *Brassica nigra* (1), *Calophyllum inophyllum* (1), *Cassia tora* (1), *Catharanthus roseus* (1), *Cheilocostus pictus* (1), *C. speciosus* (1), *Cissus quadrangularis* (1), *Citrullus colocynthis* (1), *Clerodendrum glandulosum* (2), *Clitoria ternatea* (1), *Coriandrum sativum* (12), *Ctenolepis cerasiformis* (2), *Cuminum cyminum* (1), *Curcuma amada* (1), *Daphne oleoides* (1), *Datura metel* (4), *D. stramonium* (3), *Dioscorea deltoides* (1), *Diplocyclos palmatus* (5), *Eclipta prostrata* (1), *Elsholtzia communis* (2), *Eryngium foetidum* (3), *Fritillaria roylei* (1), *Globba multiflora* (1), *Hedychium gardnerianum* (1), *H. thyrsiforme* (1), *H. gracile* (1), *Heracleum nepalense* (1), *Hornstedtia arunachalensis* (1), *Hyoscyamus niger* (1), *Indigofera tinctoria* (1), *I. trifoliata* (1), *Jasminum grandiflorum* (1), *J. humile* (1), *Lawsonia inermis* (2), *Leonotis nepetifolia* (6), *Lepidium sativum* (6), *Leucas aspera* (1), *Lilium polyphyllum* (1), *Lycianthes laevis* (1), *Mesosphaerum suaveolens* (4), *Murraya koenigii* (2), *Nicotiana tabacum* (1), *Ocimum africanum* (2), *O. americanum*

Crop-group (accs.)	Crop/wild species (accessions)
	(14), *O. basilicum* (3), *O. basilicum* var. *pilosum* (6), *O. gratissimum* (8), *O. tenuiflorum* (4), *Oroxylum indicum* (1), *Pedalium murex* (1), *Pemphis acidula* (1), *Piper attenuatum* (2), *P. betle* (1), *P. betleoides* (2), *P. lonchiltes* (1), *P. longum* (2), *P. nigrum* (1), *P. pedicellatum* (3), *P. peepuloides* (1), *P. porphyrophyllum* (1), *P. sarmentosum* (1), *P. sylvaticum* (4), *Polygonatum verticillatum* (1), *Rhus chinensis* (1), *Rubia manjith* (1), *Salvia hispanica* (1), *Selinum wallichianum* (2), *Senna hirsuta* (2), *S. occidentalis* (2), *Sida acuta* (1), *S. cordifolia* (1), *S. rhombifolia* (1), *Solanum nigrum* (3), *S. xanthocarpum* (2), *Spilanthes oleracea* (2), *Swertia paniculata* (1), *Tephrosia purpurea* (1), *T. strigosa* (1), *Teramnus labialis* (1), *Terminalia chebula* (1), *Tetrastigma lanceolarium* (1), *Tinospora cordifolia* (3), *Trachyspermum ammi* (1), *Trigonella foenum-graecum* (6), *Urena sinuata* (1), *Xanthium indicum* (1), *X. strumarium* (1), *Zanthoxylum oxyphyllum* (1), *Z. rhetsa* (1) and *Zingiber ligulatum* (2)
Forages (2)	*Medicago sativa* (1) and *Melilotus indicus* (1)
Other economic species (17)	*Colubrina asiatica* (1), *Ipomoea nil* (2), *I. obscura* (1), *I. violacea* (1), *Rosa banksiae* (1), *R. canina* (1), *R. centifolia* (1), *R. multiflora* (2), *R. viridiflora* (1), *R. webbiana* (2), *Saccharum arundinaceum* (1), and *S. spontaneum* (3)

1.2 Explorations undertaken and germplasm collected by the Headquarters

During the reporting period, 13 explorations were undertaken in parts of Arunachal Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Manipur, Maharashtra and Sikkim. A total of 660 accessions (cultivated: 382 and crops wild relative species: 278) of different agri-horticultural crops were collected (Table 1.3).

Table 1.3: Explorations undertaken by the ICAR-NBPGR, Headquarters (2022)

Sl. No.	Crops collected	Districts, state and period	No. of Accessions			Collaborating Institute/ SAU
			Cult.	Wild	Total	
1	*Morus* spp.	Jammu, Udhampur, Reasi, Rajauri, Kathua (Jammu & Kashmir), Chamba, Kangra (Himachal Pradesh), 07-16th Apr., 2022	6	29	35	
2	Multi-crops and CWR	Hailakandi, Cachar, Karimganj (Assam), 09-20th Apr., 2022	44	2	46	KVK, Hailakandi
3	Tropical underutilized fruits	Aurangabad, Ahmednagar, Nashik, Jalna (Maharashtra), 12-18th Apr., 2022	10	19	29	
4	Tropical underutilized fruits	Vadodara, Chhota Udaipur (Gujarat); Alirajpur (Madhya Pradesh), 4-12th May, 2022	1	27	28	KVK Alirajpur, Madhya Pradesh
5	*Garcinia* spp.	Dibrugarh, Tinsukia and North Lakhimpur (Assam), 7-17th June, 2022	-	49	49	ICAR-IISP, Kozhikod
6	Wild edibles & MAPs.	East Sikkim (Sikkim), 07- 15th Oct.,2022	3	24	27	Dr. KM Rai (Bhowali)
7	CWR & other economic species	Kutch, Patan, Banaskantha (Gujarat), 10- 20th Oct.,2022	25	68	93	ICAR-IIVR, Varanasi, KVK, Bhuj
8	CWR of vegetables & pulses	Shivpuri, Sheopur (Madhya Pradesh), 11- 20th Oct.,2022	25	22	47	ICAR-IIVR, Varanasi
9	Makhana	Madhubani, Sitamarhi, Supaul, Madhepura, Araria (Bihar), 02-13th Nov., 2022	102	-	102	BPSAC, BAU, Purnea

Sl. No.	Crops collected	Districts, state and period	No. of Accessions			Collaborating Institute/ SAU
			Cult.	Wild	Total	
10	Multi-crops incl. CWR	East Kameng (Arunachal Pradesh), 07-18th Nov., 2022	46	12	58	KVK, East Kameng
11	Multi-crops and CWR	Kamjong and Ukhrul (Manipur), 07-18th Nov., 2022	47	6	53	KVK, Ukhrul,Manipur
12	*Citrus* spp.	Karbi Anglong (Assam), Tamenglong (Manipur), 10-20th Dec., 2022	27	3	30	KVK, Tamenglong
13	Multi-crops and CWR	Nawada, Jamui, Banka (Bihar) 19-28th Dec., 2022	46	17	63	KVK, Nawada, Jamui, Banka Bihar
		Total	**382**	**278**	**660**	

1.2.1 *Morus* spp. germplasm from foot hills of Jammu & Kashmir and Himachal Pradesh

A total of 35 samples of *Morus* spp. were collected from foot hills (Shiwalik) and mid hill areas of Himachal Pradesh and Jammu & Kashmir. Different populations/provenance was occurring in sub-tropical to temperate climates in the hills of Rajaouri district of J&K, and Chamba district of Himachal Pradesh was surveyed. Trees with good growth and desirable fruiting were marked and populations of four species viz. *M. alba, M. indica, M. macurura, M. lavegata* were selected for collection. Rich variability (inter-specific and intra-specific) was observed in fruit length, fruit colour (black, red, creamy white), fruit diameter and shape etc. (Fig. 1.2).

Fig. 1.2. Variability in fruit morphology of *Morus* spp. collection from Himachal Pradesh and J&K

1.2.2 Multi-crop and CWR germplasm from remote districts of Assam

A total of 46 accessions of local crop diversity comprising of *Cucumis sativus* (9), *Brassica juncea* var. *rugosa* (8), *Cajanus cajan* (5), *Mesosphaerum suaveolens* (4) *Sesamum indicum* (4) *Phaseolus vulgaris* (4) *Lablab purpureus* (4), *Corchorus capsularis* (2) and others (6) were collected from parts of Hailakandi, Cachar and Karimganj districts of Assam. During the exploration, a dual purpose scaly cucumber was found cultivated widely in the Hailakandi, Cachar and Karimganj districts of Assam. Farmers getting revenue of Rs. 0.8-1.2 Lakh per acre during peak season. It is cultivated twice in a year fetching high revenue to the local farmers. Some farmers are cultivating it along with French bean (Rajmah), a commercial crop in the banks of Barak valley of Assam.

1.2.3 Tropical underutilized fruits from Marathwada region of Maharashtra

Twenty-nine germplasm samples of 14 species comprising of *Buchanania lanzan* (8), *Annona reticulata* (5), *Pithocelbium dulsce* (3), *Balanites aegyptica* (2), *Muntingia calubra* (2) and Others (9) were collected from forest localities, wastelands, kitchen gardens in Nashik, Aurangabad, Jalna and Ahmednagar districts of Marathwada region of Maharashtra. The entire area is dry but soil fertility is good hence is considered suitable for growing many agri-horticultural crops. *Muntingia calabura* –a small tree has been naturalized as ornamental species along road side, its small berries are eaten by children. Kernel from roasted seed of *Ziziphus rugosa* locally known as 'Toran' is eaten while fruits are sold in local market. Variability was observed in fruit shape (rounded & flat), size (0.51 cm X 0.51 cm, 0.54 cm X 0.46 cm, 0.50 cm X 0.53 cm, 0.41 cm X 0.43 cm) and

Fig. 1.3. Cultivation of dual purpose scaly cucumber A, B & C by local farmer in the Barak valley of Assam

Fig. 1.4. (A) *Citrus medica*, (B) *Annona reticulata*, (C) *Ziziphus rugosa*, (D) *Muntingia calubra*

TSS (35.0-37.6% brix, 31-33% brix, 27-28.5% brix, 26-28.4 brix), early and late types, with leaves and without leaves of chironji (*Buchanania lanzan*); fruit and seed size of *Pithecellobium dulce;* fruit size (8-16 cm) shape (spherical, oblong or irregular) and weight (517-667 g) of *Annona reticulata;* fruit size (25.5 cm X 11 cm) and weight (16.14 g) recorded in *Citrus medica.* In addition, indigenous knowledge was also recorded from local people of the region.

1.2.4 Tropical underutilized fruits from parts of Gujarat

Twenty-eight diverse germplasm of tropical minor fruits comprising of *Buchanania lanzan* (6), *Diospyros melanoxylon* (5), *Cordia myxa* (3), *Pithecellobium dulce* (3), *Aegle marmelos* (2), *Alangium salviifolium* (2), *Manilkara hexandra* (2) and Others (5) were collected from parts of Vadodara, Chhota Udaipur districts of Gujarat and Alirajpur district Madhya Pradesh. Variability was observed in chironji (*Buchanania lanzan*) for fruit size, shape, colour of and *Diospyros melanoxylon* for fruit size, shape (oblong, oval) & colour at maturity (light yellow, yellow, light brown and orange).

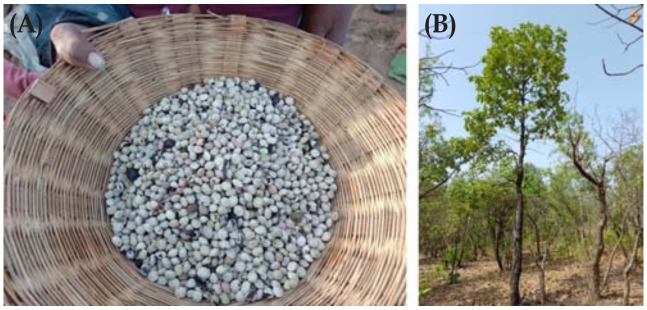


Fig. 1.5. (A) *Buchanania lanzan* seeds collected from parts of Gujarat; (B) dense population of *B. lanzan*

1.2.5 *Garcinia* spp. germplasm from upper Brahmaputra valley, Assam

A total of 49 germplasm accessions (25 species) were collected which include wild fruits (27 acc.) and spices (22 acc.). Rich species diversity of *Garcinia* was observed and a total of nine *Garcinia* species (24) were collected. Fruits of *Garcinia lancifolia* are used in dysentery and fruit juice is useful in fever, jaundice and urinary

Fig. 1.6. Variability collected in *Garcinia* species; (A) *G. pedunculata*, (B) *G. lanceifolia*, (C) *G. assamica*, (D) *G. acuminata*

troubles. *G. morella* is a commercial source of gamboge, and fruit juice is used to treat fever, diabetes and jaundice. Fruits of *G. pendunculata* are eaten raw, sliced into pieces, dried and made into pickle, while its dried pericarp is useful in dysentery and digestive troubles. Besides, rich diversity, variability was also observed in spices and a total of nine *Piper* species (16 accessions) were collected. The area also harbours rich diversity of *Syzygium* spp. however; the fruits were available only in *Sygygium jambos* (rose apple).

1.2.6 Wild edibles and M&APs from Nathang Valley, East Sikkim

Total of 27 accessions belonging to wild edibles *(Actinidia callosa, Docynia indica, Prunus rufa, Houttuynia cordata, Vaccinium sikkimense, Rubus* spp. *(accumunatus, calycinus, lineatus, rugosus), Allium fasciculatum, A. wallichii;* M&APs (*Hedychium gardnerianum, Heracleum nepalense, Ocimum gratissimum, Rubia manjith, Selinium wallichianum, Swertia paniculata, Zanthoxylem oxyphyllum*) and other economic species (*Trichosanthes tricuspidata, Tupistra clarkei, Vigna angularis var. nipponensis, Capsicum annuum, Eryngium foetidum*) were collected from Nathang valley in *East Sikkim.* The upper part of Nathang valley (above 2000m) is very rich in availability of wild edibles; RET species and medicinal and aromatic plants. Different species of *Rhododendron* were also occurring in the surveyed area. *Allium wallichii, Vaccinium sikkimense, Actinidia callosa, Docynia indica, Tupistra clarkei, Zanthoxylem oxyphyllum, Prunus rufa* were specific germplasm collections from the valley, whereas edible value of kernels of *Trichosanthese tricuspidata* by the Nepali inhabitants (consumed like pumpkin seeds mainly by children) was most interesting information from the area surveyed. Good population of *Vigna angularis* var. *nipponensis*-a close relative of adzuki bean observed along road side in Pakyong was also collected (first time from Sikkim). Edible

Fig. 1.7. (A) *Actinidia callosa*-wild kiwi fruit, (B) *Trichosanthes tricuspidate*- kernels are eaten by children, (C) *Tupistra clarki* 'Nakima'- a popular ingredient of pickle in Sikkim, *(D) Vaccinium sikkimense*- a wild fruit

medicinal value of the flower heads of *Tupistra clarkei* 'Nakima' being sold in local market for pickle making; inflorescence of *Gerardiana parviflora* locally known as 'Shishun' consumed as vegetable and considered good for retaining the colour of hair; seeds of *Heracleum nepalense* locally known as 'Chimping', grow at higher elevations and are used in giddiness were among the interesting information recorded from area surveyed.

1.2.7 Collection of CWR and other economic species germplasm from parts of Gujarat

Ninety-three germplasm accessions belonging to 42 species of different crops including crop wild relatives (31 species) were collected from parts of Banaskantha, Kutch and Patan districts of Gujarat. Germplasm comprising of *Luffa actangula* var. *amara* (7), *Sesamum indicum* (6), *Cucumis melo* var. *momordica* (5), *S. malabaricum* (5), *Pennisetum glaucum* (4), *Solanum virginianum* (4), *S. coagulans* (3), *Abelmoschus tuberculatus* (3), *Cleome viscosa* (3), *Cucumis prophetarum* (3), *Suaeda fruticosa* (3), *Triticum aestivum* (2), *Triticum durum* (2), *Vigna aconitifolia* (2), *Vigna radiata* (2), *Cymopsis tetragonoloba* (2), *Ctenolepis cersaiformis* (2), *Corchorus aestuans* (2), *Cucumis melo* var. *agrestis* (2), *Momordica balsamina* (2), *M. charntia* var. *muricata* (2), *Trichosanthes cucumeria* var. *cucumerina* 2), *Ocimum gratissimum* (2), *Physalis angulata* (2), and others (21) were collected. Variability in *Cucumis* spp. was observed for fruit size, shape, colour & aroma while in *Cucumis melo* var. *momordica* for fruit size (250-1500g), shape (round, oblong/cylindrical, oval & colour at maturity (light yellow, yellow, light brown and yellowish green).

1.2.8 Collection of CWR of vegetables & pulses from Palpur Kuno Wild Life Sanctuary in Shivpuri, Madhya Pradesh

A total of 47 accessions representing significant diversity in cucurbits (*Cucumis* spp., *Lagenaria* spp., *Luffa* spp., *Cucurbita pepo*, *Trichosanthes* spp.) and *Abelmoschus* spp. were collected from Palpur Kuno Wild Life Sanctuary and adjoining area in Shivpuri, Madhya Pradesh. The collected CWR species include wild okra (*Abelmoschus manihot* subsp. *tetraphyllus* var. *tetraphyllus, A. ficulneus, A. tuberculatus*), *Bryonia laciniosa, Cajanus scarabaeoides,* wild cucurbits (*Cucumis melo* var. *agrestis, Luffa acutangula* var. *amara, L. aegyptiaca, L. echinata, Trichosanthes bracteata* and *T. cucumerina), Rhynchosia minima, Solanum insanum,* from the un-explored buffer areas of sanctuary. *Abelmoschus ficulneus* and *A. tuberculatus* locally called as 'jangli bhendi' were harvested by Sahariya & Kushwaha tribes as seasonal vegetable. Variability in pigeon pea for grain shape, size and colour was also observed.

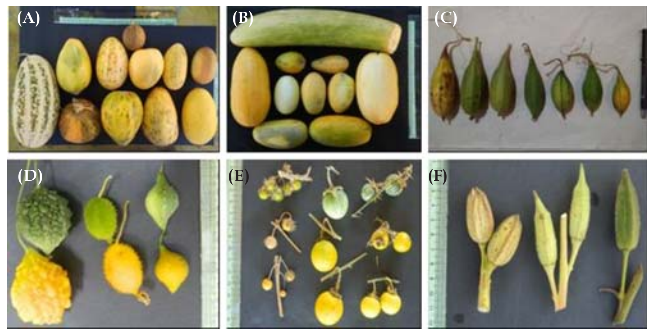


Fig. 1.8. (A&B) Variability in fruits of *Cucumis melo* group species, (C) Variability in fruits of *Luffa acutangula* var. *amara*, (D) L-R Variability in fruits of *M. muricata*, *M. dioica*, & *M. balsamina*, (E) L-R Variability in fruit of *Solanum coagulans*, *S. incanum* and *S. virginianum*, (F) L-R Variability in fruit of *Abelmoschus tetraphyllus*, *A. tuberculatus* and *A. ficulneus*

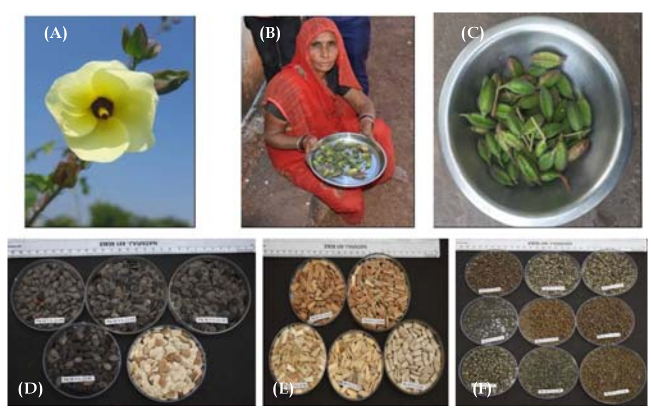


Fig. 1.9. (A) Freshly harvested immature fruits of *Abelmoschus manihot subsp. tetraphyllus var. tetraphyllus* (A&B) and *Abelmoschus ficulneus* (C) for vegetable purpose; Diversity in seeds of: (D) *Luffa* spp. E. *Lagenaria* spp. (E) *Abelmoschus* spp.

1.2.9 Exploration for collection of makhana germplasm from parts of Bihar

A total of 102 diverse germplasm of makhana were collected from Madhubani, Sitamarhi, Supaul, Madhepura, Araria districts of Bihar.

Variability in makhana (*Eyurale ferox*) was observed for seed size, seed colour and seed shape. In surveyed areas almost all the farmers have their independent ponds for growing makhana and to perform other domestic work pertaining to washing, bathing, irrigation and livestock. Makhana seeds are packed in gunny bags and kept in water bodies till supply for processing. They grow vegetables like brinjal, chilli, cucurbits, ginger, turmeric, cowpea, tannia, taro etc. in their kitchen gardens as main source of livelihood. The farmers do not apply chemical fertilizers in their fields.

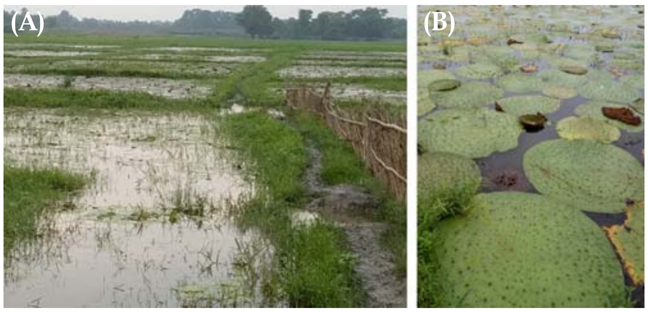


Fig. 1.10. Field view of makhana germplasm in parts of Bihar

1.2.10 Multi-crop germplasm from East Kameng district of Arunachal Pradesh

Fifty-eight germplasm accessions of different agri-horticultural crops comprising of *Coix lacryma-jobi* (6), *Zea mays* (6), *Perilla frutescens* (4), *Phaseolus vulgaris* (4), *Chenopodium album* (3), *Glycine max* (3), *Oryza sativa* (3), *Fagopyrum esculentum* (2), *Vigna umbellata* (2), *Vigna angularis* (2), *Capsicum chinense* (2), *Cucurbita moschata* (2), *Brassica juncea* var. *rugosa* (2), *T. majuscule* (2), *Tubocapsicum anomalum* (2) and others (13) were collected from remote localities of East Kameng district of Arunachal Pradesh. Significant variability was observed in Coix, perilla, maize, French bean, and soybean. In Coix, variability was observed for grain colours (yellowish/straw colour, pinkish, reddish), grain size (small, med. & bold) and shape and for grain colour (white, cream, yellow, and dark red/reddish black), cob shape & size in maize. In soybean, four types of grain (bold creamy, greenish white medium, whitish small flatted-primitive type) were notable collections. Good variability was also observed in French bean for grain colour (white, brown, dark reddish), grain shape (kidney and round/spherical type) and size (small, medium, bold), mostly being cultivated in Bana, Thrizino, Seppa and Bameng areas of the district. Wild edible fruits namely *Meyna spinosa* and *Stauntonia elliptica* collected from Bameng area of East Kameng were notable collections.

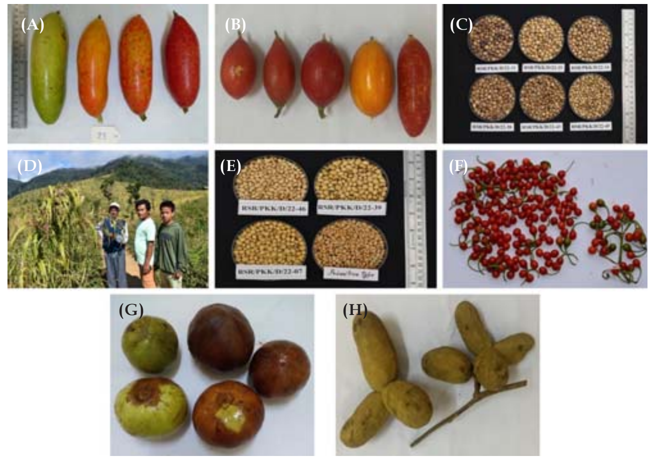


Fig. 1.11. Unique fruits of wild *Trichosanthes majuscula* (L X W- 18.0 X 6.0cm) a close CWR of snake gourd, collected first time from Thrizino area of East Kameng (A) Variability in fruits size (L 7-18cm X W 4-6cm) of *Trichosanthes* species for fruit shape & fruit colour (B) Variability in seeds of Coix landraces collected (C) Collecting Coix germplasm from *Jhoom* field in Fengche villages (D) Variability in soybean seeds (E) Mature fruit of *Tubocapsicum anomalum* collected near Palezi (F), *Meyna spinosa* a local wild edible fruit (G) and *Stauntonia elliptica* collected from Bameng area of East Kameng (H)

1.2.11 Multi-crop germplasm from remote districts of Manipur

In an exploration to parts of Ukhrul and Kamjong districts of Manipur, a total of 53 accessions comprising of *Glycine max* (7), *Coix lacryma-jobi* (6), *Capsicum annuum* (6), *Phaseolus vulgaris* (5), *Setaria italica* (5), *Perilla frutescens* (4), *Solanum violaceum* (4) *Vigna umbellata* (4) *Solanum aethiopicum* (3), *Abelmoschus manihot* subsp. *tetraphyllus* (2), *Brassica juncea* (2), and others (5) were collected. Variability was observed in *Glycine max,* French bean, job's tear and rice bean for maturity duration (early and late), plant height, seed shape, size and colour. In soyabean, variability was observed for seed size (small and bold types), shape (round/lens shape) and colour (white, creamy white and ivory white). The tribal of Ukhrul district use soyabean in the form of roasted seed, as pulse and also mixed with

Fig. 1.12. Variability in seed shape, size and colour of (A) *Glycine max;* (B) *Phaseolus vulgaris* and (C) *Coix lacryma-jobi*

vegetables. While grains of job's tear are consumed in the form of porridge and roasted kernels as snacks and Tangkhul Naga and Thadou people used their grain for brewing purposes throughout the year. Its fresh leaves are used as substitute of tea. *Cucumis metuliferus* commonly known as African horned cucumber introduced by some progressive farmers has adapted to the local condition of Manipur.

1.2.12 Citrus from Karbi Anglong district of Assam and Tamenglong district Manipur

A total of 30 diverse germplasm of citrus and other crops comprising of *C. medica* (7), *C. megaloxycarpa* (3), *C. jambhiri* (3), *C. macroptera* (2) and others (15) were collected from parts of Karbi Anglong district of Assam and adjoining Tamenglong district of Manipur. Variability was observed for fruit size, shape, colour of *Citrus medica*. Also rich variability was observed in *Citrus megaloxycarpa* for fruit size and shape (oblong, oval & colour at maturity-light yellow, yellow, light brown and orange).

1.2.13 Multi-crop germplasm from parts of Bihar

A total of 63 accessions comprising of *Eleusine coracana* (5), *Zea mays* (5), *Lathyrus sativus* (4), *Oryza sativa* (4), *Linum usitatissimum* (4), *Macrotyloma uniflorum* (3), *Sesamum indicum* (3), *Sorghum bicolor* (3), *Trichosanthes cucumerina* (3), *Amaranthus viridis* (2), *Coix aquatica* (2), *Hibiscus sabdariffa* (2), *Hordeum vulgare* (2), *Lens culinaris* (2), *Ziziphus nummularia* (2) and *others* (17) were collected from parts of Nawada, Jamui and Banka districts of Bihar. Variability was observed for maturity (early and late), plant height, seed shape, size and colour in *Eleusine coracana, Lathyrus sativa* and *Linum usitatissimum* grown

Fig. 1.13. Display of citrus species (A) during orange festival in Tamenglong, Manipur; (B) a rare species - *Citrus indica* collected from Tamenglong

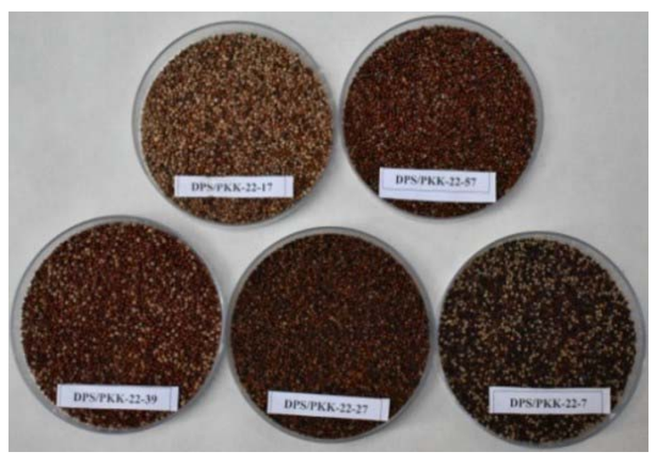


Fig. 1.14. Grain variability in finger millet from Bihar

in tribal areas of all three districts. Variability was also observed in named rice landraces *viz. Jhada dhan, Desi dhan, Lal Sita* (red) and *Katrani dhan* (Scented, suitable for chevda and kheer making) for grain size (small and bold types), shape and colour (light yellow, golden and red). Use of the flowers of *Crotolaria tetragona* as vegetables by tribal people in Jamui district of Bihar was also recorded.

1.3 National Herbarium of Cultivated Plants

A total of 542 herbarium specimens, fifty-four seed samples/economic products were added to the National Herbarium of Cultivated Plants (NHCP), making total collection of 25,681 herbarium specimens (representative of 4,394 species belonging to 1,551 genera and 267 families), 3186 seed samples and 771 economic products. During the report period, 22 new taxa, not represented earlier, were added as in the form of herbarium specimens to the NHCP. A total of 549 specimens/taxa including 22 taxa unrepresented belonging to crop genepool were authenticated and digitised making a total of 10,818 digitised images. The webpage for use as herbarium digital resource was made available to the users. Identification services were provided and authentication certificates (23) were issued to students and researchers for their experimental study.

1.4 Diversity mapping in kidney bean (*Phaseolus vulgaris*), horsegram (*Macrotyloma uniflorum*) and lentil (*Lens culinaris*)

Kidney bean: Geo-referencing and mapping of 6,845 accessions collected from various parts of the country was done. Mapping of assembled diversity have shown that Himachal Pradesh (2,303), followed by Uttarakhand (1,130), Jammu & Kashmir (550), Arunachal Pradesh (327), Sikkim (180), Tamil Nadu (155), Manipur (150), Andhra Pradesh (102), Nagaland (98), Kerala (86), Meghalaya (83) West Bengal (82) and Mizoram (74) were extensively explored states. The areas identified for future collections are: Arunachal Pradesh (Anjaw, Lower Dibang Valley, East Kameng, Upper Subansiri, Upper Siang and West Siang); Nagaland (Longleng, Noklak, Mokokchung and Tuensang), Manipur

Table 1.4: New taxa added in NHCP during 2022

Family	New Species	State	W/C*
Acanthaceae	*Pseuderanthemum carruthersii* (Seem.) Guillaumin	Andaman & Nicobar Island	C
Apiaceae	*Ligusticopsis wallichiana* (DC) Pimenov & Kijuykov	Sikkim	W
	Heracleum nepalense D. Don.		
Asclepiadaceae	*Gomphocarpus physocarpus* E. Mey	Uttarakhand	
Asteraceae	*Anaphalis longifolia* (Blume) Blume ex DC.		
Brassicaceae	*Erysimum perofskianum* Fisch. & C.A.Mey.		
Commelinaceae	*Tradescantia occidentalis* (Britton) Smyth	Arunachal Pradesh	
Cupressaceae	*Thuja cupressoides* L.	Uttarakhand	
Cupressaceae	*Juniperus communis* L.	Himachal Pradesh	
Fabaceae	*Rhynchosia rothii* Aitch.	Odisha	W
	Saraca asoca (Roxb.) Willd.		CW
	Adenanthera pavonina L.	Gujarat	
	Lathyrus amphicarpos L.	New Delhi	
Gentianaceae	*Crawfurdia speciosa* Wall.	Sikkim	W
Geraniaceae	*Pelargonium inquinans* (L.) L'Hér.	Himachal Pradesh	
Grossulariaceae	*Ribes takare* D. Don	Sikkim	
Lardizabalaceae	*Stauntonia elliptica* Hemsl.	Arunachal Pradesh	
Myrtaceae	*Syzygium macrocarpum* Bahadur & R. C. Gaur		
	Syzygium nervosum A. Cunn. Ex DC.	Himachal Pradesh	
Rosaceae	*Rubus lineatus* Reinw.ex Blume	Sikkim	
	Neillia thyrsiflora D.Don		

(Kamjong and Churachandpur) and Tripura (Dhalai, Khowai and North Tripura) based on gaps in collection.

Horse gram: Geo-referencing and mapping of 3,770 accessions collected from various parts of the country was done (Fig. 1.15A) Mapping of assembled diversity have shown that that Andhra Pradesh (399) followed by Himachal Pradesh (373), Karnataka (283), Jharkhand (267), Uttarakhand (265), Maharashtra (246), Tamil Nadu (241), Chhattisgarh (230), Odisha (186), Madhya Pradesh (164), Kerala (129), Rajasthan (125) were extensively explored states. The areas identified for future collections are: Chhattisgarh (Balrampur, Jashpur, Korea and Surajpur), Karnataka (Hassan, Kodagu, and Mandya), Odisha (Malkangiri, Koraput, Gajapati and Rayagada), Maharashtra (Beed, Dhule, Jalgaon, Nandurbar and Latur) and Tamil Nadu (Madurai, Ramanathapuram, Sivaganga and Theni).

Lentil: Geo-referencing and mapping of 5,202 accessions collected from various parts of the country was done (Fig. 1.15B). Mapping of assembled diversity have shown that Uttar Pradesh (362) followed by Uttarakhand (262), Bihar (236), Himachal Pradesh (224), Madhya Pradesh (181) were extensively explored states (Fig. 1.4.1b). The areas identified for future collections are: Madhya Pradesh (Agar Malwa, Guna and Rajgarh); Maharashtra (Beed, Latur and Nanded) and Rajasthan (Baran, Jhalawar and Banswara) based on gaps in collection.

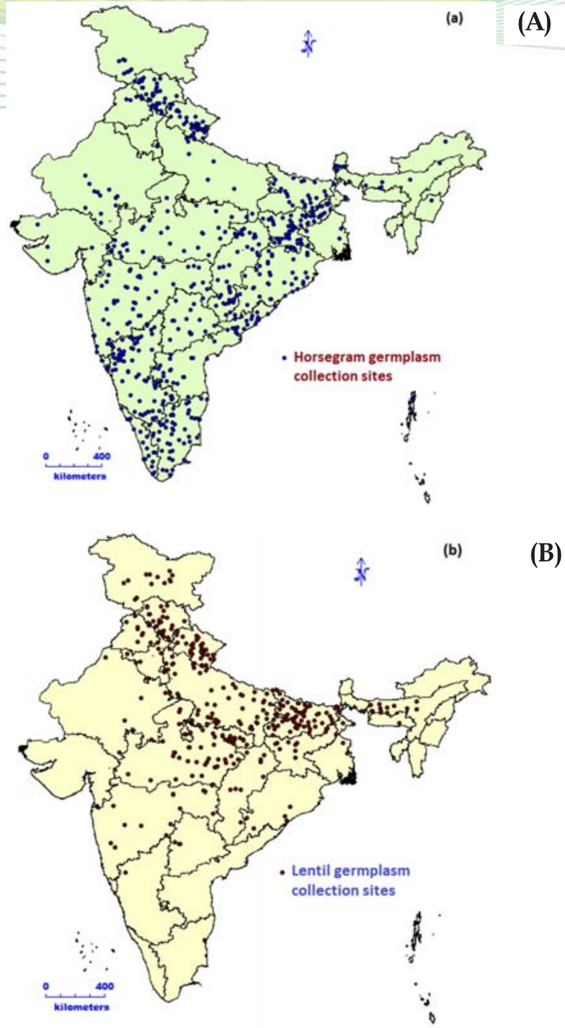


Fig.1.15. Germplasm collection sites of (A) horsegram and (B) lentil

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 (**SP Ahlawat**)
Projects (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, S Nivedhitha (up to 22.1.22), RK Pamarthi, PK Malav, Pankaj Kumar Kannaujia (w.e.f. 22-11-2021) *NS Panwar* and *OP Dhariwal*)
PGR/DPEGC-BUR-DEL-01.02: Exploration for collection of genetic resources of horticultural crop species and their wild relatives (**RS Rathi** (w.e.f. 01.04.2022), KC Bhatt, DP Semwal, SK Malik, Puran Chandra, S Nivedhitha (up to 22.1.22), Pankaj Kumar Kannaujia (w.e.f. 13-11-2021) *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 (Anjula Pandey (up to 31.10.2022), **KC Bhatt (w.e.f.01.11.2022)**, K Pradheep, RK Pamarthi, S Nivedhitha (up to 22.1.22), Pankaj Kumar Kannaujia (w.e.f. 13-11-2021) and *Rita Gupta*)
PGR/DPEGC-BUR-DEL-01.04: Geo-informatics for assessment of diversity distribution in agri-horticultural crops (**DP Semwal**, KC Bhatt, Anjula Pandey (up to 31.10.2022), N Sivaraj, Soyimchiten, RK Pamarthi, PK Malav and *NS Panwar*)

2 GERMPLASM EXCHANGE AND POLICY UNIT

सारांशः रिपोर्ट के तहत इस अवधि के दौरान 68,770 एक्सेशनों (2,01,655 नमूनों) का आयात किया गया था, जिसमें जननद्रव्य के 52,072 एक्सेशन (53,942 नमूने) और सीजीआईएआर नर्सरियों/परीक्षण की 16,698 प्रविष्टियां (1,47,713 नमूने) शामिल हैं। सीआरपी के तहत कुल 1747 नमूनों का निर्यात किया गया था जिसमें गेहूं के 700 नमूने (350 बोलिविया को और 350 बांग्लादेश को) और उज्बेकिस्तान के लिए शीतोष्ण फल फसलों के 1,047 नमूने हैं। सामग्री हस्तांतरण समझौते (एमटीए) के तहत अनुसंधान कर्मियों से प्राप्त अनुरोधों के आधार पर विभिन्न फसल सुधार कार्यक्रमों में उपयोग के लिए देश के भीतर उपयोगकर्ताओं को विभिन्न फसलों की कुल 10,573 नमूने की आपूर्ति की गई। इसके अलावा, 66,475 नमूनों को पुनर्जनन/वृद्धि/रूपात्मक लक्षण वर्णन/प्रारंभिक मूल्यांकन /वर्गीकरण संबंधी पहचान/डीएनए फिंगरप्रिंटिंग/ व्यवहार्यता परीक्षण के लिए आपूर्ति की गई। विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय स्तर पर पीजीआर प्रबंधन से संबंधित मुद्दों पर बातचीत और नीतियों के निर्माण के लिए नीति निर्माताओं की आवश्यकताओं के अनुसार विश्लेषणात्मक इनपुट प्रदान किए गए। जैसा कि दिल्ली घोषणा में भोजन और पोषण संबंधी जरूरतों को पूरा करने के लिए भारत प्रतिबद्ध है, भारत ने आनुवंशिक संसाधनों की आदान–प्रदान की सुविधा के लिए बहुपक्षीय और द्विपक्षीय दोनों तरीकों को अपनाया, जिससे कि समान पहुंच और लाभ साझा करने के अवसर सुनिश्चित की जा सके। (एआईसीएचआई लक्ष्य–रणनीतिक लक्ष्य डी, लक्ष्य 17; एसडीजी 2.5)

Summary: : During the period under report 68,770 accessions (2,01,655 samples) were imported including 52,072 accessions (53,942 samples) of germplasm and 16,698 entries (1,47,713 samples) of CGIAR nurseries/trials. A total of 1747 samples were exported under CRP which include 700 samples of wheat (350 to Bolivia and 350 to Bangladesh) and 1,047 samples of temperate fruit crops to Uzbekistan. A total of 10,573 samples of different crops were supplied to 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, 66,475 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. As committed in Delhi Declaration to meet the food and nutritional needs, India adopted both multi-lateral and bilateral instruments to facilitate the exchange of genetic resources, while ensuring equitable access and benefit sharing opportunities (Aichi Target -Strategic Goal D, Target 17; SDG 2.5).

2.1 Import of Plant Genetic Resources

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. Details of import of seed/ planting material during the year 2022 are as follows:

Germplasm accessions procured and processed	: 52,072 accessions (53,942 samples)
CGIAR nurseries for trials	: 16,698 entries (1,47,713) samples
No. of countries involved	: 38
No. of Import Permits issued	: 537
Resource generated	: ₹ 1,28,36,164

Cereals: *Hordeum vulgare* (19) from Australia; (126) from the Netherlands; (1169) from the USA; *Oryza alta* (5) *Oryza ridleyi* (4) from the Philippines; *Oryza sativa* (379) from Bangladesh, (125) from Brazil, (40) from Colombia, (1) from Malaysia, (29) from Mozambique, (8) from the Netherlands, (2652) from the Philippines, (630) from the USA, (459) from Vietnam; *Triticum aestivum* (196) from Australia; (3) from Mexico;

(2) from UK; (1) from the USA; *Triticum durum* (1) from Mexico; (1) from the USA, *Triticum monococcum* (198) from USA; *Triticum timopheevii* (48) from Mexico; *Zea mays* (762) from Brazil, (18780) from Chile, (60) from France, (7394) from Guatemala, (225) from Indonesia, (89) from Kenya, (2999) from Mexico, (3) from the Netherlands, (381) from the Philippines, (631) from South Africa, (3873) from Thailand, (2029) from the USA and (76) from Zimbabwe.

Millets: *Eleusine coracana* (28) from Kenya; *Pennisetum glaucum* (8) from Sudan; (20) from Kenya; *Sorghum×drummondii* (5) from Hungary; *Sorghum bicolor* (70) from Argentina; (117) from Kenya, (10) from Sudan; *Sorghum* sp. (8) from Hungary.

Grain legumes: *Cajanus cajan* (57) from Kenya, (61) from Niger; *Lathyrus annuus* (16), *L. aphaca* (32), *L. articulatus* (5), *L. blepharicarpus* (5), *L. boissieri* (2), *L. cassius* (4), *L. chloranthus* (2), *L. chrysanthus* (1), *L. cicera* (14), *L. cilicicus* (1), *L. clymenum* (3), *L. gorgoni* (6), *L. hierosolymitanus* (6), *L. hirsutus* (9), *L. inconspicuus* (11), *L. marmoratus* (4), *L. ochrus* (7), *L. pseudocicera* (4), *L. sativus* (710) and *L. sphaericus* (7) all from Lebanon; *Lens culinaris* (238) from Lebanon, (2) from the USA; *Phaseolus acutifolius* (10) from Burkina Faso; (17) from the USA; *Vigna radiata* (163) from Taiwan; *Vigna subterranea* (96) from Nigeria; *Vigna unguiculata* (3) from Niger, (5) from Tanzania and (10) from Uganda.

Oilseeds: *Arachis hypogaea* (2) from Kenya; *Alyssum alyssoides* (5), *A. dasycarpum* (2), *A. desertorum* (1), *A. granatense* (2), *A. lenense* (1), *A. loiseleurii* (1), *A. minutum* (1), *A. scutigerum* (1), *A. simplex* (3), *A. stapfii* (1), *A. strigosum* (1), *A. tortuosum* (1), *A. wulfenianum* (1) all from the USA; *Meniocus linifolius* syn *A. linifolium* (1) from the USA, *Odontarrhena alpestris* syn. *A. murale* (1), *Odontarrhena obovate* syn. *A. obovatum* (1) *Odontarrhena pateri* syn. *A. pateri* (1) all from the USA; *Brassica balearica* (2) from the USA, *B. barrelieri* (1) from Australia, (1) from the USA, *B. cretica* (1) from Australia, *B. cretica* subsp. *cretica* (3) from the USA, *B. deflexa* (1) from Australia, *B. deflexa* subsp. *leptocarpa* (1) from the USA; *B. elongata* (1) from Australia, *B. fruticulosa* (1) from Australia, (4) from the USA, *B. fruticulosa* subsp. *cossoniana* (1), *B. fruticulosa* subsp. *glaberrima* (1), *B. fruticulosa* subsp. *pomeliana* (1), *B. fruticulosa* subsp. *radicata* (1), *B. gravinae* (1) *B. incana* (3) all from the USA, *B. insularis* (1) from Australia, (3) from the USA, *B. macrocarpa* (2) from Australia, (2) from the USA, *B. maurorum* (1) from Australia, (1) from the USA, *B. montana* (1) from Australia, *B. oxyrrhina* (1) from Australia, (1) from the USA, *B. souliei* subsp. *amplexicaulis* (1) from Australia, *Brassica* sp. (1) from Australia, (2) from the USA, *B. tournfortii* (1) from Australia, (1) from the USA and *B. villosa* (3) from the USA; *Camelina alyssum* (1), *C. hispida* var. *grandiflora* (1), *C. laxa* (4), *C. microcarpa* (20), *C. rumelica* (1) and *C. rumelica* subsp. *transcaspica* (1) all from the USA; *Carthamus* sp. (7), *C. tinctorius* (175), *C. turkestanicus* (3), all from the USA; *Glycine max* (20) from Taiwan and (949) from the USA; *Helianthus annuus* (48) from France, (20) from Netherlands and (222) from the USA, *Helianthus petiolaris* subsp. *petiolaris* (1), *Helianthus* sp. (2) both from the USA; *Linum bienne* (1), *L. catharticum* (1), *L. flavum* (1), *L. pallescens* (1), *L. perenne* (1), *L. tenuifolium* (1) and *L. usitatissimum* (217) from the USA; *Sesamum indicum* (50) from the USA.

Vegetables: *Abelmoschus caillei* (214) from Taiwan, (43) from Thailand, *A. crinitus* (1) from the USA, *A. esculentus* (105) from Nigeria, (397) from Taiwan, (50) from Thailand, (618) from the USA, *A. manihot* (38) from Taiwan, (2) from Thailand, (25) from the USA, *A. manihot* var. *tetraphyllus* (2) from the USA; *A. moschatus* (10) from Taiwan, (6) from the USA and *A.* sp. (2) from Taiwan; *Allium cepa* (11) from Philippines and (166) from the USA; *Brassica oleracea* var. *acephala* (14) and *B. oleracea* var. *botrytis* (12) from Netherlands; *Capsicum annuum* (568) from Netherlands, (216) from Taiwan, (19) from Thailand and (130) from the USA, *C. baccatum* (5) from Taiwan, (1) from the USA, *C. baccatum* var. *pendulum* (12) from the USA, *C. chacoense* (1) from Taiwan, *C. chinense* (5) from Taiwan, (6) from the USA, *C. frutescens* (4) from Korea, (1) from the USA and *Capsicum* sp. (7) from Italy,(15) from the USA; *Citrullus amarus* (68) from the USA, *C. colocynthis* (8) from the USA, *C. lanatus* (16) from Italy, (6) from Thailand, (385) from the USA and *C. mucosospermus* (20) from the USA; *Cucumis dipsaceus* (1) from the USA, *C. melo* (36) from Thailand, (18) from the USA; *C. metuliferus* (7), *C. prophetarum* (1), *C. pustulatus* (1) all from the USA, *C. sativus* (8) from Korea, (3) from Netherlands, (6) from Taiwan, (34) from Thailand and (13) from the USA, *C. sativus* var. *sativus*

Table 2.1: Wild species and trait specific (promising) seed/planting material imported in 2022

Crop/ EC No/Country	Traits/ Species	Indentor/ Distribution
Cereals		
Rice		
EC1123580-1123734/ Philippines	CMS and Maintainer lines	ICAR-IIRR, Hyderabad
EC1118139-1118433/ Philippines	Lines with high Zn content and high yielding	ICAR-IIRR, Hyderabad
EC1124070-EC1124335/ Philippines	Early maturing breeding lines	ICAR-IARI, New Delhi
Wheat		
EC1144646-1144669/ USA	*Triticum timopheevi* (CMS Lines)	ICAR-IARI, New Delhi
Barley		
EC1130766-1130767/ USA	Golden promise is a heritage variety known for brewing and distilling qualities. As a base malt, it is a leading choice of brewers around the world	ICAR-NBPGR, New Delhi
Maize		
EC1144551-1144557/Mexico	Traditional cultivars/ landraces from Guatemala, Panama, Mexico, Ecuador and Peru	ICAR-IARI, New Delhi
EC1131471-1131477/ USA	Selected inbred lines potentially utilized for trait donors in breeding programs for developing Fall army worm (FAW) tolerant/ resistant cultivars	ICAR-IARI, New Delhi
Oilseeds		
Linseed		
EC1123759-1123981	Wild species and germplasm with very high linoleic acid, high oil content, large seeded, early maturing and wilt resistant	ICAR-IIOR, Hyderabad
Mustard		
EC1153155- EC1153179/ USA	Wild species - *Alyssum alyssoides* (5), *A. dasycarpum* (2), *A. desertorum* (1), *A. granatense* (2), *A. lenense* (1), *A.loiseleurii* (1), *A. minutum* (1), *A. scutigerum* (1), *A. simplex* (3), *A. stapfii* (1), *A. strigosum* (1), *A. tortuosum* (1), *A. wulfenianum* (1)	ICAR-NBPGR, New Delhi
EC1124024-EC1124051/ USA	Wild species- *Camelina alyssum* (1), *Camelina hispida* var. *grandiflora* (1), *Camelina laxa* (4), *Camelina microcarpa* (20), *Camelina rumelica* (1) and *Camelina rumelica* subsp. *transcaspica* (1)	ICAR-NBPGR, New Delhi
EC1124956- 1124968/ Australia	Wild species- *Brassica oxyrrhina* (1), *B. souliei* subsp. *amplexicaulis* (1), *B. tournfortii* (1), *B. barrelieri* (1), *B. cretica* (1), *B. deflexa* (1), *B. elongate* (1), *B. fruticulose* (1), *B. insularis* (1), *B. macrocarpa* (1), *B. maurorum* (1), *B. montana* (1)	ICAR-NBPGR, New Delhi
EC1129471-1129476/ USA	Wild species- *Brassica cretica* subsp. *cretica* (2), *B. macrocarpa* (1), *B. balearica* (1), *B. villosa* (1), *B. insularis* (1)	ICAR-NBPGR, New Delhi
EC1123368-1123417/ USA	Promising lines-white with large seed, strong stemmed, multi-capsular with long capsules	ICAR-IIOR, Hyderabad
Sunflower		
1119717-1119941/USA	Improved varieties Oleifera, Szaratovszkurani, Techrinianka, Vostok, Sunburst and other elite lines	ICAR-IIOR, Hyderabad
Grain legumes		
Lentil		
EC1112023/ USA	Cultivar- Mason tall, erect with higher yields, larger seeds and easier harvesting. Light green seeds without mottling. variety's tall, erect. The pods are placed higher on the plant for easier harvest without seed loss	ICAR-NBPGR, New Delhi

Crop/ EC No/Country	Traits/ Species	Indentor/ Distribution
Cowpea		
EC1122422/ Niger	Resistance to Striga and Alectra	ICAR-NBPGR, New Delhi
Lathyrus		
EC1132211-1132358/Lebanon	Wild species - *Lathyrus annuus* (16), *L. aphaca* (32), *L. articulatus* (5), *L. blepharicarpus* (5), *L. boissieri* (2), *L. cassius* (4), *L. chloranthus* (2), *L. chrysanthus* (1), *L. cicera* (14), *L. cilicicus* (1), *L. clymenum* (3), *L. gorgoni* (6), *L. hierosolymitanus* (6), *L. hirsutus* (9), *L. inconspicuus* (11), *L. marmoratus* (4), *L. ochrus* (7), *L. pseudocicera* (4) and *L. sphaericus* (7)	ICAR-NBPGR, New Delhi
Tepary bean		
EC1131312-1131328/ USA	Registered germplasm lines with broad abiotic stress tolerance, rust and common blight (TARS-TEP-23, TARS—TEP-22, TARS-TEP 32 and other germplasm lines having high yield component	ICAR-NBPGR, New Delhi
Vegetable crops		
Musk melon		
EC1144606/USA	Lines resistant to downy mildew (*Pseudoperonospora cubenis* pathotype 3), powdery mildew (races 1 and 2 and Fusarium wilt (*Fusarium oxysporum* f. sp.*melonis*, races 0, 1 and 2)	ICAR-NBPGR, New Delhi
EC1144607/USA	Powdery mildew resistant -multiple strain resistant	ICAR-NBPGR, New Delhi
Cucumber		
EC 114409-10, 1144605, 1144608-616, 1144621/ USA	Wild species resistant to Fusarium wilt and tolerant to melon aphid and Root knot nematode [*Cucumis dipsaceus* (1), *C. metuliferus* (7), *C. prophetarum* (1), *C. pustulatus* (1), *C. zeyheri* (1)]	ICAR-NBPGR, New Delhi
EC1144618/USA	Line resistant to downy mildew	ICAR-NBPGR, New Delhi
Pea		
EC1124052-69/USA	Improved varieties namely Strubes Early Viktoria, Early Dwarf, Early Green May, Early Perfection no. 1, Early Perfection no. 2, Improved Stratagem, Granada, No. 6060 Freezer, Grant, Dante, Poltatch/ Stratagem, Green Bay, Alaska Sweet, Small Late Canner, Ponderosa, Trident, SH 90-19, JI 2480	ICAR-NBPGR, New Delhi ICAR-VPKAS, Almora
Fruits		
Cassabanana		
EC1144603-604/USA	New crop, rich in vitamin B and C	ICAR-NBPGR, New Delhi
Grapes		
EC1117626- EC1117635/ Uzbekistan	Improved varieties namely Janjal Kora, Pushti toyfi, Parkent, Nimrang, Rizamat, Khusayne beliy, Khusane Kelin Barmoq, Kora Kishmish, Oktaybskiy	ICAR-NBPGR, New Delhi
Kiwi fruit		
EC1124951-55/ USA	Wild species -*Acinidia arguta*, *A. arguta* var *purpurea* and *A. macrosperma*	ICAR-NBPGR, New Delhi
Persimmon		
EC1144702 /USA	Wild species *Diospyros texana*	ICAR-NBPGR, New Delhi

Crop/ EC No/Country	Traits/ Species	Indentor/ Distribution
Ornamentals		
Marigold		
EC1138974-989/Czech Republic	Wild species *Tagetes tenuifolia* and *T. minuta*	ICAR-IARI, New Delhi
Rose		
EC1144680/USA	Species- *Rosa canina* having fruits rich in polyphenols and vitamin C	ICAR-DFR, Pune
EC1144681-701/USA	Wild species cold hardy and drought tolerant *Rosa hemisphaerica* (1), *R. moschata* (1), *R. roxburghii* (1), *R. woodsii* (8), *R. carolina* (1), *R. palustris* (8) and R. *virginiana* (1)	ICAR-DFR, Pune

Fig. 2.1. Variations in growth pattern and leaf morphology of grape genotypes imported from Uzbekistan (EC1117626-1117635) (Photo courtesy : Div. of Fruits & Horticulture, Technology, ICAR- IARI, New Delhi

(50) from the USA, *Cucumis* sp. (1) and *C. zeyheri* (1) both from the USA; *Cucurbita moschata* (29) from Taiwan and (66) from Thailand; *Luffa acutangula* (43) from Taiwan; *Momordica balsamina* (1) from the USA, *M. charantia* (253) from Thailand, (2) from Philippines and *M. rostrata* (1) from the USA; *Praecitrullus fistulosus* (5) from the USA; *Solanum arcanum* (1), *S. cheesmaniae* (1), *S. chilense* (1), *S. chmielewskii* (2), *S. galapagense* (3), *S. habrochaites* (2), *S. huaylasense* (1), *S. corneliomulleri* (1), *S. lycopersicum* (5) from Guatemala, (4) from Korea, (257) from Taiwan, (29) from Thailand and (58) from the USA, *S. lycopersicum* var. *cerasiforme* (4) from the USA, *S. pennellii* (1), *S. peruvianum* (3) both from the USA, *S. pimpinellifolium* (1) from Taiwan and (3) from the USA, *S. neorickii* (1) from the USA; *S. aethiopicum* (5), *S. americanum* (1), *S. anguivi* (2), *S. aviculare* (1), *S. elaeagnifolium* (1), *S. incanum* (2), *S. laciniatum* (1), *S. lichtensteinii* (1), *S. linnaeanum* (1), *S. macrocarpum* (1), *S. mammosum* (2) all from the USA, *S. melongena* (2) from Japan and (4) from Taiwan, *S. pseudocapsicum* (5), *S. scabrum* (1), *S. tomentosum* (1), *S. nigrum* (1), *S. viarum* (1), *S. villosum* (1), *S. violaceum* (1), *S. virginianum* (1) all from the USA; *Pisum sativum* (18) from the USA.

Forages & Agroforestry: *Eucalyptus cloeziana* (2), *E. longirostrata* (4), *E. moluccana* (4), *E. pellita* (5), *E. sideroxylon* (3) and *E. urophylla* (7) from Australia; *Medicago truncatula* (7) from the USA.

Fibres: *Gossypium barbadense* (3), *G. costulatum* (1), *G. darwinii* (1), *G. gossypioides* (1), *G. harknessii* subsp. *armourianum* (1), *G. hirsutum* (69), *G. incanum* (1), *Gossypium* sp. (3), *G. trilobum* (1) all from the USA.

Fruit crops: *Actinidia arguta* (3), *A. macrosperma* (2) both from the USA; *Corylus avellana* (2) from Uzbekistan; *Cydonia oblonga* (2) from Uzbekistan; *Diospyros texana* (1) from the USA; *Juglans regia* (4) from Uzbekistan; *Malus domestica* (8) from Belgium, (2) from Netherlands, (5) from the USA and (13) from Uzbekistan; *Musa* spp. (2) from Tanzania; *Prunus amygdalus* (4) from Uzbekistan; *P. armeniaca* (6) from Uzbekistan; *P. avium* (3) from Uzbekistan; *P. domestica* (4) from Uzbekistan; *P. dulcis* (6) from the USA; *P. persica* (1) from Uzbekistan; *P.* sp. (3) from Uzbekistan; *Ribes aureum* (4) from Uzbekistan; *Sicana odorifera* (2) from the USA; *Vasconcellea quercifolia* (1), *Vasconcellea stipulata* (1) both from the USA; *Vitis vinifera* (10) from Uzbekistan; *Ziziphus jujuba* var. *jujuba* (1) from Uzbekistan.

Ornamentals: *Rosa canina* (1), *R. carolina* (1), *R. hemisphaerica* (1), *R. moschata* (1), *R. palustris* (8), *R. roxburghii* (1), *R. virginiana* (1), *R. woodsii* (8) all from the USA; *Tagetes erecta* (7), *T. minuta* (1), *T. patula* (4), *T. tenuifolia* (4) all from Czech Republic.

Spices: *Cuminum cyminum* (3) from Australia.

Tubers: *Solanum tuberosum* (5) from France, (3) from Ireland, (41) from Netherlands, (137) from Peru; *Sphenostylis stenocarpa* (92) from Nigeria.

Medicinal: *Duboisia* spp (3) from Australia.

Narcotics: *Nicotiana tabacum* (8) from Brazil and (6) from France.

Sugar yielding crops: *Saccharum* sp. (2) from Brazil.

Potential crops: *Fagopyrum esculentum* (3) from Switzerland; *Vicia faba* (308) from Lebanon.

Others: *Arabidopsis thaliana* (3) from Japan.

2.2 Export of Plant Genetic Resources

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 2022 are indicated below.

a) **Collaborative Research Projects:** 41 accessions (1047 samples) of temperate fruit crops [apple (11), pear 94), plum (5), peach (6), apricot (5), almond (2), walnut (3), sweet cherry (4)] exported to Uzbekistan and 350 accessions (700 samples) of wheat to Bolivia (through Mexico) and 350 to Bangladesh for screening against blast disease under MTA

b) **National Biodiversity Authority Approval**: 10 accessions of carrot exported to Poland

c) **ICRISAT and CIMMYT Trials**: Facilitated supply of 2,319 samples of ICRISAT mandate crops (FAO designated accessions and breeding material developed from FAO designated accessions or exotic material) to different countries and 558 entries of CIMMYT, HTMA trials.

Facilitated supply of 39000 plus accessions of ICRISAT mandate crops [pigeonpea(13,000), groundnut (15000), fingermillet (7000), foxtail millet (1500), barnyard millet (700), kodo millet (600), little millet (400) and proso millet (800)] for safety duplication to USDA, USA and Chickpea 20000 plus accessions for safety duplication to World Vegetable Centre, Taiwan.

d) **Issuance of Phytosanitary Certificate:** Facilitated proposals for issuance of phytosanitary certificate for export of 80 accessions of rice from Bayer Bio science, India to Bayer Bioscience, Philippines and 18 accessions of cucumber from Rizk Zwan, India to Rizk Zwam, Netherlands.

2.3 National supply of Plant Genetic Resources

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 received 10,573 samples were supplied under the Material Transfer Agreement (MTA). The cropwise samples and the recipient institutes are listed in Table 2.2. In addition, a total of 66,475 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

2.4 Policy Issues on Agrobiodiversity Management

2.4.1 Ninth Governing Body Meeting of the International Treaty on Plant Genetic Resources for Food and Agriculture (GB9 -ITPGRFA) held in India (19-24 September 2022). The following activities are undertaken

- Analysis of the main Agenda Items was undertaken and prepared for India's position. For this activity three stakeholders meetings were organized including: (a)Breeders/users of PGRFA, (b)Farmers and (c)Seed Industry.
- The views and agreed positions were compiled and got approval by the National Focal Point and the competent authority.
- Organised and participated in Asia regional meetings prior to GB9 and during GB9 for finalization of submission by the Asia region for GB9.

Table 2.2: National supply of seed/planting material to recipients during 2022

Crop/Crop group	Number of samples	Indenter
Cereals (1265)		
Aegilops	4	NIPB, New Delhi
Triticale	13	LPU, Phagwara
Wheat	821	RLKBCAU, Jhansi; IARI, New Delhi; SKUAST-J, Jammu; NIPB, New Delhi Banasthali Vidyapith, Banasthali; IISS, Mau; PDKV, Akola; IARI, Jharkhand; PAU RRS, Gurdaspur; IIWBR, Karnal; Geeta University, Panipat; Sh. Sukhpreet Singh S/o Sh. Gurjit Singh; Tehsil Payal, Ludhiana
Rice	278	SVPUA&T, Bijnor; NRRI,Cuttack; IIRR, Hyderabad; Amity University, Noida; IISS RS, Bangalore; Karunya Institute of Technology and Sciences, Coimbatore; Rasi Seeds (P) Ltd; Mr. G. Moghanraj Yadhav, Amman Nagar, Sikkal, Nagapattinam
Maize	149	Maulana Azad Urdu University (MANUU),Hyderabad; IIMR, Ludhiana; SMMPG College, Balia; Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata
Millets (112)		
Sorghum	112	IGFRI, Jhansi
Grain legumes (4558)		
Chickpea	364	SKUAST- J, Jammu; NAU, Navsari; Greenvoice Foundation, Korba
Cowpea	2517	SKLTSHU, Hyderabad; UAS, Dharwad & Vijaypur; Dr. BSKVV,Dapoli; IGFRI, Jhansi; SKUAST-K, Kashmir; ZARS, Mandya; NIPGR, Delhi; ICAR RC for Eastern Region, Patna; IIFSR, Modipuram; ILS, Bhubaneswar; PJTSAU, Hyderabad; Birsa Agricultural University, Ranchi; IIPR, Kanpur
Frenchbean	65	UAS, Dharwad & Vijaypura
Rajmash	139	CSKHPKV, Kukumseri; RARS, Hittinahalli Farm, Vijayapur
Horsegram	102	CRIDA, Hyderabad
Lentil	170	SKUAST-K, Srinagar
Mothbean	70	ITM University, Gwalior; Punjab University, Chandigarh
Mungbean	534	Mali Agri Tech Private Limited, Nadia; KAU, Thrissur, Pattambi & Kayamkulam; PJTSAU, Hyderabad; Karunya Institute of Technology and Sciences, Coimbatore; Goldking Biogene Private Limited, Sabarkantha; Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata; SHUATS, Prayagraj; Malla Reddy University, Hyderabad; Dr. PDKV, Akola; University of Delhi, Greenvoice Foundation, Korba
Ricebean	6	Ishwar Pranidhan Foundation, Mumbai; Amity University, Noida
Pigeonpea	100	IGKVV, Raipur
Urd bean	489	ANGRAU, RARS, Tirupati; NIPGR, Delhi; SHUATS, Prayagraj; WASSAN, Hyderabad; UBKVV, Cooch Behar; IARI, New Delhi; PAJANCOA&RI, Karaikal; Greenvoice Foundation, Korba
Vigna marina	2	IIPR, Kanpur
Oilseeds (1432)		
Castor	33	IIOR, Hyderabad
Groundnut	50	Sri Manakula Vinayagar Engineering College, Madagadipet, Puducherry
Linseed	169	PAU, Ludhiana

Crop/Crop group	Number of samples	Indenter
Sesame	564	Goldking Biogene Private Limited, Sabarkantha; ANGRAU, Kadapa & Tirupati; KAU, Onnamkutti; PAJANCOA&RI, Karaikal; Banda University of Agriculture and Technology, Banda; VNMAU, Parbhani; Annamalai University, Annamalai
Mustard	337	Rasi Seeds Private Limited; Mali Agri Tech Pvt Ltd, Nadia; Malla Reddy University, Hyderabad; BHU, Varanasi; CCR(PG) College, Muzaffarnagar; Dr. PDKV, Nagpur; Geeta University, Panipat; GBPUAT, Pantnagar
Toria	50	GBPUAT, Pantnagar
Brassica juncea var. *rugosa*	50	IGFRI, Jhansi
Soybean	164	IARI, New Delhi & RRS, Dharwad
Sunflower	15	IIOR, Hyderabad
Vegetables (2996)		
Allium stracheyi	1	Hemvati Nandan Bahuguna Garhwal University, Srinagar (Garhwal)
Ash gourd	1	VNR Seeds Private Ltd, Hyderabad
Bitter gourd	127	SVBPUAT, Meerut; KAU, Thrissur & Kollam; UHS Bagalkot; SKUAST-K, Srinagar
Bottle gourd	3	KAU, Thrissur; Green Voice Foundation, Korba
Brinjal	643	JNKVV, Jabalpur; Dr YSPUHF, Solan; Scottish Church College, Kolkata; KAU, Thrissur; Mali Agri Tech Private Limited, Nadia; BAU, Sabour; Annamalai University, Annamalai TN; SVBPUAT, Meerut; LPU, Phagwara; Integral University, Lucknow; AAU, Jorhat; VIT, Vellore; SKLTSHU, Hyderabad; SKNAU, Jobner; Malla Reddy Univ., Hyderabad; Greenvoice Foundation, Korba; IIHR, Bangalore; NIBSM, Raipur
Broccoli	7	SKUAST- K, Srinagar
Cabbage	17	Dr. YSPUHF, Solan; Green Voice Foundation, Korba
Cauliflower	11	NIPGR, Delhi; IIVR, Varanasi
Chilli	255	SKLTSHU, Hyderabad; Mansoon Crop Science, Nashik; KAU, Thrissur; CSUAT, Kanpur; SHUATS, Prayagraj; SKUAST- J, Jammu, Annamalai University; Farming System Research Centre for Hill and Plateau Region, Ranchi; Khalsa College,Amritsar; IIPR, Kanpur; Green Voice Foundation, Korba
Cucumber	183	Malla Reddy University,Hyderabad; Vasantrao Naik Marathwada Krishi Vidyapeeth,Parbhani; UHS, Bagalkot; IARI, New Delhi; IIHR, Bangalore; Greenvoice Foundation, Korba
Cucumis spp.	23	KAU, Thrissur; IIHR, Bangalore
Dolichos bean	50	SKLTSHU, Hyderabad
Lablab bean	4	Green Voice Foundation, Korba
Jackbean	10	SKLTSHU, Hyderabad
Pea	884	Greenvoice Foundation,Korba; IIPR, Kanpur; Dr YSPUHF, Solan ; IGKVV, Raipur; IIHR, Bangalore; Abhilashi University,Mandi
Pumpkin	56	KAU, Thrissur; Dr. YSRHU, Venkataramannagudem, SVBPUAT, Meerut ; SKUAST-K, Srinagar
Radish	3	PAU, Bathinda; Green Voice Foundation, Korba
Ridge gourd	90	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani; Green Voice Foundation, Korba; IIHR, Bangalore

Crop/Crop group	Number of samples	Indenter
Okra	122	LPU, Phagwara; PJTSAU, Hyderabad; Goldking Biogene Private Limited, Sabarkantha; Greenvoice Foundation, Korba; NIBSM, Raipur
Snakegourd	28	UHS, Bagalkot; VNR Seeds, Hyderabad
Spongegourd	29	Green Voice Foundation, Korba; KAU, Thrissur
Tomato	404	SKLTSHU, Hyderabad; IIPR, Kanpur; Dr. YSPUHF, Solan; KAU, Thrissur; Jaitha College,Jalgaon; SVBPUAT, Meerut; LPU, Phagwara; UAS, Kalaburgi; Malla Reddy University, Hyderabad
Husk tomato	24	Gautam Budha University, Greater Noida
Watermelon	1	PAU, Bathinda
Winged bean	20	IARI, New Delhi
Fibres (734)		
Cotton	734	CICR, Nagpur; TNAU, Coimbatore
Potential crops (340)		
Amaranth	72	UAS, Dharwad; Dr YSRHU, Nuzvid; SKUAST(J), Jammu; UBKVV, Dinajpur
Buckwheat	86	University of Kashmir, Srinagar; Manav Rachna International Institute of Research and Studies, Faridabad; UBKVV, Dinajpur
Chenopodium	100	SKUAST- J, Jammu
Quinoa	82	IIT, Delhi; Agriculture University, Nagaur; RLKBCAU, Jhansi
Fruit crops (163)		
Banana	17	Chandigarh University, Mohali; NABI, Mohali; Gargi College, New Delhi
Cape gooseberry	24	PAU, Ludhiana
Grapes	29	IARI, New Delhi; NRC Grapes, Pune
Strawberry	8	GBPUAT, Pantnagar & Almora; Graphic Era Hill University, Bhimtal; SVBPUAT, Meerut
Papaya	25	SVBPUAT, Meerut
Pomegranate	60	NRC Pomegranate, Solapur
Medicinal and aromatic plants (181)		
Alpinia galanga	16	KAU, Thrissur
Bunium persicum	3	SHUATS, Prayagraj
Centella asiatica	8	DTU, Delhi
Dioscorea deltoidea	21	DTU, Delhi
Ocimum	88	CCSHAU, Hisar
Mucuna	16	CIMAP, Lucknow
Withania sominifera	20	KSNUAHS, Shivamogga
Swertia chirayta	3	VG Shivdare College of Arts, Commerce & Science, Solapur
Valeriana wallichii	6	VG Shivdare College of Arts, Commerce & Science, Solapur
Spices (50)		
Coriander	50	IISc, Bangalore
Sugar yielding (7)		
Beet root	7	SKUAST-K, Srinagar


Fig. 2.2. Participation in the 9th Session of Governing Body Meeting of ITPGRFA

Fig. 2.3. Exhibition displaying diversity in PGR during 9th GB of ITPGRFA

Fig.2. 4 Officials from Crop Trust and delegates of 9th GB of ITPGRFA during visit to NGB

- Dr Pratibha Brahmi and Dr Sunil Archak participated in the GB9 from India. Contributed to the resolution on Agenda 7 on "Celebrating the Guardians of Crop Diversity", as member of the Contact Group. Scientists Drs. Pragya, Sherry R. Jacob, Puran Chandra, Vartika Srivastava and Kuldeep Tripathi associated with Policy Project also participated in the event as internal observers. An exhibition was put up by ICAR-NBPGR exhibiting diversity in Plant Genetic Resources and also by Indian Society of Plant Genetic Resources (ISPGR) and Officials from Crop Trust and delegates of 9th GB of ITPGRFA during visit to NGB.
- India (Dr Sunil Archak) selected as Co-Chair of the Group of Enhancement of the Multilateral system (MLs) of the Treaty.
- Post meeting Report of the delegation was prepared and submitted to the National Focal Point and ICAR-DARE.

2.4.2 Data for UN Sustainable Development Goals submitted

SDG 2.5.1 data submitted to FAO and for Country Status on SDGs related to conservation of PGR. Status Data submitted to Ministry of Statistics and Programme Implementation (MoSPI) after participation in the preparatory meetings organised by MoSPI to discuss the reporting format shared by FAO.

2.4.3 Participation in Expert Committee Meetings of the National Biodiversity Authority (NBA)

Inputs provided to NBA in the 62nd, 63rd, 64th and 65th meeting of the Expert Committee on Access and Benefit Sharing (ABS) for recommendation on access and Patent applications related to Biological Resources considered by NBA.

2.4.4 Biodiversity Sectional Committee, SSD (TC 331 Biodiversity)

Inputs provided on ballots and being Member of Biodiversity Sectional Committee SSD 2.0, participated in first and second meeting held on March 2022 and July 2022 and participated in related training programmes.

2.4.5 Conference of Parties (CoP-15.2) of the Convention on Biological Diversity (CBD)

As Member of Working-Group to prepare India's position at the CoP-15.2 provided inputs for targets 13 and 19, pertaining to the Digital Sequence Information (DSI)

2.5 Policy Issues related to Biosecurity

2.5.1 Inputs provided to ICAR/ DARE/ MoA

- The Plant Quarantine (Regulation of Import into India) Order 2003 was further analyzed and sections where revision needed were identified.
- Quarantine requirements for the import of various crops under the India-Uzbekistan exchange project on twenty temperate fruit crops were conducted.
- Inputs provided during meeting of expert committee to review phasing out of Methyl Bromide as a quarantine treatment and recommended as follows:
  - It would not be possible to phase out Methy Bromide (MB) as a fumigant in one

Table 2.3: Pathway-based generic PRA for facilitating import of crops for the first time

S.No.	Crop species	Pathway	Country
1.	*Sinapis arvensis* subsp. *arvensis*	Seeds	USA
2.	Almond (*Prunus dulcis*)	Seed/ vegetative propagule	Spain
3.	Marula tree (*Sclerocarya birrea*)	Seed/ Vegetative propagule	Africa
4.	Shea butter tree (*Vitellaria paradoxa*)	Seed/Vegetative propagule	Africa
5.	Argan tree (*Argania spinosa*)	Seed/ Vegetative propagule	Africa
6.	False banana of Ethiopia (*Ensete ventricosum*)	Seed/ vegetative propagule	Africa
7.	Persimmon(*Diospyros texana*)	Seed	USA
8.	Spinach (*Spinacea oleracea)*	Seed	Switzerland
9.	Ryegrass (*Lolium perenne)*	Seed	Switzerland
10.	Papaya (*Vasconcellea quercifolia* and *V. stipulata*)	Seed	Hilo
11.	Cumin	Seed	Australia, Austria, Azerbaijan, Belgium, Bangladesh, Croatia, Germany, Greece, Israel, Iran, Moldova, Romania, Spain, Taiwan, Tajikistan,Turkey, UK and USA
12.	Guayule (*Parthenium argentatum)*	Seeds	USA
13.	Tepary bean (*Phaseolus acutifolius)*	Seeds	USA
14.	Tepary bean (*Phaseolus acutifolius)*	Seeds	Burkina Faso
15.	Jaboticaba (*Plinia cauliflora*)	Budwood	USA
16.	*Pigeon Pea (Cajanus cajan)*	Seed	Australia
17.	*Lotus japonicus*	Seeds	Japan
18.	*Momoradica balsmina*	Seeds	USA
19.	*Momordica rostrata*	Seeds	USA
20.	Wild rose (*Rosa* spp.)	Seeds	USA
21.	Lettuce (*Lactuca sativa*)	Seeds	Sweden
22.	*Sphenostylis stenocarpa*	Seed	Nigeria
23.	*Cajanus cajan*	Seed	Niger
24.	*Banana (Musa* spp.*)*	Tissue Culture Tubes/bottles	Tanzania
25.	*Tobacco (Nicotina tabacum)*	In vitro cell cultures	Japan
26. 27.	*Calea urticifolia* *Momordica foetida*	Seeds Seeds	Mexico Kenya
28.	*Zea mays*	Dried leaves	Philippines
29.	*Prunus dulcis*	Budwood/ cutting	USA
30.	*Echinochloa frumentacea* and spp.	Seed	Africa, Japan

go, rather it could be done only in a phased manner.

- Phosphine could be recommended as an alternative to MB, however, we would require more data for larger spaces and its efficacy against the insect eggs need to be confirmed. Also, there is a need for data on its efficacy when used in transit.
- During bilateral negotiations, when looking for treatment options, exporting country needs to develop phytosanitary treatment against exotic/ regulated pest present in their country.

- Participated in EXIM Committee meeting every month and provided expert comments from quarantine viewpoint to facilitate import of various planting materials for import received by DAC
- Undertook country specific, pathway-based generic PRA following crops facilitating import of these crops for the first time:
- Comments given on the risk involved in import of several agricultural commodities, certain insect cultures, pathogens and other biocontrol agents.

2.5.2 Inputs provided to MEA

- Inputs also provided on cooperation and assistance with particular focus on strengthening cooperation and assistance on Article X of BWC.
- Possibility of India making a contribution to the BWC Article X database on offers for assistance with other(s) of assistance. This could include opportunities for participation in training, seminars/ workshops, collaborative research, access to literature, etc.
- Updates on international cooperation and assistance activities especially on bio-safety and bio-security aspects being provided by India
- Inputs given on the latest pest incursions in the country as part of the Confidence building measures under BWC.

2.5.3 Inputs provided to MoEF&CC

Provided inputs on National Report on the implementation of the Cartagena Protocol on Biosafety presented in the Meeting of Parties of the CBD.

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

PGR/GEPU-BUR-DEL -01.00: 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 **(Vandana Tyagi)**

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 (**Vandana Tyagi,** Pratibha Brahmi, Puran Chandra, *S P Singh, 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. (**S K Yadav,** Pragya, *S P Singh, 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. (**Pragya,** S K Yadav, *SP Singh, Surender Singh, PC Binda*)

PGR/GEPUBUR-DEL -02.00: PGR management policy and back up research (Pratibha Brahmi)

PGR/GEPU- BUR-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. (**Pratibha Brahmi,** Dr Celia Chalam, Gurinder Jit Randhawa (till August 31, 2022), Veena Gupta, Kavita Gupta, Vandana Tyagi, Sunil Archak, Pragya, Puran Chandra, Kuldeep Tripathi and *Rajeev Gambhir*)

PGR/GEPU- BUR-DEL-02-02: Policy Issues Related to Biosecurity. (**Dr Celia Chalam,** Kavita Gupta, Pratibha Brahmi, Gurinder Jit Randhawa (till August 31, 2022), KS Hooda)

3 DIVISION OF PLANT QUARANTINE

सारांशः आयातित जननद्रव्य एक्सेशन (गैर–ट्रांसजेनिक) के कुल 1,33,170 नमूनों के साथ–साथ विभिन्न फसलों और उनकी वन्य प्रजातियों के अंतरराष्ट्रीय परीक्षण/नर्सरी को संगरोध मंजूरी के लिए संसाधित किया गया। इन नमूनों में ट्रू बीज, जड़ित पौधे, कटिंग, राइजोम, चूषक, बल्ब, नट और ऊतक संवर्धन पादप शामिल थे। पर्याक्रांत/संक्रमित नमूनों (2,939) में कीड़े (337), नेमाटोड्स (398), कवक (1,757), वायरस (420) और खरपतवार (27) जिसमें कई विदेशी नशीजीव शामिल थे। 2,939 पर्याक्रांत /संक्रमित/दूषित नमूनों में से, 2671 को भौतिक–रासायनिक तरीकों जैसे धूमन, एक्स–रे रेडियोग्राफी, कीटनाशक उपचार, मैकेनिकल क्लीनिंग और ग्रोइंग–ऑन टेस्ट के माध्यम से बचाया गया था, जबकि 268 संक्रमित नमूनों को बचाया नहीं जा सका, इसलिए अस्वीकार कर दिया गया। इन अस्वीकृत नमूनों में पेरोनोस्पोरा मंशुरिका के कारण संयुक्त राज्य अमेरिका से सोयाबीन के आठ नमूने और बांग्लादेश, मोजांबिक, वियतनाम, फिलीपींस और संयुक्त राज्य अमेरिका से तिलेतिया बार्कलय के कारण चावल के 260 नमूने शामिल थे। विभिन्न देशों/स्रोतों से आयातित विभिन्न फली फसलों के विदेशी जननद्रव्य के कुल 1232 नमूने पोस्ट–एंट्री क्वारंटाइन (पीईक्यू) ग्रीनहाउस में उगाए गए थे और वायरस से मुक्त पौधों की फसल को मांगकर्ताओं को जारी किया गया था। 2022 के दौरान इंडेंटर के स्थलों पर आयातित खेपों के लिए पादप संगरोध वैज्ञानिकों द्वारा कुल 45 पोस्ट–एंट्री संगरोध निरीक्षण किए गए थे। विभिन्न फसलों के कुल 1855 नमूनों को निर्यात के लिए संसाधित किया गया, जिनमें से 18 संक्रमित नमूनों को बचाया गया और 6 फाइटोसैनिटरी प्रमाण पत्र जारी किए गए। जापान से 10 आयातित ट्रांसजेनिक नमूनों (एराबिडोप्सिस थैलियाना –3, और यूएसए से मेडिकागो ट्रंकाटुला –7, का संगरोध प्रसंस्करण किया गया। मेडिकागो ट्रंकाटुला के दो नमूने बोट्रियोडिप्लोडिया थियोब्रोमा और क्लेडोस्पोरियम एसपी से संक्रमित पाए गए। संक्रमित बीजों की बिक्री की गई, टर्मिनेटर जीन की अनुपस्थिति सुनिश्चित की गईय रिलीज से पहले सभी नमूनों को बचाया गया और पीईक्यू निरीक्षण किया गया। बीज स्वास्थ्य परीक्षण के तहत, राष्ट्रीय जीन बैंक में कीट मुक्त संरक्षण से पहले बीज स्वास्थ्य परीक्षण (एसएचटी) के लिए जननद्रव्य संरक्षण प्रभाग के माध्यम से स्वदेशी रूप से एकत्र या वृद्धि की गई कुल 6577 बीज सामग्री प्राप्त की गई। एसएचटी के परिणामस्वरूप, कुल 1181 नमूने संक्रमित/पर्याक्रांत/कवक (151), नाशीजीव कीट (776), नेमाटोड (194), खरपतवार (52) और वायरल रोग (08) से दूषित पाए गए। इसके अलावा, 190 क्रायो नमूनों को संसाधित किया गया था, जिनमें से दो कवक रोगजनकों से संक्रमित थे, दो नाशीजीव से संक्रमित थे और सभी को सेल्वाज कर दिया गया था।

Summary: : A total of 1,33,170 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 (2,939) comprised-insects (337), nematodes (398), fungi (1,757), viruses (420) and weeds (27) including several exotic pests. Of the 2,939 infested/ infected/ contaminated samples, 2,671 were salvaged through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test while 268 infected samples could not be salvaged, hence rejected. These rejected samples included eight samples of soyabean from USA due to *Peronospora manshurica* and 260 samples of rice due to *Tilletia barclayana* from Bangladesh, Mozambique, Vietnam, Philippines and USA. A total of 1,232 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 45 post-entry quarantine inspections were carried out by Plant Quarantine Scientists for imported consignments at indentor's sites during 2022. A total of 1,855 samples of various crops were processed for export of which 18 infested samples were salvaged and 6 Phytosanitary Certificates were issued. Quarantine processing of 10 imported transgenic samples (*Arabidopsis thaliana* -3, from Japan and *Medicago truncatula* -7, from USA) was undertaken. Two samples of *Medicago truncatula* were found infected with *Botryodiplodia theobromae* and *Cladosporium* sp. Infected seeds were salvaged, absence of terminator gene was ensured; all samples were salvaged prior to release and PEQ inspection undertaken. Under seed health testing, a total of 6,577 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, total 1,181 samples were found infected/ infested/ contaminated with fungi (151), insect pests (776), nematodes (194), weeds (52) and viral diseases (08). In addition, 190 cryo samples were processed of which two were infected with fungal pathogens, two infested with insects and all were salvaged.

3.1 Import Quarantine

3.1.1 Quarantine examination

A total of 1,33,170 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, 7,325 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids. Of these, 337 samples were found infested with insects/ mites, including 168 with hidden infestation; 398 samples infected with nematodes, 1,757 infected with fungi, 420 with viruses and 27 with weeds (Fig. 3.1). The photographs of some of the quarantine weeds are given in Fig 3.2.

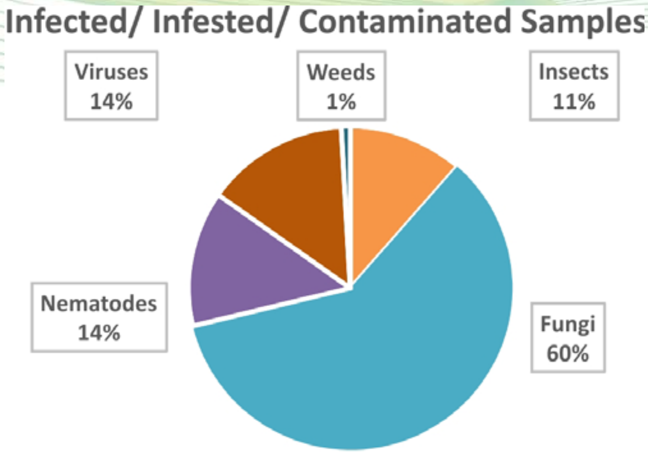


Fig. 3.1. Infected/ infested/ contaminated samples detected through quarantine examination

Bromus secalinus *Polygonum lapathifolium* *Echinochloa crus-pavonis* *Phalaris paradoxa* *Polygonum cuspidatum*

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

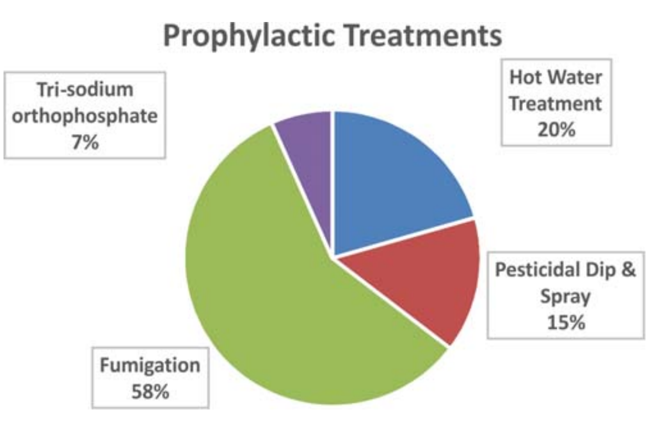


Fig. 3.3. Prophylactic treatments of introduced germplasm samples

3.1.2 Salvaging of infested/ infected/ contaminated germplasm

Of the total 2,939 infested/ infected/ contaminated samples, 2,671 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 337 insect infested samples, all were salvaged by X-ray radiography (168), fumigation (16) using aluminium phosphide (Phosphine @ 2 g per cubic metre for 72 hrs)/ EDCT @ 320 mg/litre for 48 hrs and mechanical cleaning (186). Of these, 1,489 infected samples were salvaged by various disinfection techniques/ treatments such as fungicidal seed treatment and ethyl alcohol wash and remaining 268 infected samples were rejected. In addition, due to mechanical damage, 20 samples of safflower from USA and one *in vitro* culture of potato was also rejected. The rice samples infected with nematode (341) were salvaged by hot water treatment. Apple cuttings infected with nematode (57) were salvaged by 0.25 per cent formalin root dip treatment. A total of 27 samples contaminated with weed seeds were salvaged by mechanical cleaning.

3.1.3 Prophylactic treatments

A total 9,507 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 2,437 vegetative propagules were given pesticidal dip/spray treatment against insect-pests. A total of 3,382 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 (867) and tomato (234) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate.

3.1.4 Growing out test for detection of viruses

A total of 1,232 accessions of exotic germplasm comprising *Glycine max* (934), *Vigna unguiculata* (12), *Pisum* sp. (61) and *Vicia faba* (225) were grown in PEQ greenhouses. 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 immunosorbent assay (ELISA), electron microscopy and Reverse-transcription-PCR. The interceptions are presented in Table 3.1.

3.1.5 PEQ Inspection at Indenter's site

A total of 45 post-entry quarantine inspections of various crops consisting of 85,107 samples of almond (61), apple (490), apricot (111), barley (2120), ber (20), bitter gourd (383), camelina (2), capsella (3), cauliflower (3), Chinese abelia (60), chickpea (5), corylus (46) cotton (73), tepari bean (11), cucumber (6), cydonia (80), English walnut (95), gladiolus (9), golden currant (43), soybean (350), lentil (210), linseed (123), maize (12,152), okra (1,056), peach (20), pear (9), pepper (95), plum (100), pumpkin (146), rice (470), Sweet cherry (52), tomato (119), water melon (56) and wheat (66,591) imported from various countries were carried out at various indenters' sites during this period (Table 3.2). As a result of inspections, suspected samples were uprooted and properly destructed in the field.

During PEQ inspection of M/s Syngenta India Ltd, Hyderabad on Dec 5th, 2022, a total of 38 accessions of maize imported under Import Permit No. 66/2022 & IQ No. 130/2022 from Thailand were observed suspected to be infected with Stewart wilt (21 acc.), viruses (10 acc.), Maydis blight -Race T (four acc.) and Brown sheath rot (thee acc.). Of these, 18 entries were completely uprooted and incinerated as they were suspected to be infected with Stewart wilt (eight acc. *viz*., EC1128163, EC1128720, EC1128967, EC1129036, EC1129077, EC1129153, EC1129310 and EC1129368), Maydis blight - Race T (three acc. viz., EC1128562, EC1127077 and EC1127012) and viruses (seven acc. *viz*., EC1127355, EC1127357, EC1127858, EC1128914, EC1128921, EC1128905 and EC1129272). In addition, three plants each of entry nos., EC1129249, EC1128675 and EC1129366 due to suspected viruses and acc. nos. EC1127822, EC1127 and EC1127564 due to Brown sheath rot; one plant each of entry nos. EC1127758, EC1128153, EC1128182,

Table 3.1: Pests intercepted in the exotic germplasm during 2022

Pests	Host	Source/ Country
Insect pest		
**Bruchus dentipus*	*Vicia faba*	Lebanon
Callosobruchus maculatus	*Vigna subterranea*	Nigeria
**Callosobruchus rhodesianus*	*V. unguiculata*	Nigeria
**Callosobruchus subinnotatus*	*V. subterranea*	Nigeria
Immature form of bruchid	*Lens culinaris*	Lebanon
Rhizopertha dominica	*Oryza sativa*	Bangladesh, Mozambique, Philippines
Sitotroga cerealella	*O. sativa*	Bangladesh, Brazil, Mozambique, Philippines, USA
Sitophilus oryzae	*O. sativa*	Bangladesh, Brazil, Philippines
Sitophilus zeamais	*Zea mays*	Guatemala, Thailand
Stegobium paniceum	*O. sativa*	Philippines
Tribolium castaneum	*O. sativa*	Bangladesh
Alternaria sp.	*Abelmoschus* sp.	Thailand
Bipolaris oryzae	*O. sativa*	Brazil
Bipolaris rostrata	*Solanum melongena*	Taiwan
Bipolaris sorokiniana	*O. sativa*	Brazil
	Hordeum vulgare	USA
Botryodiplodia theobromae	*Momordica charantia*	Thailand
Cephalosporium	*Abelmoschus esculentus*	Thailand
Cercospora kikuchii	*Glycine max*	USA
Colletotrichum capsici	*Sphenostylis stenocarpa*	Nigeria
Fusarium oxysporum	*Abelmoschus* sp.	Taiwan, Thailand
	Capsicum annuum	Taiwan
	Citrullus lanatus	Italy
	G. max	USA
	Solanum lycopersicum	Taiwan, Thailand
Fusarium semitectum	*Solanum tuberosum*	The Netherlands
Fusarium solani	*Abelmoschus* sp.	Thailand
	S. lycopersicum	Taiwan, USA
Fusarium verticillioides	*Abelmoschus* spp.	Taiwan, USA
	Capsicum sp.	Taiwan
	Cucumis sativus	Taiwan
	O. sativa	Philippines
	S. lycopersicum	Taiwan
	Triticum aestivum	Australia, USA
	Z. mays	Guatemala, Mexico, Thailand, USA
Macrophomina phaseoli	*Phaseolus acutifolius*	Burkina Faso
Myrothecium verrucaria	*Momordica charantia*	Thailand
Peronospora manshurica	*G. max*	USA
Phoma exigua	*Cucurbita moschata*	Thailand
	M. charantia	Thailand
Puccinia helianthi	*Carthamus* sp.	USA
Pyricularia oryzae	*O. sativa*	Brazil
Rhizoctonia solani	*Z. mays*	USA
Tilletia barclayana	*O. sativa*	Bangladesh, Mozambigue, USA, Vietnam
Ustilaginoidea virens	*O. sativa*	Bangladesh, Philippines

Pests	Host	Source/ Country
Viruses		
*#cherry leaf roll virus	*G. max*	USA
cowpea aphid-borne mosaic virus	*G. max*[c&]	USA
*cowpea mottle virus	*G. max*	USA
	V. unguiculata	Nigeria
cowpea mild mottle virus	*G. max*	USA
	V. unguiculata	Nigeria
*#cucumber leaf spot virus	*Momordica charantia*	Thailand
	Cucumis sativus	USA
#grapevine fan leaf virus	*G. max*[c&]	USA
*#Pepper mild mottle virus	*S. lycopersicum*	Taiwan, thailand
#pepper mottle virus	*Capsicum annuum*	Taiwan, Thailand
	S. lycopersicum	Taiwan
soybean mosaic virus	*G. max*	USA
#squash mosaic virus	*C. moschata*	Thailand
#tobacco mosaic virus	*C. annuum*	Taiwan, Thailand
	S. lycopersicum	Taiwan, Thailand
#tobacco ringspot virus	*C. annuum*	Taiwan
	G. max	USA
	S. lycopersicum	Taiwan, Thailand
#tomato mosaic virus	*C. annuum*	Taiwan, Thailand
	S. lycopersicum	Taiwan, Thaialnd
*#tomato ringspot virus	*G. max*	USA
#Watermelon mosaic virus-2	*M. charantia*	Thailand
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Bangladesh, Brazil, Colombia, Malaysia, Mozambique, Philippines, USA, Vietnam
Pratylenchus penetrans	*Malus domestica*	Belgium, USA
Meloidogyne incognita	*M. domestica*	Netherlands, USA
Paratylenchus sp.	*M. domestica*	Netherlands
Aphelenchus avenae	*M. domestica*	Belgium, Netherlands
Weeds		
**Bromus diandrus*	*H. vulgare*	USA
[9]*Bromus secalinus*		
Centaurea melitensis	*H. vulgare*	Morocco
Convolvulus arvensis	*T. aestivum*	Turkey
Convolvulus erubescens	*T. aestivum*	Lebanon, Mexico, Turkey
Echinochloa colona	*O. sativa*	Bangaladesh
Echinochloa crus-galli	*O. sativa*	Bangaladesh, Philippines and USA
#*Echinochloa crus-pavonis*	*O. sativa*	USA
Phalaris minor	*T. aestivum*	Mexico
**Phalaris paradoxa*		
Polygonum aviculare		
#*Polygonum cuspidatum*	*H. vulgare*	Morocco
#[9]*Polygonum lapathifolium*	*T. aestivum*	Lebanon
	H. vulgare	Morocco
Rumex crispus	*T. aestivum*	Mexico
Vicia villosa	*O. sativa*	USA

#Pest regulated under PQ Order, 2003; * Pest not yet reported from India
[c&]Virus present in India but not recorded on the host on which intercepted

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

IQ No.	IP No.	Country	Crop	Sample	Indentor	Date	Scientist
353/2021	156/2021	USA	*Citrullus* sp.	20	Noble Seeds, Sonepat	Jan 12 2022	VC Chalam, Z Khan, J Akhtar, P Kumar, DS Meena
355/2021	250/2021	Thailand	*M. Charantia*	126			
356/2021	156/2021	USA	*Cucurbita moschata*	70			
40/2021	425/2020	Canada	*Linum usitatissimum*	123	ICAR-NBPGR New Delhi	Jan 21 2022	VC Chalam, K Gupta, Z Khan, J Akhtar
304/2021	310/2021	Thailand	*Z. mays*	174	Bayer Crop Science, Bengaluru	Feb 1 2022	VC Chalam, J Akhtar, BH Gawade, AK Maurya
336/2021	340/2021	Mexico	*T. aestivum*	1319	Krishidhan Seeds Pvt Ltd, Jalna	Feb 02 2022	Z Khan, BR Meena
345/2021	391/2021	Mexico	*T. aestivum*	2921	Mahyco Pvt Ltd, Jalna	Feb 02 2022	Z Khan, BR Meena
399/2021	392/2021	Mexico	*T. aestivum*	316			
397/2021	358/2021	Australia	*Camelina sativa*	02	ICAR-NBPGR, New Delhi	Feb 17 2022	MC Singh, J Akhtar, Sadhana
398/2021	359/2021	Australia	*Capsella* sp.	03			
353/2021	156/2021	USA	*C. lanatus*	20	Noble Seeds Pvt Ltd, Bengaluru	Feb 24 2022	VC Chalam, J Akhtar
355/2021	250/2021	Thailand	*M. charantia*	126			
356/2021	251/2021	Thailand	*C. moschata*	70			
421/2021	411/2021	Taiwan	*S. lycopersicum*	12	Nuziveedu Seeds Ltd, Bengaluru	Feb 24 2022	VC Chalam, J Akhtar
422/2021	412/2021	Taiwan	*C. sativus*	06			
423/2021	413/2021	Taiwan	*C. moschata*	06			
342/2021	380/2021	Mexico	*T. aestivum*	540	Ajeet Seeds Pvt Ltd, Aurangabad	Feb 24 2022	Z Khan, BR Meena
387/2021	459/2021	Taiwan	*S. lycopersicum*	05	Nunhems India Pvt Ltd, Bengaluru	Feb 24 2022	VC Chalam, J Akhtar
118/2019	055/2019	Taiwan	*S. lycopersicum*	03			
130/2021	061/2021	Taiwan	*S. lycopersicum*	05			
388/2021	460/2021	Taiwan	*C. annuum*	12			
89/2021	66/2021	Gautemala	*C. annuum*	12	Bayer Crop Science, Bengaluru	Feb 25 2022	VC Chalam, J Akhtar
128/2021	65/2021	USA	*S. lycopersicum*	84			
141/2021	64/2021	USA	*C. annuum*	4			
173/2021	611/2020	Nether-lands	*B. oleracea*	3			

IQ No.	IP No.	Country	Crop	Sample	Indentor	Date	Scientist
251/2021	260/2021	Thailand	*M. charantia*	54			
263/2021	242/2021	USA	*C. annuum*	3			
330/2021	376/2021	USA	*A. esculentus*	6			
341/2021	375/2021	Mexico	*T. aestivum*	2176	Eagle Seeds Ltd, Indore	Mar 2 2022	J Akhtar, N Kumar
363/2021	443/2021	Lebanon	*L. culinaris*	210	ICARDA, Amlaha	Mar 3 2022	J Akhtar, N Kumar
384/2021	415/2021	Turkey	*H. vulgare*	2120			
351/2021	409/2021	Mexico	*T. aestivum*	2256	Suraj Crop Sci Ltd, Gandhinagar	Mar 5 2022	BR Meena, P Kumari
350/2021	406/2021	Mexico	*T. aestivum*	1676	Ankur Seeds Pvt Ltd, Nagpur	Mar 8 2022	P Kumar, P Kumari
401/2021	458/2021	Mexico	*T. aestivum*	296			
400/2021	444/2021	Mexico	*T. aestivum*	2205	Nirmal Seed Pvt Ltd., Jalna	Mar 10 2022	J Akhtar, P Kumar
344/2021	390/2021	Mexico	*T. aestivum*	12619	BISA, Ludhiana	Mar 10 2022	Z Khan, P Kumari, N Yadav
406/2021	512/2021	Mexico	*T. aestivum*	592			
348/2021	401/2021	Mexico	*T. aestivum*	442	Aastha Biocare Pvt Ltd, Jalna	Mar 11 2022	J Akhtar, P Kumar
419/2021	426/2021	Mexico	*T. aestivum*	1240	ICAR-IARI New Delhi	Mar 11 2022	VC Chalam, BH Gawade
337/2021	343/2021	Mexico	*T. aestivum*	1761	Bioseed India Pvt Ltd, Ludhiana	Mar 11 2022	Z Khan, P Kumari, N Yadav
349/2021	404/2021	Mexico	*T. aestivum*	2785	Kaveri Seeds Company Ltd, Agra	Mar 19 2022	MC Singh, BH Gawade
335/2021	314/2021	Mexico	*T. aestivum*	21666	ICAR-IIWBR, Karnal	Mar 22 2022	Z Khan, P Kumar, N Yadav
343/2021	389/2021	Mexico	*T. aestivum*	176			
361/2021	421/2021	Turkey	*T. aestivum*	334			
403/2021	463/2021	Mexico	*T. aestivum*	4144			
483/2021	502/2021	Australia	*T. aestivum*	1001			
347/2021	397/2021	Mexico	*T. aestivum*	1096	ICAR-CSS Institute, Karnal	Mar 22 2022	Z Khan, P Kumar, N Yadav
339/2021	354/2021	Mexico	*T. aestivum*	2550	Nuziveedu Seeds Ltd, Karnal	Mar 23 2022	Z Khan, N Yadav
340/2021	368/2021	Mexico	*T. aestivum*	2480	Rasi Seeds Pvt Ltd, New Delhi	Mar 10 2022	K Gupta, BH Gawade
104/2021	58/2022	Australia	*Cicer* sp.	05	ICAR-NBPGR, New Delhi	Apr 6 2022	J Akhtar, BH Gawade

IQ No.	IP No.	Country	Crop	Sample	Indentor	Date	Scientist
09/2022	308/2021	Belgium	*Malus domestica*	100	Mahyco Pvt Ltd. Jalna	Apr 6 2022	Z Khan, P Kumari
10/2022	585/2021	Belgium	*M. domestica*	25			
11/2022	586/2021	Belgium	*M. domestica*	25			
45/2022	587/2021	USA	*M. domestica*	32			
50/2022	562/2021	USA	*S. lycopersicum*	2			
439/2021	355/2021	Chile	*Z. mays*	692	Syngenta India Ltd, Hyderabad	Apr 12 2022	Z Khan, P Kumari
23/2022	546/2021	Thailand	*Z. mays*	4			
438/2021	547/2021	South Africa	*Gladiolus* sp.	09	ICAR-IARI, New Delhi	Jun 28 2022	MC Singh, Z Khan, BR Meena
14/2022	577/2021	Mexico	*Zea mays*	4	Bayer Crop Science, Bengaluru	Jul 5 2022	J Akhtar, P Kumar
15/2022	583/2021	Mexico	*Z. mays*	2480			
16/2022	572/2021	Thailand	*Abelmoschus* sp.	95	Noble Seeds Pvt Ltd, Bengaluru	Aug 23 2022	VC Chalam, Z Khan, K Gupta
375/2021	306/2021	Thailand	*Momordica charantia*	65	Bayer Crop Science, Bengaluru	Aug 24 2022	VC Chalam, K Gupta
434/2021	498/2021	USA	*Capsicum* sp,	13			
488/2021	506/2021	USA	*S. lycopersicum*	3			
436/2021	510/2021	Taiwan	*S. lycopersicum*	5			
437/2021	511/2021	Taiwan	*Capsicum* sp,	12			
485/2021	523/2021	Thailand	*Capsicum* sp,	5			
464/2021	524/2021	Korea	*Capsicum* sp,	13			
486/2021	525/2021	Thailand	*Capsicum* sp,	14			
51/2022	048/2022	Italy	*Citrullus lanatus*	16			
65/2022	071/2022	Italy	*Capsicum* sp,	7			
25/2022	331/2021	USA	*A. esculentus*	391			
75/2022	049/2022	Taiwan	*Abelmoschus* sp.	459			
81/2022	552/2021	USA	*Vigna* sp.	11	ICAR-NBPGR Issapur	Aug 22 2022	BR Meena, P Kumari
79/2022	560/2021	USA	*Zea* sp.	257	Syngenta India Ltd, Pune	Aug 30 2022	J Akhtar, P Kumar
355/2021	439/2021	Chile	*Zea mays*	5908	Syngenta India Ltd, Hyderabad	Sep 2 2022	MC Singh, J Akhtar
451/2021	319/2021	USA	*Glycine max*	200	ICAR-NBPGR RS, Hyderabad	Sep 3 2022	MC Singh, J Akhtar
133/2021	107/2021	France	*Pyrus communis*	9	FIAT, Srinagar	Sep 8 2022	VC Chalam, J Akhtar
49/2022	521/2021	Mexico	*Zea mays*	191	Alp Giri Seed Ltd, Gandhi nagar	Sep 8 2022	Z Khan, P Kumari

IQ No.	IP No.	Country	Crop	Sample	Indentor	Date	Scientist
41/2022	67/2022	Uzbekistan	*Corylus avellana*	46	ICAR-CITH, Srinagar	Sep 9 2022	VC Chalam, J Akhtar
41/2022	67/2022	Uzbekistan	*Juglans regia*	95			
41/2022	67/2022	Uzbekistan	*Prunus amygdalus*	61			
42/2022	68/2022	Uzbekistan	*Prunus armenica*	111			
42/2022	68/2022	Uzbekistan	*Prunus avium*	52			
42/2022	68/2022	Uzbekistan	*Prunus persica*	20			
42/2022	68/2022	Uzbekistan	*Ziziphus jujube*	20			
43/2022	69/2022	Uzbekistan	*Cydonia oblonga*	80			
43/2022	69/2022	Uzbekistan	*Malus domestica*	308			
43/2022	69/2022	Uzbekistan	*Prunus divaricana*	60			
43/2022	69/2022	Uzbekistan	*Prunus domestica*	100			
43/2022	69/2022	Uzbekistan	*Ribes aureum*	43			
451/2021	319/2021	USA	*Glycine max*	150	ICAR-NBPGR RS, Bhowali	Sep 24 2022	J Akhtar, P Kumari
82/2022	402/2021	USA	*Gossypium* sp.	73	Ankur Seeds Pvt Ltd, Nagpur	Oct 3 2022	BR Meena, AK Maurya
08/2022	286/2021	Nether-lands	*Oryza sativa*	8	Savannah Seeds Pvt Ltd., Sonipat	Oct 10 2022	Z Khan, J Akhtar, BR Meena
54/2022	429/2021	Philippines	*Oryza sativa*	24			
46/2022	129/2021	Philippines	*Oryza sativa*	16			
120/2022	098/2022	Philippines	*Oryza sativa*	359			
130/2022	66/2022	Thailand	*Z. mays*	2500	Syngenta India Ltd, Hyderabad	Dec 5 2022	Kavita Gupta, J Akhtar
142/2022	108/2022	Thailand		3			
23/2022	546/2021	Thailand		4			
146/2022	151/2022	Mexico		2			
131/2022	088/2022	Thailand	*Z. mays*	13	Bayer Crop Science, Bengaluru	Dec 21 2022	J Akhtar, BH Gawade
177/2022	197/2022	Thailand		25			
205/2022	249/2022	Mexico		69			
101/2022	82/2022	Thailand	*M. charantia*	12	Noble Seeds Pvt Ltd, Bengaluru	Dec 21 2022	J Akhtar, BH Gawade

EC1128188, EC1128236, EC1128242, EC1128636, EC1128660, EC1128965, EC1129016, EC1129046, EC1129152 and EC1129350 and entry no. EC1128173 suspected to be infected with Stewart wilt and Maydis blight -Race T, respectively, were also uprooted and incinerated. In another PEQ inspection of M/s Syngenta India Ltd, Hyderabad undertaken on Sep 2nd, 2022, out of 6,952 accessions of maize imported under Import Permit No. 355/2021 & IQ No. 439/2021 from Chile, five accessions viz., EC1113861, EC1114042, EC1114667, EC1116430 and EC1116484) observed suspected to be infected with Stewart wilt were uprooted and incinerated.

3.2 Export Quarantine

A total 1,855 samples of crops comprising *Oryza sativa* and *Triticum aestivum* were exported to Bangladesh, Mexico, Netherlands, Poland, Philippines and Uzbekistan. Eighteen samples of *T. aestivum* 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 676 samples. Twenty five samples of them found infected with pathogens like *Tilletia barclayana* in 22 samples and *Fusarium verticillioides* in one sample of rice and were salvaged. Eight samples of wheat was found contaminated with *Phalaris minor* and 04 samples of rice were found contaminated with *Echinochloa crus-galli* (Table 3.3), and all samples were salvaged by mechanical cleaning. A total of six phytosanitary certificates were issued.

3.3 Seed health testing for pest free conservation of indigenously collected planting material

A total 6,577 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. A total of 776 samples infested by various insect-pests. As a result of SHT, 1,173 samples were found infected with different fungal pathogens (151), insects (776), nematodes (194), viral diseases (8) and weed seeds (52)

Visual/ stereoscopic examination resulted in detection of fungal (82) and viral (08) pathogens in germplasm samples which included purple stain (*Cercospora kikuchii*) in 10 soybean samples; 20 sunflower samples infested with rust (*Puccinia helianthi*); 29 samples of rice infected with *T. barclayana* and 14 samples with false smut (*Ustilagenoidea virens*); five samples of wheat infected with *T. indica* and two samples of wheat infected with *T. caries;* two sample of *Elymus* spp. infected with *Claviceps purpurea*.

Blotter test revealed detection and identification of many seed-borne fungi/ bacteria in 69 accessions of various crop germplasm. The important fungi detected include *Bipolaris oryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsici*, *Fusarium oxysporum*, *Microdochium oryzae, Rhizoctonia solani* etc. and the details of pathogens detected are given in Table 3.4. A total of 41 samples rejected including *Triticum aestivum* infected with *Tilletia carries* from Uttrakhand (2); *T. indica* from Haryana (5); *Oryza sativa* infected with *T. barclayana* from Andhra Pradesh (2), Arunachal Pradesh (9), Delhi (14), Odisha (2), Maharashtra (1) and West Bengal (1) and *Elymus* spp. infected with *Claviceps purpurea* from Jammu & Kashmir (2); *Glycine max* (1), due to heavily contaminated with fungal saprophytes were rejected as they could not be salvaged. Additionally, two chemically treated samples were also rejected.

Table 3.3: Detection of pests in germplasm samples for export during 2022

Pest Detected	Crop	Source	Export to
Insect			
Rhizopertha dominica	*T. aestivum*	ICAR-IIWBR, Karnal	Bangladesh, Mexico
Weeds			
Echinochloa crus-galli	*O. sativa*	Bayer Crop Science Ltd., New Delhi	Philippines
Phalaris minor	*T. aestivum*	ICAR- IIWBR, Karnal	Bangladesh
	T. aestivum	ICAR- IIWBR, Karnal	Mexico

A total of 52 samples accessions of indigenously collected seed material and multiplied material at various centers were found contaminated with 22 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

Pests	Host	Source/ Collection site
Insect Pests		
Aubeus himalayanus	*Cordia myxa*	Gujarat & Madhya Pradesh
Acanthoscelides obtectus	*Phaseolus vulgaris*	Himachal Pradesh, Jammu & Kashmir
Bruchus pisorum	*Pisum sativum*	Uttar Pradesh, Jharkhand
Bruchus lentis	*Lathyrus sativus*	Kerala
	Lens culinaris	Maharashtra, Punjab
Callosobruchus spp	*Luffa aegyptiaca*	Maharashtra
	Vigna radiata	Jammu & Kashmir
Callosobruchus Cajanus	*Cajanus cajan*	Jharkhand, New Delhi, Maharashtra
	Macrotyloma uniflorum	New Delhi
Callosobruchus. analis	*Vigna mungo*	Maharashtra, Tamil Nadu
	Sesbania, Lens culinaris, Lathyrus sativus, Vigna radiata	New Delhi
Callosobruchus chinensis	*Cicer arietinum*	Uttar Pradesh, New Delhi, Maharashtra
	Cajanus cajan	Meghalaya, Maharashtra
	Vigna radiata	Odisha, Andhra Pradesh, New Delhi
	Vigna aconitifolia, Vigna mungo, Vigna radiata	Maharashtra
	Macrotyloma uniflorum	Uttarakhand
	Glycine max	New Delhi
	Vigna unguiculata	Himachal Pradesh
	Vigna mungo	Jharkhand
Callosobruchus maculatus	*Vigna unguiculata ssp. sesquipedalis*	Gujarat
	Vigna radiata, Vigna mungo, Vigna unguiculata	New Delhi
	Macrotyloma uniflorum	Himachal Pradesh, Jharkhand
	Lathyrus sativus	Kerala
	Pisum sativum	Maharashtra
	Vigna radiata, Vigna mungo	Jharkhand
Callosobruchus phaseoli	*Vigna umbellata*	Meghalaya
Callosobruchus theobromae	*Vigna mungo*	Andhra Pradesh
Conicobruchus albopubens	*Cyamopsis tetragonoloba*	Rajasthan
Dead adult bruchid	*Abelmoschus esculentus*	Maharashtra
Egglings & immature form of bruchid	*Lablab purpureus*	Maharashtra

Pests	Host	Source/ Collection site
	Vigna radiata	Maharashtra, Andhra Pradesh
	Macrotyloma uniflorum	Jharkhand
	Cajanus cajan	New Delhi
Heavily infested with Eggs	*Vigna radiata, Vigna mungo*	Telangana
Immature form of bruchid	*Phaseolus vulgaris*	Himachal Pradesh
	Lens Culinaris	Uttar Pradesh, Uttarakhand, Madhya Pradesh, New Delhi, Himachal Pradesh
	Cajanus cajan	Maharashtra, New Delhi, Odisha
	Vigna mungo, Macrotyloma uniflorum	Odisha
	Vigna mungo	Madhya Pradesh
	Vigna unguiculata	Mizoram, Maharashtra, Jammu & Kashmir
	Pisum sativum	Kerala, Uttar Pradesh, Uttarakhand
	Tamarindus indica	Kerala
	Vigna radiata	Karnataka, New Delhi
	Cicer arietinum	New Delhi
	Vigna vexillata	Uttar Pradesh
Lasioderma sericorne	*Bunium persicum*	Jammu & Kashmir
	Ricinus communis	Rajasthan
Rhizopertha dominica	*Oryza Sativa*	New Delhi, Gujarat, Arunachal Pradesh, Telangana, Andhra Pradesh, Bihar, Meghalaya, Punjab, Tamil Nadu, Kerala
	Triticum aestivum	Chhattisgarh
	Daucus carota	Himachal Pradesh
Sitotroga cerealella	*Oryza Sativa*	New Delhi, Gujarat, Jammu & Kashmir, Arunachal Pradesh, Assam, Punjab, Bihar, Andhra Pradesh, Telangana, Manipur, Meghalaya, Madhya Pradesh, Kerala, Nagaland, Jharkhand, West Bengal
	Zea mays	Madhya Pradesh, New Delhi
Sitophilus oryzae	*Oryza Sativa*	Arunachal Pradesh, Assam, Manipur, Meghalaya, New Delhi, Nagaland
	Pennisetum glaucum, Sorghum bicolor	Telangana
	Sorghum bicolor	Maharashtra
	Triticum aestivum	New Delhi, Maharashtra
Sitophilus zeamais	*Zea mays*	Chhattisgarh, Madhya Pradesh, New Delhi, Jharkhand
Spermophagus albofasciatus	*Abelmoschus esculentus*	New Delhi
	Abelmoschus tetraphyllus	Kerala
Tribolium castaneum	*Gossypium*	Tamil Nadu
	Oryza Sativa	New Delhi, Assam, Andhra Pradesh, Meghalaya
	Triticum aestivum	Uttarakhand
	Zea mays	Chhattisgarh, Maharashtra
	Sorghum bicolour, Glycine max	Maharashtra

Pests	Host	Source/ Collection site
Pathogens		
Bipolaris cynodontis	*Vigna mungo*	Uttar Pradesh
B. oryzae	*Oryza sativa*	Meghalaya, Telangana
B. sorokiniana	*Triticum aestivum*	Tamil Nadu
	Capsicum annuum	Karnataka
B. tetramera	*Sorghum bicolor*	Maharashtra
Botryodiplodia theobromae	*Cucumis sativus*	Kerala
	Luffa acutangula	Rajasthan
Botrytis cinerea	*Capsicum annuum*	Karnataka
Cercospora kikuchii	*Glycine max*	Delhi, Himachal Pradesh, Jammu & Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Uttarakhand
Claviceps purpurea	*Elymus caninus*	Jammu & Kashmir
	Elymus dentatus	Jammu & Kashmir
Colletotrichum capsici	*Cucumis melo*	Odisha
Fusarium semitectum	*Solanum melongena*	Delhi
F. verticillioides	*Capsicum annuum*	Himachal Pradesh, Karnataka
	Abelmoschus esculentus	Delhi
F. verticillioides	*Brassica juncea*	Rajasthan
	Cajanus cajan	Gujrat, Madhya Pradesh
	Crotolaria pallida	Kerala
	Hibiscus cannabinus	West Bengal
	Luffa acutangula	Delhi
	Oryza sativa	Arunachal Pradesh, Delhi, Gujrat, Odisha
	Solanum melongena	Delhi, Jharkhand
	Triticum aestivum	Haryana
	Vigna unguiculata	Uttar Pradesh
	Zea mays	Delhi, Jharkhand, Punjab
F. oxysporum	*Cajanus cajan*	Gujarat
	Luffa acutangula	Rajasthan
	Momordica charantia	Rajasthan
	Oryza sativa	Nagaland
	Solanum lycopersicum	Delhi
	Solanum melongena	Delhi, Kerala
Microdochium oryzae	*Oryza sativa*	Delhi
Myrothecium roridum	*Lagenaria siceraria*	Gujarat
Phomposis helianthi	*Helianthus annuus*	Karnataka
Protomyces macrosporus	*Coriandrum sativum*	Delhi
Rhizoctonia solani	*Oryza sativa*	Delhi, Odisha
T. barclayana	*Oryza sativa*	Andhra Pradesh, Arunachal Pradesh, Delhi, Maharashtra, Odisha, Punjab, West Bengal
T. indica	*Triticum aestivum*	Delhi, Haryana

Pests	Host	Source/ Collection site
Tilletia caries	*Triticum aestivum*	Uttrakhand
Ophiostoma ulmi	*Capsicum annuum*	Karnataka
Ustilaginoidea virens	*Oryza sativa*	Arunachal Pradesh, Delhi, Odisha, Kerala, Telangana
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Odisha, Tamil Nadu, Telangana, Tripura, West Bengal
Weeds		
Achyranthes aspera	*Abelmoschus esculentus*	New Delhi
Amsinckia intermedia	*Oryza sativa*	Arunachal Pradesh
Convolvulus arvensis	*Spinacia oleracea*	Uttar Pradesh
	Macrotyloma uniflorum	Odisha
	Linum usitatisimum	Uttar Pradesh
Corchorus olitorius	*Oryza sativa*	New Delhi
Dactyloctenium aegyptium	*Oryza sativa*	New Delhi
Echinochloa colona	*Oryza sativa*	Jammu & Kashmir, New Delhi
Echinochloa crus-galli	*Oryza sativa*	Jammu & Kashmir, New Delhi, Telangana
Festuca sp.	*Fagopyrum esculentum*	Jammu & Kashmir
Ipomoea batatas	*Sesamum indicum*	Odisha
Ipomoea hederacea	*Cajanus cajan*	Gujarat
Locthyrus aphaca	*Hordeum vulgare*	New Delhi
Lathyrus sativus	*Glycine max*	Meghalaya
Lolium perenne	*Fagopyrum esculentum*	Jammu & Kashmir
Medicago denticulata	*Trachyspermum ammi*	Chhattisgarh
	Daucus carota	Himachal Pradesh
	Fagopyrum esculentum	Jammu & Kashmir
Melilotus alba	*Brassica juncea*	New Delhi
Melilotus indica	*Macrotyloma uniflorum*	Odisha
	Brassica juncea	New Delhi
Parthenium hysterophorus	*Linum usitatisimum*	Uttar Pradesh
Phalaris minor	*Brassica juncea*	New Delhi
	Trachyspermum ammi	Chhattisgarh
	Daucus carota	Himachal Pradesh
	Triticum aestivum	Uttarakhand
Rumex crispus	*Daucus carota*	Himachal Pradesh
	Abelmoschus esculentus	New Delhi
	Hordeum vulgare	Jammu & Kashmir
Sorghum halepense	*Deschampsia cespitosa*	New Delhi
Vicia hirsuta	*Hordeum vulgare,*	New Delhi
Vicia sativa	*Trigonella foenum-graecum*	New Delhi

A total 1825 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 96 samples were found infested while visual infestation of insect-pests was recorded in 613 samples. A total 776 samples were found infested by various insect-pests. The insect pests detected are given in Table 3.4. Out of total 776 infested samples, 707 were salvaged by X-ray radiography (96), cold treatment (588) and mechanically (613) while 69 samples could not be salvaged hence rejected. A total of 194 samples were found infected with nematodes from eighteen different states / UT of the India.

In addition, 190 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. A toal 64 samples were X-rayed to detect any hidden infestation of insect pests and two were salvaged.

3.4 Supportive Research

3.4.1 Development of multiplex PCR for detection of *Alternaria padwickii*, *Bipolaris oryzae* and *Pyricularia oryzae* infecting rice

Alternaria padwickii, Bipolaris oryzae and *Pyricularia oryzae* are consider as important seed-borne fungal pathogens causing stackburn, brown leaf spot and rice blast disease, respectively. A set of primers namely ApEF-1F and ApEF-1R was designed from elongation factor 1 region of *A. padwickii*, SCAR marker, BoP7-F and BoP7-R was developed from ISSR markers and PoM-1F and PoM-1R designed from *Pyricularia oryzae hydrophobin-like protein* (*MPG1*) gene region. The specific bands of 175 bp, 325 bp and 520 bp for *A. padwickii*, *B. oryzae* and for *P. oryzae* were obtained in multiplex PCR (Fig. 3.4). The detection sensitivity of the primer pairs was performed by dilution of genomic DNA and results revealed that it could detect up to 0.5 ng ìl^{-1} of template DNA of the pathogens.

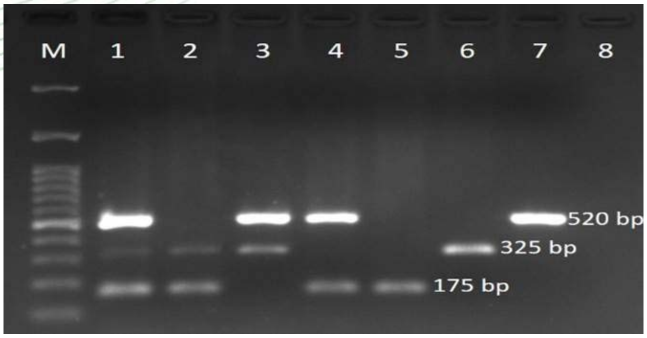


Fig. 3.4. PCR based amplification of seed borne fungal pathogens using *A. padwickii, B. oryzae* and *P. oryzae* specific primers. L: 100 bp plus DNA ladder, Lane 1- *A. padwickii + B. oryzae + P. oryzae*, Lane 2- *A. padwickii + B. oryzae*, Lane 3- *B. oryzae + P. oryzae*, Lane 4- *A. padwickii + P. oryzae*, Lane 5- *A. padwickii*, Lane 6- *B. oryzae*, Lane 7- *P. oryzae*, Lane 8- Negative control

3.4.2 Development of multiplex PCR for detection of *Alternaria padwickii*, *Pyricularia oryzae* and *Ustilaginoidea virens* infecting rice

Alternaria padwickii, Pyricularia oryzae and *Ustilaginoidea virens* are causing stackburn, rice blast and false smut disease of rice, respectively. Species-specific primers, ApEF-1F and ApEF-1R were designed from elongation factor 1 region of *A. padwickii*, PoM-1F and PoM-1R designed from *Pyricularia oryzae hydrophobin-like protein* (*MPG1*)

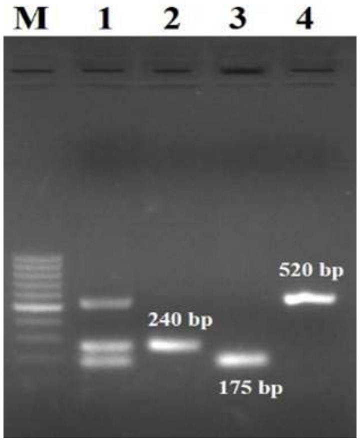


Fig. 3.5. PCR based amplification of seed borne fungal pathogens using *U. virens, A. padwickii,* and *P. oryzae* specific primers. L: 100 bp plus DNA ladder, Lane 1- *U. virens + A. padwickii + P. oryzae*, Lane 2- *U. virens*, Lane 3 - *A. padwickii*, Lane 4- *P. oryzae*

gene region and UvP1-F and UvP1-R primers were designed based on ITS gene region of *U. virens.* The specific bands of 175 bp, 520 bp and 240 bp for *A. padwickii*, *P. oryzae* and *U. virens* for were obtained in multiplex PCR (**Fig.** 3.5). The detection sensitivity of the primer pairs was performed by dilution of genomic DNA and results revealed that it could detect up to 0.5 ng ìl^{-1} of template DNA of the pathogens.

3..4.3 Development of species-specific marker for PCR based detection of *Colletotrichum acutatum* causing Chilli anthracnose disease

The isolate of *Colletotrichum acutatum* 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.* The DNA was extracted from mycelial mat and PCR conditions were standardized with annealing temperature of 65 ^{o}C and an expected PCR product size of 180 bp was observed in *C. acutatum* isolate, but failed to amplify in other *Colletotrichum* spp. And other seed borne fungal pathogens (Fig. 3.6).

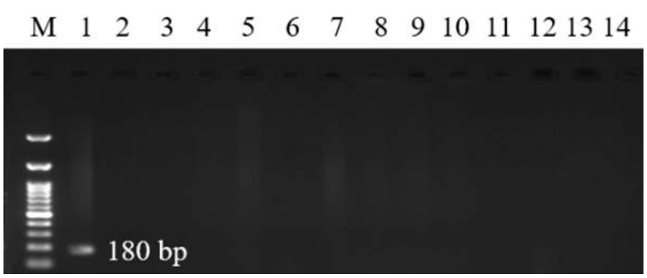


Fig. 3.6. PCR based amplification of seed borne fungal pathogens *Colletotrichum acutatum* using specific primers. L: 100 bp plus DNA ladder, 1: *C. acutatum*, 2: *C. capsici*, 3: *C. gloeosporioides*, 4: *A. alternata*, 5: *Bipolaris oryzae*, 6: *B. rostrata*, 7: *B. sorokiniana*, 8: *B. maydis*, 9: *Curvularia lunata*, 10: *Curvularia hawaiiensis*, 11: *Fusarium verticillioides*, 12: *Ustilaginoidea virens*, 13: Healthy seed, 14: Negative control

3.4.4 Screening of germplasm for resistance to root-knot nematode

A total of 2927 accessions of various agri-horticultural crops, *viz*., rice, cowpea, chickpea, pea, urdbean, cucumber and brinjal 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 3.4).

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	1674	Nine
Cowpea	123	One
Chickpea	490	One
Mungbean	193	Two
Pea	58	Nil
Urdbean	128	Nil
Cucumber	183	Nil
Brinjal	75	Two

3.4.5 *Emex australis* Steinh.-An emerging weed problem of wheat crop in Delhi NCR

Emex australis was introduced into India along with large scale wheat import from Australia and has become a weed in wheat crop in Delhi NCR. Wheat field was selected for experimentation where the species was recorded in Delhi. It was growing gregariously in small to large patches. It is monoecious winter herb, prostrate, annual and having three angled nut enclosed in spinescent perianth. The species is highly invasive. The plant has tendency to spread rapidly and may become an aggressive weed of wheat crop. It is considered as noxious weed in several countries like Australia, USA, Japan and New Zealand. The seed have potential to remain viable for many years within the soil enabling the species to persist through long period of unfavourable conditions. A huge quantity of seeds production of these weeds when added to soil, leads to frequent weed germination under favourable moisture and temperature. It reduces the yield of wheat crop and may become a havoc in near future. In present scenario, this weed needs to be controlled on the urgent basis to restrict its population, so that it could not become a nationwide problem.

3.4.6 Molecular detection of Phytoplasma

Molecular detection of phytoplasma was carried out at group level in various crops viz., tomato, wild brinjal, linseed, pea, cumin and jasmine.

3.4.7 Screening germplasm against viral diseases

The causative agent of bhendi yellow vein mosaic disease (BYVMD) is begomovirus i.e., bhendi yellow vein mosaic virus (BYVMV) 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. moschatus* ssp. *moschatus*) infected samples exhibiting conspicuous symptom of BYVMD using PCR-based detection technique on two wild okra symptomatic samples *viz.,* EC361170 and EC361148 collected from experimental farm of ICAR-NBPGR. Full length amplification of BYVMV satellite molecule and partial amplification of DNA-A was carried out using PCR and cloning of both randomly selected samples showed the presence of monopartite BYVMV. In both samples, presence of DNA-A molecule, alphasatellite and betasatellite were noticed. This is the first study which showed the presence of alphasatellite molecule of BYVMV from New Delhi region in wild okra (*A. moschatus* ssp. *moschatus*).

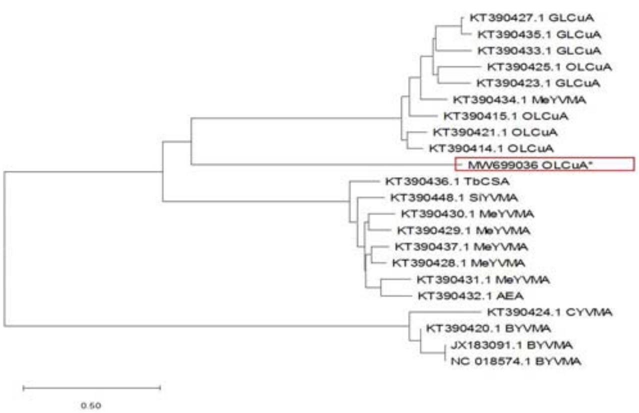


Fig. 3.7. Phylogenetic dendrogram showing the relationship of Okra leaf curl alphasatellite (OLCuA, this study) complete genomes with other isolates of BYVMA, SiYVMA, MeYVMA, CYVMA, OLCuA, GLCuA, TbCSA and AEA. Star symbol indicate sequences obtained from samples exhibiting bhendi yellow vein mosaic disease (BYVMD)

Okra enation leaf curl disease (OELCuD) is a recently emerged whitefly insect vector transmissible viral disease of okra which adversely affect the quality and quantity of okra fruits. okra enation leaf curl virus (OELCuV) is a main disease causative agent. Artificial screening experiment was conducted using viruliferous whitefly vector and VRO-6 as susceptible check. One day acquisition access period (AAP) and inoculation access period (IAP) was used for artificial transmission of virus using 15 viruliferous whiteflies per plant in 20 days old wild okra seedlings. Prominent okra enation leaf curl symptom appeared after a minimum incubation period of 15 days under controlled conditions. Four accessions *viz.*, EC360794, EC360586, EC360830 EC361171 were found free from virus. DNA-â amplification was noticed in susceptible check (VRO-6) and no amplification was observed in these four accessions. Four promising accessions *viz.*, EC360794, EC360586, EC360830 and EC361171 found resistant during artificial screening would serve as resistance source in breeding programmes to develop varieties resistant to OELCuV.

Fig. 3.8. Artificial screening of wild okra (*Abelmoschus moschatus* ssp. *moschatus*) against okra enation leaf curl virus using whitefly vector A: Cage inoculation of viruliferous whitefly to four test accessions viz., EC360794, EC360586, EC360830 and EC361171 along with VRO-6 susceptible check. B: Resistant response to tested wild okra accession C: Okra enation leaf curl disease symptom development in the susceptible check VRO-6

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

A total of 85 diverse cowpea germplasm along with one susceptible and one resistant check were screened against BCMV both under natural conditions in the field and after artificial inoculation in controlled conditions. For detection of BCMV, EM, DAC-ELISA and Reverse transcription-PCR (RT-PCR) were used. EM revealed the flexuous rod viral particles of 725nm. RT-PCR protocol was standardized with newly designed three primers pairs (BCMV1, BCMV2 and BCMV3) and amplified PCR products were sequenced. The PCR products showed 92.75%, 90.68% and 92.5% nucleotide similarity with BCMV. Among these IC 418505 and IC568946 were identified as highly susceptible with 40% disease incidence and four accessions viz., IC 199699, IC 199701, IC 202791 and IC 202814 showed immune response to BCMV infection both under natural and controlled conditions.

3.4.9 Potential quarantine pests for India in cucurbitaceous and solanaceous vegetable crops

Information on viruses, viroids and phytoplasma of tropical and sub-tropical 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. A total of 44 viruses/ phytoplasma are of quarantine significance in cucurbitaceous and solanaceous vegetable crops for India.

3.5 Externally funded projects

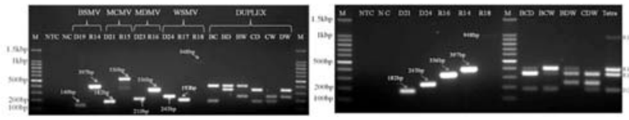
3.5.1 National Programme for quarantine and GM diagnostics for genetically engineered plant material (Component A): (V Celia Chalam, Kavita Gupta, Z Khan and Jameel Akhtar)

- **Quarantine processing of imported transgenic germplasm**

With the approval of RCGM, 10 imported transgenics samples (*Arabidopsis thaliana* -3, from Japan and *Medicago truncatula* -7, from USA) were received. Two samples of *Medicago truncatula* were found infected with *Botryodiplodia theobromae* and *Cladosporium* sp. Fungicidal seed treatment was given with carbandazim and mancozeb to the samples and released to the indenters in pest-free state. Seeds of transgenic *Medicago truncatula* from USA were grown in the Containment Facility for 45 days for detection of seed-transmitted pests not detectable in the laboratory tests. Post-entry quarantine inspections (1) of *Medicago truncatula* imported from USA were undertaken and tested for different pests using ELISA, EM, PCR and RT-PCR. None of the tested samples showed the presence of any pests. The samples of *Arabidospsis thaliana* were found to be free from any pest during quarantine processing and released to the indenters in pest-free state.

- **Development of diagnostics for plant viruses**

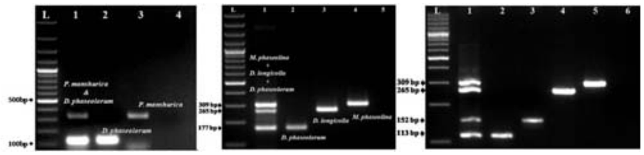
Simplex, duplex, triplex and tetraplex RT-PCR protocols for individual as well as simultaneous detection of quarantine significant viruses *viz.*, BSMV, MCMV, MDMV and WSMV infecting maize were developed.



Singleplex and multiplex RT-PCR for the detection of Maize viruses BSMV, MCMV, MDMVand WSMV

- **Development of diagnostics for plant pathogenic fungi**

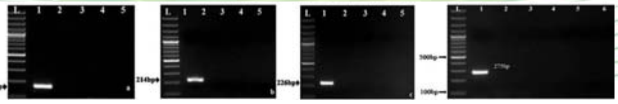
Quadruplex for *Diaporthe phaseolorum*, *D. longicolla*, *Macrophomina phaseolina* and *Perenospora mashurica*, triplex for *D. phaseolorum*, *D. longicolla*, *M. phaseolina* and duplex PCR for *D. phaseolorum* and *P. mashurica* were developed for simultaneous detection in soybean.



Duplex, triplex and quadruplex PCR for simultaneous detection of fungal pathogens infecting soybean

- **Development of diagnostics for Insects**

Developed three sets of markers from mt 12S ribosomal DNA and one set of marker from Cox1 region specific to *Sitophilus zeamais* and tested for their sensitivity using conventional and qPCR.



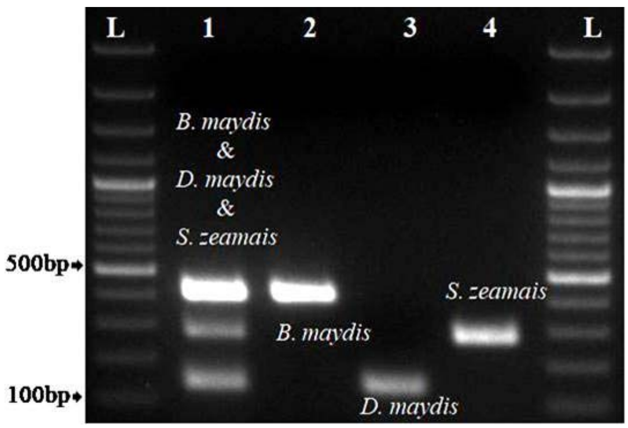
Specific markers developed for *Sitophilus zeamais*

- **Diagnostics for simultaneous detection of fungi and insect infecting maize**

Developed triplex PCR for simultaneous detection of fungi (*Bipolaris maydis* and *Diplodia maydis*) and insect (*Sitophilus zeamais*) infecting maize.

- **Operational maintenance of national containment facility**

The Containment Facility is maintained in full functional condition with necessary safety and security measures and the soil bay 16 TR air conditioner was repaired with refrigerant charging and replaced other parts.



Triplex PCR for simultaneous detection of fungi and insect infecting maize

3.5.2 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

3.5.2.1 Molecular diversity analysis of *Macrophomina phaseolina* using ISSR, SRAP and URP markers

Macrophomina phaseolina isolates were isolated and identified from infected sesame samples collected from six states including Delhi, Rajasthan, Punjab, Gujrat, Maharashtra and Tamil Nadu. The DNA was extracted and diversity study was done using ISSR (16), SRAP (19) and URP (6) polymorphic markers. The dendrogram of markers grouped into two major clusters. Although there was no clear cut, grouping of isolates based on geographical origin but Gujrat isolates except one group grouped in separate sub-cluster (Fig. 3.9).

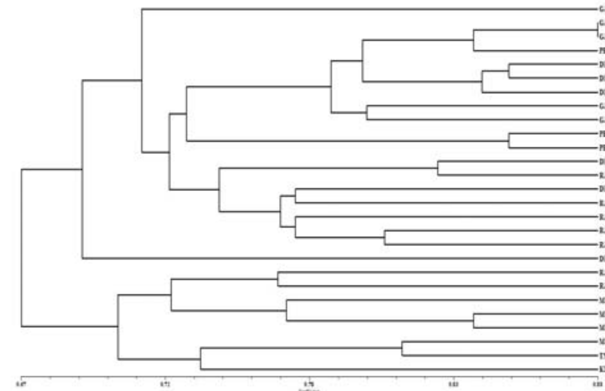


Fig. 3.9. UPGMA clustering based dendrogram of ISSR, SRAP and URP markers showing the genetic relationship among *Macrophomina phaseolina* isolates

3.5.3 Characterization, evaluation of genetic resources for genetic enhancement and improvement of minor pulses Subproject 3, Component 1, 1010668, DBT-funded (Co-PI)

A total of 1200 accessions of cowpea were screened against yellow mosaic disease under natural field conditions. A total of 130 accessions were found highly susceptible to yellow mosaic disease. Association of mungbean yellow mosaic virus (MYMV) and mungbean yellow mosaic India virus (MYMIV) has been confirmed using PCR.

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 2,053 accessions of sesame germplasm have been evaluated against phytoplasma under field conditions and disease incidence was low during kharif 2022. 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.

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

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

Pot experiment was conducted for large scale phenotyping of rice landraces against Sheath blight (SB) caused by *Rhizoctonia solani* under artificial inoculation conditions using 1000 accessions with 5 checks *viz*., Pusa 44, IR 64, Swarna, Jaya and P1850. Data were measured following 0-9 standard evaluation system (SES) scale adopted by IRRI. Out of 1000 accessions, 807 accessions were established while remaining accessions could not germinate. Artificial inoculation of *R. solani* colonized typha pieces five plants per accession was done at the maximum tillering stage (Fig. 3.10). The observation revealed that the incubation period for SB varied from 3-10 days. The lesion length was recorded after two weeks of inoculation of *R. solani*. The relative lesion length (%) for SB in relation to plant height was calculated which ranged from 5.92 - 79.76%. According to 0-9 standard evaluation system scale, only three accessions *viz*., RL-1 (6.78%), IRGC145 (5.92%) and IRGC174 (6.80%) showed resistance against sheath blight and 10 accessions were recorded with moderately resistant reaction namely, RL-127, RL-274, RL-664, RL-986, RL-3900, RL-10067, IRGC155, IRGC228, IRGC288 and IRGC295.

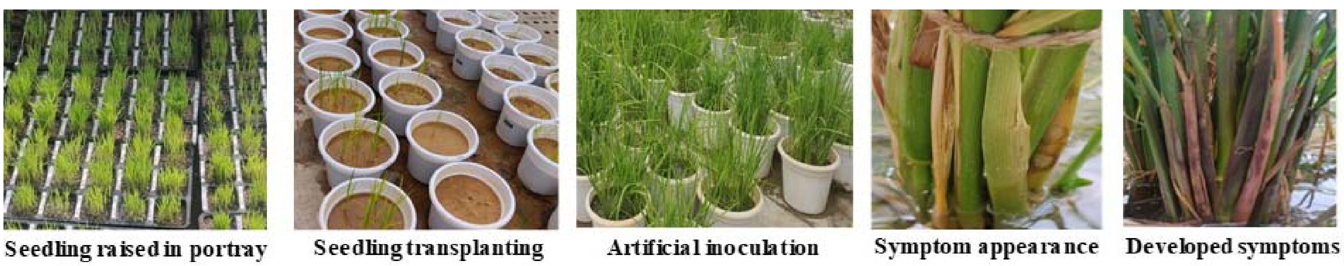


Fig. 3.10. Schematic picture represents phenotyping against Sheath blight (*R. solani*)

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, Raj Kiran (till Jan 20, 2022) and Ashok Kumar Maurya)
PGR/DPQ-BUR-DEL-01.02 Detection and identification of viruses in quarantine and supportive research. (**V Celia Chalam,** Pooja Kumari, *AK Maurya)*
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, Zakaullah Khan, Jameel Akhtar, Pardeep Kumar, Bharat Raj Meena, Raj Kiran (till Jan 20, 2022), Pooja Kumari, *Ashok Kumar Maurya* and *DS Meena*)
PGR/DPQ-BUR-DEL-01.07 Quarantine processing of imported transgenic germplasm and supportive research (**V Celia Chalam,** Kavita Gupta, Zakaullah Khan, Jameel Akhtar *AK Maurya, DS Meena*)
PGR/DPQ-BUR-DEL-01.08: 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, Rraj Kiran (till Jan. 20, 2022), Pooja Kumari, Veena Gupta, Sushil Pandey, Sandhya Gupta, *AK Maurya, DS Meena* and *Smita Lenka*)

4 DIVISION OF GERMPLASM EVALUATION

सारांशः वर्ष 2022 के दौरान, विभिन्न कृषि–बागवानी फसलों की कुल 29,706 एक्सेशन का लक्षण वर्णन/मूल्यांकन/गुणन किया गया। चना (5,084 एक्सेशन), अलसी (2,576), गेहूं (2534), चिली (1,100), जंगली साइकर (513), रेपसीड और सरसों (402), मक्का (244), यार्ड लोंग बीम (210), और अन्य फसलों के (572) एक्सेशन मौसम के दौरान लक्षणवर्णन के लिए उगाए गए। ब्रैसिया (1,000 एक्सेशन), जौ (678), गेहूं (581), और ब्रासिका और उसके वन्य प्रजातियों (350) को ओरोबंचे के समक्ष प्रारंभिक स्क्रीनिंग के लिए उगाया गया था, बायोटिक स्ट्रेस के लिए स्पॉट ब्लॉचय और विभिन्न महत्वपूर्ण बायोटिक स्ट्रेस के लिए ब्रासिका, ओकरा, चिली, सोयाबीन, उद्यान मटर और मक्का की 177 जर्मप्लाज्म लाइनों की उन्नत स्क्रीनिंग की गई थी। इसके अलावा, विभिन्न दलहन फसलों की 2,797 एक्सेशनों की रूट–नॉट नेमाटोड के लिए उनकी मेजबान स्थिति के लिए मूल्यांकन किया गया। कुल 4,281 एक्सेशनों जिसमें अलसी (2,612 हेक्टेयर) और नेशनल जीनबैंक कोर और ग्लोबल ड्यूरम पैनल (750 एक्सेशनों) सूखा स्ट्रेस के लिएय जौ कोर (678 एक्सेशनों) और ट्रिटिकम डिकॉक्यूम (196 एक्सेशनों) टर्मिनल हीट स्ट्रेस के लिएय और ट्रिटिकम स्फेरोकोकम (45 acc.) सूखा और टर्मिनल हीट स्ट्रेस का मूल्यांकन किया गया। चावल (745), गेहूं (564), अमरांथ (57), चिनोपोडियम (74), फोक्स बाजरा (28), तिल (3752), अलसी (2539), कोविया (520), उड़द बीन (142), अदजुकी बीन (179), मोथ बीन (525), हरा चना (151) और ब्रासिका जुनसिया वार रुगोसा (100) सहित विभिन्न फसलों की कुल 9,376 एक्सेशनों का मूल्यांकन महत्वपूर्ण जैव रासायनिक लक्षणों के लिए किया गया। कृषि–जैव विविधता–पीजीआर घटक–II पर सीआरपी के तहत, जैविक स्ट्रेस लक्षणों के लिए रबी 2021–22 के दौरान कुल 581 गेहूं के एक्सेशनों का मूल्यांकन किया गया। जेनेटिक बेस एन्हांसमेंट के लिए प्री–ब्रीडिंग ब्रैसिका, फ्लेक्स, चिली और सीसर में की गई थी। लक्षण वर्णन के उद्देश्यों के लिए विग्ना वजीफा कुंटजे, एक छोटी फली की फसल के उदाहरण वर्णक विकसित किए गए थे। इस्सापुर फार्म में फील्ड जीनबैंक में बहुउद्देश्यीय पेड़ प्रजातियों की स्थापना के प्रयास किए गए हैं। वर्तमान में, 38 परिवारों से संबंधित 79 ऐसी पौधों की प्रजातियां स्थापित की गई हैं। इस अवधि के दौरान जननद्रव्य क्षेत्र दिवस, किसान दिवस, वन महोत्सव और जलवायु लचीलेपन के लिए पीजीआर जागरूकता जैसे विभिन्न जननद्रव्य जागरूकता–उन्मुख कार्यक्रम आयोजित किए गए। आईसीएआर संस्थानों, एसएयू और अन्य अनुसंधान संगठनों से संबंधित मांगकर्ताओं को विभिन्न फसलों की कुल 6,243 एक्सेशनों की आपूर्ति की गई।

Summary: During 2022, a total of 29,706 accessions of various agri-horticultural crops were characterized/ evaluated/ multiplied. Chickpea (5,084 acc.), linseed (2,576 acc.), wheat (2,534 acc.), chilli (1,100 acc.), wild *Cicer* (513 acc.), rapeseed and mustard (402 acc.), maize (244 acc.), yard long bean (210 acc.), and other crops (572 acc.) were grown for characterization during the season. *Brassica* (1,000 acc.), barley (678 acc.), wheat (581 acc.), and *Brassica* and its wild relatives (350) were grown for preliminary screening against orobanche, spot blotch for biotic stresses; and advanced screening of 177 germplasm lines of *brassica*, okra, chilli, soybean, garden pea and maize for various important biotic stresses was done. In addition, 2,797 accessions of various pulse crops were evaluated for their host status to root-knot nematode. A total of 4,281 accessions comprising linseed (2,612 acc.) and national genebank core and global durum panel (750 acc.) for drought stress; barley core (678 acc.) and *Triticum dicoccum* (196 acc.) for terminal heat stress; and *Triticum sphaerococcum* (45 acc.) for drought and terminal heat stress were evaluated. A total of 9,376 accessions of different crops comprising rice (745), wheat (564), amaranth (57), *Chenopodium* (74), foxtail millet (28), sesame (3752), linseed (2539), cowpea (520), urd bean (142), adzuki bean (179), moth bean (525), green gram (151) and *Brassica juncea* var *rugosa* (100) were evaluated for important biochemical traits. Under CRP on Agro-biodiversity-PGR Component- II, total of 581 wheat accessions were evaluated during *rabi* 2021-22 for biotic stress traits. Pre-breeding for genetic base enhancement was done in *Brassica*, flax, chilli and *Cicer*. Illustrative descriptors of *Vigna stipulacea* Kuntze, a minor legume crop, were developed for characterization purpose. Efforts have been taken up to establish multipurpose tree species in Field Genebank at Issapur farm. Currently, 79 such plant species belonging to 38 families have been established. During the period various germplasm awareness-oriented programs such as Germplasm Field Days, Farmers' Day, Van Mahotsav, and PGR awareness for Climate Resillience were organized. A total 6,243 accessions of various crops were supplied to indenters belonging to ICAR institutes, SAU and other research organisations.

4.1 Characterization and evaluation of cereal crops germplasm

4.1.1 Characterization and evaluation of wheat germplasm

A total of 2534 wheat accessions comprising *T. aestivum* (806), *T. durum* (1,414), *T. dicoccum* (269 acc.), *T. sphaerococcum* (45 acc.). were grown for characterization and evaluation at NBPGR Experimental Farm, Issapur in Augmented Block Design along with ten checks HD-2967, WR-544, HD-3086, C-306, DWR-1006, UAS-415, UAS-428, DDK-1025, DDK-1029, HW-1093. There was good range of variability in the different species of wheat germplasm. Promising accessions for some agronomic traits are given in Table 4.1.

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

Crop/species	Trait	Promising accessions
Triticum aestivum	Days to heading (< 87)	IC421928, IC128388, IC35143, IC128174, IC335923, IC57472, IC542032, IC118710, IC128230, IC329585, IC128381, IC535200
	Grains per spike (> 94)	IC402022, IC539315, IC547637, IC534946, IC397815
	1000 grain weight (>54g)	IC335761, IC335772, IC402022, IC599622, IC549392, IC566633, IC252755, IC539315
T. durum	Days to heading (< 85)	EC299186, IC375867, IC113731, IC335939, IC36878, IC443755, IC547663, IC335923, IC138445
	Grains per spike (> 97)	IC533697, IC542115
	1000 grain weight (>64g)	IC252755, IC252569, IC617425, IC296483, IC296756
T. dicoccum	Days to heading (<85)	IC118763, IC28596, IC118765, IC35093IC35091, IC35097, IC35119, IC535281IC534018, IC28603
	Grains per spike (> 54)	IC535110, IC402018, IC593663, IC28603, IC547564, IC78706, IC402020, IC551397, IC535099, IC402045, EC609395
	1000 grain weight (>49g)	EC577412, IC28603, IC28604, IC32502, IC138471, IC35093, IC602442, IC535148, EC578115, IC534621
T. sphaeroccum	Days to heading (< 95)	IC53387, IC534882, EC10494, EC576654, EC613055, EC613057, EC10494, EC10492, IC634028
	Grains per spike (> 55)	IC212160, EC613057, EC187172, IC634028
	1000 grain weight (>36g)	IC534522, EC182945, EC10494, EC187176, EC13052
Maize	Days to 50% tasselling (<43)	IC0624765, IC0624766, IC209796, IC209804, IC0624767, IC209783, IC209791, IC209792, IC563999, IC209782, IC209789, IC209793
	Ears/plant (>2.00)	IC130593, IC422847, IC209814, IC625136, IC623947, IC563962, IC209809, IC209849, IC209851, IC130889, IC131190, IC200271
	Plant height (dwarf) (<129 cm)	IC254017, IC405284, IC253986, IC584583, IC621104, IC254031, IC209791, IC130551, IC584596, IC584599, IC621103, IC209804
	Plant height (tall) (>238 cm)	IC423244, IC624075, IC396850, IC209784, IC200207, IC569176, IC77578, IC411281, IC254011, IC128835, IC130857, IC396844
	Ear length (>18 cm)	IC593934, IC262803, IC563965, IC209834, IC209851, IC209832, IC411283, IC549904, IC209784, IC411285, IC209840, IC209839
	Kernels/row (>34)	IC209806, IC209832, IC209834, IC254039, IC213120, EC444446, IC448801, IC209810, IC209811
	100-grain weight (>30 g)	IC296026, IC563954, IC209851, IC447425, IC313238, IC549904, IC411281, IC253988, IC563958, IC411285

Fig. 4.1. Field view of durum wheat germplasm evaluation at NBPGR, Issapur Farm

4.1.2 Characterization and evaluation of maize germplasm

During *Kharif* 2022, 244 maize accessions were characterized and evaluated for 32 agro-morphological descriptors. The promising accessions identified are listed in the Table 4.1.

4.2 Characterization and evaluation of pulse crops germplasm

4.2.1 Characterization and taxonomic delineation of wild *Lathyrus* species

A total of 189 germplasm accessions belonging to 30 different wild species of grasspea characterized for 26 agro-morphological descriptor traits at IARI farm, ICAR-NBPGR, New Delhi during *Rabi* 2021-2022. The experiment was conducted in ABD. Variability was observed for desired traits such as earliness, plant type and biomass. Seeds per pod was ranged from 2 (*L. amphicarpos*) to 7 (*L. hirsutus*). *L. amphicarpos* has two kind of flower one is sub-aerial another is geocarpic. *L. sativus* and *L. cicera* accessions are observed with higher 100 seed weight than others.

4.2.2 Agro-morphological characterization of Yard Long Bean (YLB) *Vigna unguiculata* subsp. *sesquipedalis*

During *Kharif* 2022, the experiment was conducted on all YLB accessions conserved in Indian National Genebank in ABD using three checks *viz.* Arka Mangla, Gitika and Lola. The morphological characterization was done as per descriptors of ICAR-NBPGR developed for vegetable cowpea. The results revealed that there was lot of diversity among the germplasm for various characters studied. Growth habit varied from pole type to bush type while flower colour light purple, purple, dark purple, pink and white. However, pod colour was light green, dark green, light green with purple tip and purple with green tip. Similarly seed colour varied from red, deep red, red with white tipped, red spotted, brown, mottled brown, off white, black and buff. Based on mean performance of the accessions for targeted traits, accessions such as IC622563(28), IC546883(28), IC382942(30), EC7242939(34), EC724293(34), IC622586(35) flowered earlier than best check i.e. Arka Mangala (41 days). The first pod of IC382942 (45 days) matured earlier than all checks used in the study.

4.2.3 Identification of unique pea germplasm (IC220286) with waxiness

During large scale characterization of pea germplasm conserved in Indian national genebank, a very unique waxy germplasm, IC220286 reported in pea. This particular germplasm have been validated at ICAR-NBPGR, Delhi; ICAR-IIPR, Kanpur and NBPGR, RS, Ranchi for waxiness. Epicuticular wax deposition imparts drought resistance. So, epicuticular wax is estimated using rapid colorimetric method. The colorimetric method is based on the color change produced due to the reaction of wax with acidic $K_2Cr_2O_7$ reagent. The epicuticular wax was estimated for leaves and stipules both. A set of four accessions including three different checks were used in the study. IC220286 was recorded with 12.45 μg wax/cm^2 (leaves) and 16.15 μg wax/cm^2 (stipules). This unique accession recorded more wax in leaves and stipules both than Kashi Uday, IPFD12-2 and IPFD99-13.

4.2.4 Evaluation of black gram germplasm for pre-harvest sprouting tolerance (PHS)

PHS is a phenomenon of germinating the seeds inside the pod while still attached to the

Fig. 4.2. Prolific maize accessions (KG/VK/SKT-222)

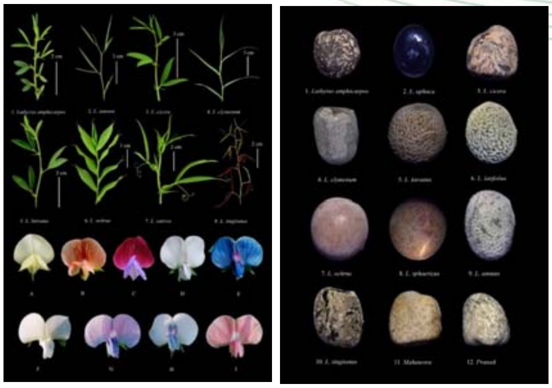


Fig. 4.3. Wild *Lathyrus* species

Fig. 4.4. Field view of Yard longbean characterization

mother plant. Germination in the seed triggers starch mobilization by α-amylase that leads to devasting damage to grain quality. The leading cause of PHS is lack of fresh seeds dormancy (FSD). Consequently, development of black gram cultivars with short period of FSD has become vital to curtail the losses caused by PHS. In the present study, we analyzed diverse black gram accessions (120 accessions) for variations in PHS, fresh seed germination (FSG) and activity of α-amylase enzyme. Wide variation for PHS tolerance and FSG among accessions were observed. The accessions such as IC485425 and IC250220 have been validated as PHS tolerant.

4.2.5 Development of illustrative descriptors of *Vigna stipulacea* Kuntze

Vigna stipulacea (Lam) Kuntz., is an important legume with tremendous potential to be utilized in the *Vigna* improvement programme. It belongs to the secondary gene pool of the cultivated green gram and black gram. This species is a reservoir of various useful traits *viz*., faster growth, shorter duration and broad resistance to various pests and diseases and can be targeted for its domestication as a new crop and while the desirable traits can be transferred to the cultivated *Vigna* species. Though *V. stipulacea* has been mistaken with *V. trilobata* since a long, it is taxonomically distinct. The agro-morphological descriptors and descriptor states have been devised considering the importance of different plant parts in this multipurpose legume. Based on critical analysis of existing variability in the germplasm, a set of 44 (27 qualitative and 17 quantitative) key illustrative descriptors have been proposed for characterization and preliminary evaluation of germplasm.

Fig. 4.5. Unique pea germplasm with waxiness

Fig. 4.6. Differential reaction of blackgram germplasm to PHS tolerance

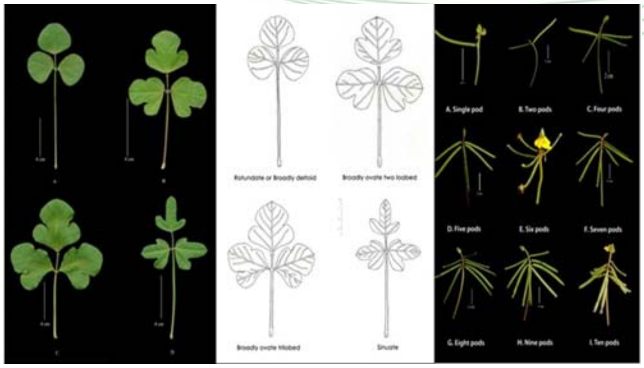


Fig. 4.7. Illustrative Descriptors of *Vigna stipulacea*

4.2.6 Wild *Cicer* germplasm characterization and seed multiplication

Total 513 accessions of important wild *Cicer* species viz. *C. reticulatum* (260 acc.), *C. echinospermum* (93 acc.), *C. bijugum* (27 acc.), *C. judaicum* (86 acc.), *C. pinnatifidum* (32 acc.) and unknown species (15 acc.) were characterized using 12 qualitative and 9 quantitative traits at experimental Farm, New Area, ICAR-NBPGR. Qualitative traits studied were: early vigour, growth habit, plant hairiness, plant pigmentation, flower colour, no. of flowers/peduncle, no. of leaflets/ leaf, no. of seeds/pod, seed colour, seed shape, seed surface texture and dots on seed coat. Good amount of variation was revalued for traits such as yield/plant, pods/plant, number of tertiary branches/plant, 100 seed weight and canopy height. Promising accessions for various important traits are given in the table 4.2.

4.2.7 Agro-morphological characterization of chickpea germplasm

Total 5,084 accessions of chickpea including 3,584 accessions form ICRISAT Genebank and 1,500 accessions from ICAR-NBPGR Genebank were characterised for DUS agro-morphological characteristics. Data was generated for traits such as growth habit, plant pigmentation, plant height, plant width, basal primary branches number, apical primary branches number, basal secondary branches number, apical secondary branches number, days to 50% flowering, days to end of flowering, flower colour, days to maturity, number of seeds per pod, seed colour, dots on seed coat, seed shape, seed surface, 100 seed weight, seed yield per plant. Promising accessions for various important traits are given in the Table 4.2.

Fig. 4.8. Partial field view of chickpea germplasm characterization at ICAR-NBPGR, Issapur Farm, New Delhi

4.2.8 Evaluation of faba bean international nurseries for traits of economic importance

A total of 181 genotypes of six Faba bean International were evaluated for traits of economic importance during *Rabi* 2020-21. Selections were effected in these 181 genotypes based on pod and seed characters separately. Accordingly, two trials were formulated and conducted during *Rabi* 2021-22 at ICAR-NBPGR, Issapur farm to evaluate and select superior genotypes for uses as vegetable purpose and seed purpose. Trial I comprising of 35 pod type genotypes including 5 checks was conducted in RBD with three replications. Among exotic checks, Ascot was best for pod yield while HFB-1 was best national check. Six genotypes produced significantly higher pod yield than both the best checks (Table 4.2). In Trial-II, 34 seed type genotypes including 4 checks were evaluated in RBD with three replications. Among exotic checks, Rebya-40 was best for seed yield while Vikrant was best national check. Two genotypes produced significantly higher seed yield than Vikrant, while 13 genotypes produced significantly higher yield thank Rebya-40. These trials will be repeated during *Rabi* 2022-23 for confirmation of results and genotypes performing consistently superior will be introduced into AICRP for multi-location testing.

Table 4.2: List of promising accessions for important agro-morphological traits in pulses

Crop/species	Trait	Promising accessions
Chickpea (*Cicer arietinum*)	Plant height (≥105 cm)	ICC 19010 (122.3), ICC 8926 (118.7), ICC 19011(116.3), ICC 8927 (114), ICC 7773 (107), ICC 19013, (106.7), ICC 7323 (105.7)
	Plant width (≥105 cm)	ICC 19010 (122.3), ICC 8926 (118.7), ICC 19011 (116.3), ICC 8927 (114), ICC 7773 (107), ICC 19013, (106.7), ICC 7323 (105.7)
	Basal primary branches number (≥12)	IC83480 (15.67), IC83673 (13), ICC 10530 (12), IC83666 (12), IC83527 (12), IC83364 (12), IC83469 (12)
	Apical primary branches number (≥55)	IC485984 (70), IC512099 (67), IC116280 (64), EC442055 (60), IC269106 (58), IC487431 (56), IC272466 (55)
	Basal secondary branches number	EC490023 (45.7), EC538494 (43.7), EC528351 (43), EC498750 (43)
	Apical secondary branches number (≥55)	EC490023 (45.7), EC538494 (43.7), EC528351 (43), EC498750 (43)
	Days to 50% flowering	ICC 13042 (70 days)
	Flowering period (≤15 days)	ICC 18909 (10), IC83790 (12), IC269785 (13), ICC 18912 (15), EC555578 (15)
	Days to maturity (≤127 days)	IC83741, IC83731, IC83568, IC83565 (127 days)
	No. of seeds/pod (≥ 2.7 seeds)	ICC2858 (3), ICC3056 (3), ICC16328 (2.7), IC269756 (2.7)
	No. of pods/plant (≥ 270 pods)	ICC2 (458), ICC11280 (387.7), ICC12476 (385), ICC14423 (376.3), ICC12275 (374.3), IC209241 (372.3)
	100 seed wt (≥ 40 g)	ICC 18806 (43.5), ICC 18802 (42.5), ICC 14198 (42.5), ICC 18753 (41), ICC 18808 (40), ICC 4897 (40)
	Seed yield/plant (≥ 50 g)	ICC 9793 9123.3), ICC 7481 (85.18), ICC 13821 (75), EC490022 (53.9), ICC 3513 (50.8)
Pea	Early flowering	IC296119, IC276596, IC613118, IC613353, IC296119, IC276597, IC276598, IC0209092, IC0255412
	High number of seeds/pod	EC0398595, IC0276603, EC0013055, EC0015322, EC0008532, EC0015299
	Unique plant type with waxiness	IC0220286
	Erect at maturity	EC838139, EC0865944, EC0865945, EC0865968, EC0865970, EC0865984, IC0220402
	Multi-flowering	EC598877
	High pods/ plant with leafless	EC0865990, EC0866007, EC0866032
	Dark green pod and seed (Suitable for freezing type)	EC598856
Cowpea	Early flowering (<35 days)	EC723684, IC548860, IC353315, EC738126, EC723880, EC738091, IC91446, EC738154, EC738159, EC738218, EC244108
	Early maturity, Erect type, upright podding and suitable to mechanical harvesting	EC244108, IC276936 EC244109, EC244116, EC517137
	High protein content (27.5%)	IC201086, EC169879

Crop/species	Trait	Promising accessions
	100 seed weight (>28 g)	IC202774, IC202779, IC202803, IC202790, IC202931, EC1030789
	Green seed (Maturity)	IC590843
	High yielding and MR to rot and YMD	EC724160, EC724153, EC724157, EC738126
	RKN resistant	EC723870, EC724441, IC406512, IC550300
	Rot resistance (*Macrophomina phaseolina*)	EC724153, EC724157, EC240928
Faba bean	Plant height (cm)	ET252782 (149)
	Branches/plant	ET273819 (8), ET272852 (7.89), ET272843 (7.44), ET252779 (7.78)
	Days to 50% Flowering (≤62 days)	ET272839, ET273767, ET272840, ET252775
	Pod length (cm)	ET273778(13.10)
	Pod width (mm)	ET273768 (13.2)
	Days to 80% maturity (≤143.3 days)	ET273768, ET273789, ET272838, ET273767, ET272840
	Pod Yield (≥58.7 q/ha)	ET273778, ET273780, ET273819, ET273768, ET272857, ET 252782
	Pod Yield (≥23 q/ha)	ET272852, ET272838, ET272839, ET272843, ET273789, ET 252793
Buckwheat	Days to flowering	IC79184, IC79185, IC274444
	Days to maturity	IC79184, IC79185, IC274444
	Plant height (cm)	IC599207, IC582977, IC583592
	No. of infl./plant	EC125940, IC599205, JCR1962
	Seed yield/plant(g)	EC125940, IC599205, JCR1958
	1000- seed wt. (g)	EC125940, JCR1957, IC412762
Wild Cicer	Days to 50% Flowering (d" 128 days)	*C. reticulatum*: EC1078506, EC1078641, EC1078643, EC1078644, EC1078647, EC1078650, EC1078653, EC1078655, EC1078656, EC1078666, EC1078668, EC1078670, EC1078671, EC1078674, EC1078675, EC1078680, EC1078711
	Days to Maturity (≤ 152 days)	*C. reticulatum*: EC1078711 (150), EC1078639 (151), EC1078524, EC1078525, EC1078616, EC1078622*C. judaicum*: EC1078738, EC1078741, EC1078742, EC1078744
	Canopy height (cm) (≥ 25.7 cm)	*C. echinospermum*: EC1078835 (29.3) *C. judaicum*: EC1078737 (27.7), EC1078735 (27.3), EC1078732 (25.7), EC1078736 (25.7) *C. echinospermum*: EC1078776 (26.3) *C. reticulatum*: EC1078671 (25.7)
	Plant width (cm) (≥ 90 cm)	*C. judaicum*: EC1078734, EC1078736, EC1078733, EC1078737, EC1078747
	Number of tertiary branches/plant (≥ 89.7 cm)	*C. judaicum*: EC1078739, EC1078744, EC1078742, *C. reticulatum*: EC1078631, EC1078633, EC1078605
	Number of pods/plant (≥ 126.7 pods)	*C. judaicum*: EC1078734 (256.0), EC1078737 (175.3), EC1078735 (155.0)*C. reticulatum*: EC1078490 (169.3), EC1078491 (153.3), EC1078624 (141.7), EC1078489 (126.7) *C. pinnatifidum*: EC1078467 (134.7)
	100 seed wt (g) (≥ 11.7 g)	*C. reticulatum*: EC1078573 (13.6), EC1078487 (13.0), EC1078569 (12.9), EC1078707 (12.2), EC1078574 (11.7), EC1078564 (11.7)
	NDVI	EC1078487 (0.49), EC1078563 (0.47), EC1078624 (0.47), EC1078486 (0.46), EC1078635 (0.46), EC1078488 (0.45), EC1078489 (0.45)

4.2.9 Characterization and evaluation of buckwheat germplasm at NBPGR RS Shimla

Total 82 germplasm accessions were characterized for important agro-morphological characters. The data revealed substantial variation for plant height, number of inflorescence/plant and seed yield/plant. The trait seed yield/plant showed range of variation from 0.16-6.61 gm. and the average yield was recorded 1.02 gm. The accession IC125940, IC599205, JCR1958 was selected promising against seed yield, out of which an accession IC125940 revealed maximum seed yield/plant (6.61 gm). Likewise, the average number of inflorescence/plant was 15.88 and it ranged from 6.00-29.66, which resulted into identification of promising accessions EC125940, IC599205, JCR1962 (Table 4.2).

4.3 Characterization, evaluation and documentation of oilseeds germplasm

4.3.1 Evaluation of trait specific accessions in the field in different *Brassica* species

402 accessions of rapeseed & mustard germplasm comprising of (*B. rapa* var. yellow sarson-95, *B. napus*- 35, *B. juncea* -272 were evaluated for agro-morphological traits. Different Brassica species were evaluated for agro-morphological traits. *Brassica* accessions of species *B. carrinata* i.e., IC 491745 was validated for short height (< 190 cm) and IC555891 for early flowering (< 60 days), *Brassica rapa* var *toria* IC20167 was found early flowering (<45 days) and resistant to rust under natural field conditions. Variability was observed using agro-morphological parameters in 272 accessions of *B. juncea* germplasm. The promising accessions are listed in the Table 4.3.

4.3.2 Development of the core collection in linseed germplasm

The large-scale characterization for 36 traits on 2,576 linseed germplasm accessions was done for upto 6-year-location environments (4 seasons at Delhi and 2 seasons at Akola) to develop a multipurpose core collection maximising genetic diversity and representativeness of whole germplasm collection conserved at National Genebank of India (Fig. 4.9). The core set comprised of 259 accessions including 222 indigenous and 37 exotic collections. In addition, trait specific reference sets were also developed for 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.) for further validation at multiple locations.

Fig. 4.9. Aerial view of linseed field at NBPGR, IARI farm, New Delhi

4.4 Characterization of germplasm for core development in Chilli

Eleven hundred accessions of chilli were planted for characterization and evaluation for various agro-morphological traits during spring-summer season, 2022-23 at ICAR-NBPGR, New Delhi. Accessions *viz*., EC772771 (25.0), IC360866 (28.0), IC445618 (25.0) and EC773142 (28.0) were found early maturing taking less than 30 days for 50% flowering as compared to standard check variety Pusa Jwala (38). Accessions IC119549 (6), IC119523 (8), EC769427 (12) were recorded with more than 5 flowers per inflorescence in comparison to standard variety Pusa Jwala which produced only one flower per inflorescence. Accessions EC769427 were recorded with maximum number of flowers per inflorescence i.e. 12 flowers/inflorescence.

4.4.1 Validation of okra germplasm

Twenty two accessions were grown for 2nd year validation of resistance against Okra Yellow Vein Mosaic Disease (OYVMD) and 14 accessions for 3rd year validation in Randomized Block Design during *Kharif* season, 2022-23 at NBPGR, New Delhi. Sixteen accessions *viz*., EC169461, EC284324, EC762071, EC762072, EC773522, EC777159, IC043369, IC089726, IC094848,

Table 4.3: List of promising accessions for important agro-morphological traits in oilseeds

Crop/species	Trait	Promising accessions
B. rapa var. yellow sarson	Dwarf habit (<96 cm)	IC276251, IC333194, IC333195
	Silique on main branch (>70)	IC355391, IC393191, IC268310, IC361509
	Seeds/siliqua (>43)	IC267716, IC212107, IC268310, IC385660
	Maturity (<118 days)	IC423130, IC447820, IC447740, IC276251,
B. napus	Dwarf habit (<110 cm)	IC399682, IC298033
	Silique on main branch (>81)	EC389916-A, EC338967, EC400804
	Seeds/siliqua (>30)	IC267716, IC212107, IC268310, IC385670
B. juncea	Dwarf habit (<95 cm)	IC426383 (63.67), IC426386 (68.67), IC491368 (78.33), IC570302 (78.33), IC426337 (83.33), IC341164 (86), IC395536 (88), IC398763 (88)
	Early maturing (<98 days)	IC343199 (91), IC589691 (91), EC766320 (91), IC426386 (92), IC426394 (94), IC422169 (96)
	Main shoot length (>125 cm)	IC296702 (142), IC312514 (139), IC491229 (133.33), IC267702 (132), IC317528 (130.67)
B. juncea	Silique on main branch (>90)	EC367885 (138.4), IC491077 (112)
	Seeds/siliqua (>22)	IC491546 (25), IC426322 (25), IC355371(24)
	Siliqua length (>6 cm)	IC570324 (6.77), IC261633 (6.27), IC520754 (6.10), EC766024 (6.10), EC766133 (6.10)
Brassica campestris var. *sarson*	Days to flowering (<45)	IC20167, IC336399, IC417665
	Dwarf habit (<105 cm)	IC334817, IC212124, IC20167, IC267704
	No. of siliqua on main branch (>50)	IC520755 (60), IC399881 (76)
	Seed/siliqua (>40)	IC355343, IC267710, IC334291, IC267716, IC 355350
Brassica juncea	Main shoot length (>95cm)	EC766292, EC766148, IC697932
	No. of silique on main branch (>80)	EC766191

IC099745, IC116989, IC257217, IC264834, IC343414, IC347819, IC372198 were validated as highly resistant and 6 accessions viz., EC280751, EC777156, IC111244, IC325745, IC602400 as resistant to OYVMD in second year. Whereas, 14 accessions namely IC598240,

Table 4.4: List of promising accessions of chilli for agro-morphological traits

Crop	Trait	Promising Accessions
Chilli	Days to 50% flowering (<30 days)	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 (38)
	>5 flowers per inflorescence	EC769427 (12), IC119549 (8), EC769386 (7), IC119523(6), EC772705(6), Check-Pusa Jwala (1)
	Pedicel length (cm)	EC559441 (6.0), IC608881 (5.2), EC559437 (4.8), IC632430 (4.8), IC361627 (4.5)Check-Kashi Anmol (2.6), Pusa Jwala (2.6)
	Fruit length (cm)	EC759977 (10.4), EC777201 (10.1), EC559673 (10.0), EC759971 (9.6), Check-Pusa Jwala (5.3)

EC769427 (12) IC119549 (8) IC119523 (6)

Fig. 4.10. Accessions showing more than five flowers per inflorescence

Fig. 4.11. Characterization of chilli germplasm for agro-morphological traits

IC598457, IC598737, IC598738, IC598747, IC620568, IC620570, IC620571, IC620573, IC620574, IC620575, IC622454, JBS/17-87-A, JBS/17-88 were validated as highly resistant to OYVMD during third year.

4.5 Germplasm evaluation for biotic stress

4.5.1 Screening of barley core collection for spot blotch resistance

Spot blotch or foliar blight caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker is more damaging than other diseases, causing major reduction in quality and grain yield of barley crop. Diverse barley germplasm in the form of core collection (678 accessions) was screened under artificial epiphytotic conditions at hot spot location- Varanasi during *Rabi* 2021-22. Data was recorded on Double digit score (DD score) at weekly intervals from flowering to hard dough stage. One accession namely, IC0533383 was found to be highly resistant and 4 accessions (EC0492129, EC0492331, IC0138279, EC0578298) as resistant.

4.5.2 Screening of maize germplasm for MLB resistance

A set of 9 inbred lines along with resistant (DML 1851) and susceptible check (CM 500) screened out of 100 inbred lines over two years (*Kharif* 2020 & 2021) was again evaluated in single row plot of 3m length at a spacing of 20 cm×75 cm during *Kharif* 2022 under artificial epiphytotic conditions at hot-spot locations *viz.*; Delhi, Ludhiana and Karnal for exploring durable resistance to MLB [*Bipolaris maydis* [(Nisikado & Miyake) Shoem] following RBD with four replications. The disease severity was recorded following a uniform rating scale of 1-9 (dˆ3.0 = Resistant; >5.0 = Susceptible/highly susceptible) (Hooda *et al.*, 2018). The disease data were analysed using R. The data analysis showed 4 lines resistant to MLB at all three locations (Score dˆ3.0). The disease mean score of these 4 inbred lines are IC0620992 (DML-1575) (Score 2.2), IC0621026 (DML-1828) (Score 1.53), IC0620960 (DML-1390) (Score 1.9), IC0621040 (DML-1851) (Score 2.53) compared to susceptible check (7.2) and resistant check (2.17). The resistant sources confirmed in the present investigation can successfully be utilized in future breeding programme for maize improvement in respect of high yield with disease resistance in the backdrop.

4.5.3 Artificial screening of *Brassica* germplasm under controlled environment against white rust

Rapeseed & mustard germplasm, its wild relatives and some introgression lines were screened and validated in multi-location trials in field conditions at ICAR-NBPGR, New Delhi & NBPGR RS, Jodhpur and under artificial conditions in collaboration with NIPB, New Delhi at National Phytotron Facility, ICAR-IARI, New Delhi against 10 isolates of *Albugo candida.* A total of 350 accessions of *Brassica* germplasm were screened for resistance against nine isolates of *A. candida* isolates. Among *B. juncea* germplasm, five accessions, EC766193, IC265495, EC766061, EC766595 and IC443623 showed immune response against six isolates; three accessions namely, EC766293, EC766207 and EC766617 showed immune response against five *A. candida* isolates; seven accessions, viz., EC766192, EC766148, EC766164, EC766576, EC766198, EC766219 and EC766030 showed immune response against four *A. candida* isolates; 10 accessions namely, EC765823, EC766136, EC766147, EC766596, EC766145, EC766230, EC766272, EC765692, EC766028 and EC766412 showed immune response against three *A.*

candida isolates; 11 accessions namely, EC766315, EC765510, EC766134, EC766211, EC766430, EC765514, EC766141, EC766191, EC766143, EC766292 and EC766437 showed immune response against two isolates; another 11 accessions, *viz*., EC766316, EC399312, EC414324, EC765416, EC766306, EC766313, EC765812, EC765098, EC766091, IC571687 and IC589651 showed immune response against one isolate of *A. candida.*

4.5.4 Screening of wild relatives of *Brassica* under artificial inoculated conditions against white rust

Wild relatives of *Brassica* species *viz*., *Brassica oxyrrhina*, *Camelina sativa*, *D. erucoides*, *D. muralis*, *D. siettiana*, *Erucastrum lyratus*, *Erucastrum canariense*, two exotic accessions of *Crambe abyssinica viz*, EC694071 and EC694138 and three indigenous accessions of *Eruca sativa viz.*, IC57706, I62597, IC62599 were found immune (PDI = 0) against the five isolates of *A. candida* under environmentally controlled artificially inoculated conditions consecutively for two years.

4.5.5 Screening of *Brassica* germplasm for identification of resistant sources for *Sclerotinia sclerotiorum*

Screening of 56 accessions of *Brassica* germplasm (15), advanced (22)/ introgressed lines (16) and released cultivars (3) under field conditions with artificial inoculation at Research Farm, ICAR-NBPGR, New Delhi revealed that EC766191 and IC20167 were resistant against *S. sclerotiorum* on the basis of lesion length on stem.

4.5.6 Screening of *Brassica* germplasm for orobanche tolerance

1000 accessions of *B. juncea* were screened for orobanche tolerance at SKNU, Jobner under field condition. Out of them 9 accessions i.e., EC766210, EC766038, EC766380, EC766489, IC310732, EC766144, IC401468, IC492643, IC400082 found tolerant to orobanche. Accessions IC76730, IC426386 found very susceptible as all plant died because of orobanche infestation.

4.5.7 Validation of yellow mosaic resistant (YMD) resistant soybean germplasm

Yellow mosaic disease (YMD) is a serious disease of soybean *(Glycine max)* affecting soybean productivity in different proportions in various areas. From amongst 500 accessions previously screened, 20 accessions were identified as potential germplasm which were further evaluated in RBD with 3 replications along with resistant as well as susceptible checks during *Kharif* 2020-21. Uniform spread of infestation was ensured by planting highly susceptible check JS335 as infector line after every two rows. White fly insect being the potential carrier of the disease, white fly count (WFC) and disease incidence (DI) over different phases of crop growth were also recorded. WFC showed significant positive correlation with leaf length (0.5), leaf width (0.4) and plant height (0.5). However, DI did not show any association with WFC which indicated that expression of YMD resistance in the resistant or susceptible genotypes is due to innate resistance mechanism irrespective of the white fly population count on the individual genotypes. The two accessions (EC993255 and EC1037786) also showed very high potential for the resistance against YMD (DI-0 and DI-0.49 respectively) despite high occurrence of white fly count on these genotypes (Count-52.73 and 75.93). Besides resistance, both of these accessions (EC993255 and EC1037786) also expressed early maturity (~ 95 days) compared to late resistant checks (JS335-113 days and JS-99 days) at Delhi. The PCR mediated detection revealed the presence of mungbean yellow mosaic virus (MYMV) in the crop at the hotspot New Delhi location. Furthermore, during *Kharif* 2022-23 the resistance of these accessions was also expressed and validated at Delhi, Ludhiana (Punjab) and Pantnagar (Uttarakhand).

4.5.8 Identification of YMD resistant accessions among early maturing photo-insensitive germplasm of soybean

Based on 3 seasons (summer 2021, summer 2022 and *Kharif* 2022) evaluation, three accessions namely; EC0034081 (83 days), EC0034402 (82 days) and EC993184 (77 days) were found early maturing (< 85 days) as compared to early maturing checks JS-2034 (99 days) and NRC-138 (83 days). Apart from early maturity, these accessions also combined YMD resistance compared to above mentioned early checks (Table 4.5).

Table 4.5: Details of some potential genotypes for early maturity and YMD resistance

S. No.	Trait	Accession
1.	YMV resistance	EC1037796, EC993255, IC501476, IC243536
2.	Early maturity combining YMD resistance	**EC0034081, EC0034402, EC993184,** EC39152, EC771172

*Accessions in bold letters are evaluated for 3 seasons for maturity duration.

4.5.9 Screening of capsicum wild species and interspecific hybrids against chilli leaf curl disease

Chilli wild species and their interspecific hybrids were screened against chilli leaf curl disease under natural epiphytotic as well as challenge inoculation conditions at ICAR-NBPGR, New Delhi and ICAR-IARI, New Delhi. Accessions EC772795 and EC787133 (*C. baccatum*), EC787119 (*C. frutescence*) were found resistant against ChiLCD under both natural epiphytotic and artificially challenged conditions at Delhi. Interspecific crosses between *C. chinense x C. frutescens*, *C. chinense x C. annuum* and *C. tovari x C. annuum* exhibited highly resistant reaction to Chili leaf curl disease along with desirable traits under natural and artificially challenged conditions at Delhi. The F_1 plants of interspecific hybrids were selfed to obtain the pure seed of F_2 population for inheritance studies during next year. F_2 population derived from the interspecific cross *C. chinense* (Tripura Sel-1) *x C. annuum* (EC771555) comprising 189 plants was screened under field conditions at Delhi. The results revealed that the resistant and susceptible plants were segregated into 3:1 ratio (135 resistant and 54 susceptible plants) suggesting that the resistance carried by accession EC771555 is controlled by a single dominant gene.

4.5.10 Validation of chilli germplasm against Chilli leaf curl virus disease

A set of 25 accessions of chilli resistant to ChiLCD were grown for second year validation against ChiLCD under natural epiphytotic conditions during *Kharif* season 2022-23 at ICAR-NBPGR, New Area Farm, New Delhi. Fifteen accessions viz. EC769438, EC692283, EC769378, EC759958, EC769427, EC769434, EC769376, EC769434, EC771555, EC771556, EC771557, EC773729, EC772795, EC787141 and EC790579 were found resistant to Chilli leaf Curl Disease at Delhi. Accessions EC769438, EC771555, EC787119 (*C. frutescens*), EC787133 (*C. baccatum*), EC772795 (*C. baccatum*), EC790590 (*C. tovari*) were found tolerant to mites and thrips. Some of the chilli selections viz., EC928988-1, EC769378-1, EC771556-1 and EC771559-2 were identified as tolerant to Chilli leaf curl virus disease, mites and thrips. Based on the observations recorded on agro-morphological and physiological traits like pollen viability, canopy temperature, number of fruits per plant and fruit set (%), some of the promising heat tolerant accessions have been identified as mentioned in the Table 4.6.

4.5.11 Validation of fusarium wilt resistant germplasm of garden pea

About 11 accessions were grown in artificially created sick pots against *Fusarium oxysporum* fsp. *pisi* (*Fop-1)* for second year validation at the Research farm of Division of Vegetable Science,

Table 4.6: Promising accessions of chilli against ChiLCD, mites and thrips

Crop	Trait	Promising Accessions
Chilli	Resistant to ChilLCD	EC769438, EC692283, EC769378, EC759958, EC769427, EC769434, EC769376, EC769434, EC771555, EC771556, EC771557, EC773729, EC772795, EC787141 and EC790579, EC787119 (*C. frutescens*), EC787133 (*C. baccatum*), EC772795 (*C. baccatum*)
	Tolerant to mites and thrips	EC769438, EC771555, EC787119 (*C. frutescens*), EC787133 (*C. baccatum*), EC772795 (*C. baccatum*), EC790590 (*C. tovari*)
	Heat tolerant	IC762291, IC608877, IC607252, IC632424, IC632423, IC631918, IC613919, IC537583, IC,119618, IC116194, IC255890, EC402118, EC777196, EC777201, EC559470, EC559502, EC559669, EC559671, EC559673, EC559977
Pea	Resistant to fusarium wilt	EC598616, EC598687, EC598656, IC279217, EC387624, EC269301, EC865952, EC598656, EC593753, IC552767 and IC469139

IARI, Pusa Campus, New Delhi during *Rabi* season 2021-22. In second year, screening trial of garden pea, accessions viz., EC598616, EC598687, EC598656, IC279217, EC387624, EC269301, EC865952, EC598656, EC593753, IC552767 and IC469139 were validated for resistance against fusarium wilt.

4.5.12 Multiplication of Faba bean International Chocolate Spot Nursery

Twenty-five genotypes including check Rebya-40 were multiplied at Issapur farm during *Rabi* 2021-22 and a trial was constituted to be conducted at ICAR-NBPGR, Bhowali during *Rabi* 2022-23 for evaluation and selection of Chocolate Spot resistant genotypes.

4.5.13 Validation of okra germplasm under CRP-Agrobiodiversity on okra

Twenty-two accessions were grown for 2nd year validation of resistance against Okra Yellow Vein Mosaic Disease (OYVMD) and 14 accessions for 3rd year validation in Randomized Block Design during *Kharif* season, 2022-23 at NBPGR, New Delhi. Sixteen accessions viz., EC169461, EC284324, EC762071, EC762072, EC773522, EC777159, IC043369, IC089726, IC094848, IC099745, IC116989, IC257217, IC264834, IC343414, IC347819, IC372198 were validated as highly resistant and 6 accessions *viz*., EC280751, EC777156, IC111244, IC325745, IC602400 as resistant to OYVMD in second year. Whereas, 14 accessions namely IC598240, IC598457, IC598737, IC598738, IC598747, IC620568, IC620570, IC620571, IC620573, IC620574, IC620575, IC622454, JBS/17-87-A, JBS/17-88 were validated as highly resistant to OYVMD during third year.

4.6 Project activities and achievements during *Rabi* 2021-22 under CRP-Agrobiodiversity

A total of 581 wheat accessions were evaluated during *Rabi* 2021-22 for biotic stress traits, yellow rust (PAU, Ludhiana and IIWBR, Karnal), powdery mildew (IARI, RS, Wellington), loose smut (VPKAS, Almora) Table 4.7. Also, promising accessions over the locations and years were validated for respective traits.

Biochemical analysis of grain samples (424 acc.) from NBPGR, Delhi was carried out at IIWBR, Karnal for protein content, hectolitre weight and sedimentation value.

4.7 Germplasm evaluation for abiotic stress

4.7.1 Evaluation of National genebank core and global durum panel for drought tolerance

A set of 750 *Triticum durum* wheat accessions belonging to national genebank core and global durum panel including five checks (HI 1531, HI 8663, HI8627, UAS 428, MACS 4028) was evaluated at NBPGR Issapur Farm, New Delhi in augmented block design during *Rabi* 2021-22. These accessions were grown under irrigated and

Table 4.7: Promising accessions identified in wheat germplasm

Traits	Locations	Promising accessions
Powdery Mildew	IARI-RS, Wellington	54 acc. (IC118774, IC531559, IC 535301, IC535118, IC47048, IC277713, IC47800, EC11071, EC12941, EC577406, EC11232, EC577400, IC138418, IC448026, IC35167, IC35170, IC35171, IC47026, EC06902, EC06908, EC08572, EC11389, IC535070, IC535072, IC535073 etc.)
Loose smut	VPKAS, Almora	Confirmed Sources (EC595317, IC589300, IC 598580, EC612492, EC598077, EC597830, EC631996, EC53058, EC530183, IC596979, EC595183, EC277186, EC675845, IC281806, EC105957, EC597878, IC610815
Yellow rust	IIWBR, Karnal and PAU, Ludhiana	EC299111, EC299157, EC577932, GDP 15, GDP 45, GDP 142, GDP 144, GDP 148, GDP 157, GDP 191, GDP 197, GDP 255, GDP 260, GDP 261, GDP 272, GDP 286, GDP 420, GDP 424, GDP 427, GDP 911, GDP 963
Quality traits Protein content > 15%	IIWBR, Karnal	IC535236, IC535244, IC535267, IC535269, IC535278, IC535647, IC535770, EC313746, EC374955, IC138348, IC138349, IC53387, IC212160, IC420038, EC313761, EC187182, EC182958, EC180041, EC182947, IC277738IC617424

drought stress conditions. Data were recorded for 18 morpho-physiological traits. Superior accessions identified under drought conditions over the best check (HI1531) based on grain yield were GDP319, GDP21, GDP552, GDP15, IC252638, IC533789, IC529557, HI8627, GDP4, IC78714 and for 1000 grain weight IC128675, IC252755, EC10596, GDP235, IC335772, GDP292, IC78714, GDP425, EC57706, EC299082 were superior.

4.7.2 Evaluation of Indian dwarf wheat (*Triticum sphaerococcum*) germplasm for terminal heat stress tolerance and drought stress tolerance

A set of 45 *Triticum sphaerococcum* wheat accessions including six checks (HD-2967, C-306, Raj-3765, WR-544, HI-1531, HD-2932) was evaluated at NBPGR Issapur Farm, New Delhi in alpha lattice design with two replications during *Rabi* 2021-22. These accessions were grown under normal, drought stress and late sown conditions. Data were recorded for 18 morpho-physiological traits. Superior accessions identified over the best check (WR544) based on Drought Susceptibility Index for grain yield were EC10494, EC187181, EC180062, EC187183, EC187167, EC182959, EC182945, EC10494, EC10492, EC182958, EC180041, EC13058, EC13056, EC13054, EC180040. Similarly under late sown condition, IC533826, EC576643, EC313761, EC613057, EC187182, EC182959, EC182945, EC10494, EC180041, EC180067, EC187176, ADP19/101, W-1614, EC13058, EC13056, EC13060, EC13054, EC13052, EC180040 were found superior based on Heat Susceptibility Index for grain yield in comparison to best check HD2932.

4.7.3 Evaluation of *dicoccum* wheat against terminal heat and drought stress under NICRA project

Under NICRA project, 196 accessions of *dicoccum* wheat germplasm were grown for evaluation against terminal heat stress and drought stress at ICAR-NBPGR Farm, New Delhi (Fig. 4.12) in alpha lattice Design under normal sown, late sown and drought conditions using six checks, DDK1025, DDK1029, C306, IC531969, MACS2925 and Raj 3765 during *Rabi* 2021-22. Observations were recorded for sixteen agro-morphological and physiological traits. Promising germplasm were identified under terminal heat stress condition for traits namely, Days to spike emergence: IC118765, IC28596, IC35119, IC35093, IC35097, IC35091, IC118763, IC534018 (<70 days); grain yield: IC593663, IC551396, EC590345, IC591073, IC535117, IC551397, IC547564, IC530555, IC138418, IC402012, EC577412, IC535071, IC212168, IC35167 (>250g); Similarly, promising germplasm were identified under drought stress condition for traits namely, days to spike emergence: IC35091, IC118763, IC118765, IC28596, IC35097, IC35119, IC534018, IC35093 (<78 days); grain yield: EC590345, IC138418,

Fig. 4.12. Evaluation of *Triticum dicoccum* wheat germplasm against terminal heat stress and drought stress at ICAR-NBPGR, New Delhi

EC11232, IC112083, EC577401, EC577412, EC577406, IC138472, IC535086 (>250g).

4.7.4 Evaluation of barley core collection for terminal heat tolerance

Barley core collection (678 accessions) was grown for evaluation against terminal heat stress at ICAR-NBPGR, Issapur farm in Augmented Block Design under normal sown and late sown conditions for second consecutive year. Observations were recorded for various agro-morphological and physiological traits. Promising germplasm were identified under heat stress conditions for traits namely; days to spike emergence: IC0137999, EC0578712, IC0138010, IC0138016, IC0138110, IC0138115, IC0138116, EC0578946 (<65 days); days to maturity: EC0578579, EC0408420, IC0533161, IC0138010, IC0138016, IC0138094, IC0138115, IC0138116, IC0073643, IC0079456 (<105 days); Tillers/plant: EC0177261, EC0578270, EC0578681, EC0492304, EC0667490, IC0551180, IC0137800 (>15); grain yield/plant: EC0578633, IC0397017, IC0445933 (>15 g); hundred grain weight: IC0138111, IC0138120, IC0138294 (>5g).

4.7.5 Development of reference set for drought tolerance in linseed germplasm

The entire collection (2,612 acc.) of linseed germplasm conserved at National genebank was screened under rainfed conditions at 3 locations (Delhi, Jhansi and Sagar) for consecutive two years (2020-21 & 2021-22) under DBT funded Linseed Network Project. The reference set for drought tolerance comprising of 200 accessions (150 tolerant, 17 moderate and 33 sensitive) was developed based on Stress Tolerance Index (STI) on yield data from multilocation-year environments. This set is being evaluated at 3 locations for further detailed physiological and agronomic evaluation and study of root system architecture under controlled (rainout shelter) conditions.

4.8 Biochemical evaluation

A total of 9,376 accessions of different crops comprising rice (745), wheat (564), amaranth (57), Chenopodium (74), foxtail millet (28), sesame (3752), linseed (2539), cowpea (520), urd bean (142), adzuki bean (179), moth bean (525), green gram (151) and *Brassica juncea* var rugosa

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

Crop (No. of Accs.)	Traits	Range (unit)	Mean ± St. Dev.	Superior Accessions
Cereals				
Rice (745)	Protein, starch,	Protein amylose, oil, dietary fibre, phytate	10.6 ± 0.46 (8.38-12.2%)	IC386358, IC206830, IC518120, IC85930, IC85930, IC612377 (>11), Best check-BPT5204 (8.4)
		14.8 -33.3%	26.1 ± 3.36	IC516811, IC518677, IC206040, IC516811, IC203309 (>28), Best check- BPT5204 (25.7)
Wheat (309 accessions)	Protein	9.13-20.7%	13.2 ± 1.54	IC296727, EC473090 (>19), Best check-PBW771 (12.5)
	Amylose	7.87-17.6%	14.2 ± 1.25	IC573902, IC317593, IC536488 (>16.5%), Best check-PBW771 (15.2)
Wheat (255 accessions)	Protein content	7.98 to 15.5%	12.4 ± 1.89	IC128620, IC260876, IC28749, IC445498, IC416073, IC290155,IC138595, IC402044, IC252392,IC177789, IC138600, HGP1-305, EC664204, EC664276, IC335711, IC252642, EC190943, IC111845, IC28872, IC252568, IC252816, EC574390, IC28649, IC138435, IC252472, IC335732, IC416089, IC584159, IC335712, IC252543, IC47528, IC335761, IC347884, IC252509, IC138617, IC28658, IC539574. (>14)

Crop (No. of Accs.)	Traits	Range (unit)	Mean + St. Dev.	Superior Accessions
Pseudocereals				
Amaranthus hypochondriacus (45 accs.)	Protein	11.53-15.90%	13.83+ 1.1	EC169790 (15.90), EC289393 (15.51), IC35363 (15.23), EC289385 (15.23), EC198127 (15.18), EC289384 (15.18), EC345797 (15.05), Best check-Durga 12.43
	Oil	7.29-9.10%	8.15+ 0.39	EC345797 (9.10), IC326896 (9.08),Best check-PRA-2 (8.48)
Amaranthus hypochondriacus (12 accs.)	Fatty acid profile	Palmitic Acid (17.69-21.96%)	19.81±1.11	
		Stearic acid (0.87-3.96%)	1.40± 0.84	
		Oleic acid (29.10-46.51%)	35.97±6.52	IC095308 (46.51%), IC094656 (43.56), IC095249 (43.30), IC042402 (38.54), IC095253 (37%)
		Linoleic acid (31.85-47.84%)	41.48±5.77	IC095277 (47.84), IC017926 (46.85), IC095304 (46.69)
		Linolenic acid (0.48-2.35%)	1.32±0.59	
A. Caudatus (10 accessions)	Fatty acid profile	Palmitic Acid (18.73-23.83%)	21.30±1.38	
		Stearic acid (0.95-1.49%)	1.23±0.17	
		Oleic acid (30.81-38.53%)	33.93±2.39	IC274467 (38.53), EC150190 (35.90), EC157415 (35.42), EC150189 (34.70)
		Linoleic acid (39.22-45.08%)	42.45±2.12	IC274465 (45.08), IC274451 (44.75), IC274463 (44.14), IC274449 (43.87)
		Linolenic acid (0.61-2.10%)	1.06±0.47	
Chenopodium quinoa (41 accs.)	Protein	11.89-16.11%	13.82 + 1.02	IC363733 (16.11), EC507738 (15.80), EC507747 (15.48), EC507746 (15.32)
	Oil	6.49-9.29%	8.13 + 0.54	EC896109 (9.29), EC896115 (9.24), EC896097 (9.15), EC896219 (8.97), EC896093 (8.92)
Chenopodium album (33 accs.)	Protein	11.75-15.64%	13.92+ 1.39	IC381106 (15.64), IC109235 (15.51), IC341707 (15.51), IC341700 (15.34), IC7957 (15.32), IC7213 (15.32), Best check-Himbathua (15.19)
	Oil	6.69-8.40%	7.53 + 0.41	IC7213 (8.40), IC341706 (8.32), Best check-Himbathua (7.74)
Oilseeds				
Sesame (3752 Accs.)	Protein	16.16-27.59%	22.09 ± 2.68	EC346572, EC11857-B (> 27), Best check- RT346 (24.57)
	Oil	30.88-55.89%	48.57 ± 3.09	IC0372575, IC0396454 (> 55), Best check- TMV-7 (53.54)
	Phytate	0.25-2.3%	1.96 ± 0.1	EC370536, EC346213, EC370500, IC0511064, IC0511090 (< 1), IFCT < 1% recommended

Crop (No. of Accs.)	Traits	Range (unit)	Mean ± St. Dev.	Superior Accessions
Linseed (2515 Accs.) (Validation)	Oil	30.14-54.64%	41.88±5.31	IC597274, EC541208, EC41720 (>54), Best check- JLS67 (45.02)
	Protein	14.11-27.37%	19.23±3.71	EC0041619, EC0041622 (>26), Best check- T397 (21.35)
Linseed (8 Accs.)	Fatty acid profile	Palmitic Acid (5.26-6.82%)	6.25±0.49	
		Stearic acid (4.92-7.77%)	6.02±0.89	
		Oleic acid (19.94-44.46%)	30.92±9.39	EC0041735 (44.46), IC0096494 (43.81)
Linseed (8 Accs.)		Linoleic acid (7.52-17.22%)	13.29±3.36	
		Linolenic acid (26.44-54.32%)	43.63±8.94	
Pulses				
Cowpea (520)	Protein, starch, amylose, dietary fibre, phytate, phenols, sugars	Protein (19.4-27.9%)	24.1 ± 1.49	EC390248, IC214752, EC 390263 (>26), Best check- GC-3 (25.2)
		Phytate (0.43 – 1.62%)	1.12 ± 0.22	EC390278 EC723824 (<0.5), Best check- GC-3 (0.8)
Urdbean (142 Acc.)	Protein, starch, amylose, dietary fibre, phytate, phenols, sugars	Protein (22.9-28.0%)	26.2 ± 0.938	IC0330874, IC0341031, IC331705 (>27), Best check- Mash 114 (24.7)
		Phytate (0.24 – 1.46%)	0.710 ± 0.22	IC297661, IC419987, IC485484 (<0.3), Best check- Mash 114 (0.63)
Adzuki Bean (179 Accs.)	Protein, starch, dietary fibre, ash, sugar, phenols, phytate, anthocyanins	Protein (18.5 - 28.2%)	24.4 ± 1.13	EC340240, EC340251, (>27), Best check- HPU-51 (25.7)
		Starch (29.4 - 50.1%)	42.5 ± 2.07	IC341955, EC281186 (>47); EC340251 (<30), Best check-HPU-51 (40.6)
Green gram (151 accs.)	Protein, starch, amylose, dietary	Protein (15.0-27.3) fibre, phenols, sugars	24.7 ± 2.16	IC148442, PLM305, IC354429 (>27%), Best check- PLM305 (27.1%)
		Phenols (0.07-0.70%)	0.273 ± 0.07	IC436605, PLM622 (<0.08), Best check- PLM622 (0.079)
Mothbean (525 accs.)	Protein, starch, amylose, dietary fibre, phytate	Protein (19.0-32.6%)	23.6 ± 1.34	IC39738, IC25938, IC36664 (>29), Best check- CZM-2 (24.5)

Crop (No. of Accs.)	Traits	Range (unit)	Mean ± St. Dev.	Superior Accessions
		Phytate (0.547 – 1.06%)	0.680 ± 0.061	IC113706, IC39640 <0.55), Best check- RMO-435 (1.506)
Brassica juncea var. rugosa leaves (100 accs.)	Ascorbic acid, Phenols, antioxidant activity, Anthocyanin, sugar, starch	Ascorbic acid (0.02-0.22%)	0.11±0.01	IC524259> 0.2), Best check- Pusa Sag (0.12)
Brassica juncea var. rugosa leaves (100 accs.)		Anthocyanin (0.004-0.150 mg/100g)	0.009±0.01	IC597939, IC386746 (>0.09), Best check- Pusa Sag (0.004)
		Sugar (0.50-2.49%)	1.58±0.04	IC597688, IC597889 (>2), Best check- Pusa Sag (1.56)
		Starch (0.20-2.65%)	1.69±0.02	IC517871, IC364031 (>2.4), Best check- Pusa Sag (2.0)
Foxtail Millet (28 accs.)	Moisture, ash, fat, total dietary fibre, protein, starch, sugar, total phenols, antioxidant activity, iron, zinc	Protein (10.9 - 16.4%)	13.5 ± 1.52	IC631445, IC624680, IC631447, IC632759 (>16), Best check- Lepakshi (13.4)
		Starch (36.4 - 64.1%)	46.5 ± 7.61	IC631487, IC631478 (>60), Best check-Lepakshi (56.3)
		Iron (1.86 - 11.3 mg/100g)	4.56 ± 2.01	IC631447, IC631488 (>9), Best check-CO-7 (5.56)
		Zinc (1.47 - 4.91 mg/100g)	2.82 ± 0.75	IC631447, IC624680 (>4), Best check-CO-7 (3.71)

(100) were evaluated for important biochemical traits. The details of results along with trait specific superior/promising accessions are provided in Table 4.8.

4.8.1 Validation of trait-specific accessions

Vernicia fordii accession IC278136 was validated for α-Eleostearic acid. Its seed were received from Shillong station and analysed for lipid profile. It contained 78.49% α-Eleostearic acid in comparison to previous value of 80.68%. In case of linseed, 24 accessions were grown at Issapur farm during Rabi 2021-22 and harvested seeds were analysed for oil content. Oil content ranged from 39.37 to 44.57% with an average value of 42.46% ± 1.59. Accessions IC0000538 (44.57%), EC0041735 (44.47%), IC0096488 (43.98%), IC0420772 (43.87%), IC0096494 (43.84), IC0268345 (43.64), IC0526058 (43.62) were found promising for oil content in comparison to best check Kartika 40.79.

4.8.2 Effect of Nitrogen treatment on protein content of *C. quinoa* germplasm

Effect of different nitrogen treatments on protein content of *C. quinoa* accessions viz. IC411825, EC507741, EC507744 and EC507749, was studied in *Rabi* 2020-21 in Randomized Block Design with five different nitrogen treatments viz. F0, Control; F1, 33%RDF; F2, 66%RDF; F3, 100%RDF; F4, 133%RDF at ICAR-NBPGR Issapur Farm. The available nitrogen of the soil was 294.99 Kg/ha. In two accessions, EC507741 and EC507749, the effect of nitrogen treatment was non-significant i.e. these two accessions showed higher seed protein content i.e. 13.82 and 13.70 %, respectively, even at control treatments. At 100% RDF treatment, these accessions had 14.76 and 14.41% seed protein content, respectively. So, these accessions showed better performance even at all treatments including low nitrogen levels. Further, accessions, IC411825 and EC507744 had significantly low protein content at control treatment i.e. 12.66 and 12.83% with respect to 100% RDF i.e. 14.47 and 13.62%, respectively. Three accessions had high protein content at 100%RDF and followed the order EC507741 (14.53%), IC411825 (14.47%), EC507749 (14.35%) and no significant seed protein content increase was observed with further increase in nitrogen content i.e. at 133% RDF level.

4.8.3 Tannin estimation in fababean germplasm

White flower selections which showed low tannin content in comparison to various checks using qualitative estimation method were grown in field during *Rabi* 2020-21 and harvested seed was analysed quantitatively for tannin estimation. Condensed tannin content was found low (negligible condensed tannin per cent Leucocyanidin equivalent) in white flower selections in comparison to checks. The results are being under validation in seed harvest of *Rabi* 2021-22.

4.8.4 Phytochemical evaluation of medicinal and aromatic plants

Quality evaluation of 86 accessions of medicinal and aromatic plants germplasm of *Bacopa monnieri* (31 accs.), *Moringa oleifera* (19 accs), *Costus speciosus* (8 accs.), *Zingiber zerumbet* (Wild Ginger-1 accs.), *Abelmoschus moschatus* (2 accs.), and *Ocimum* species (25 accs.) was performed during this period (Table 4.9 and Table 4.10). Promising accessions identified in *Bacopa monnieri* for high bacoside content were IC554588, IC554586, IC342108, IC353204, IC531621 and IC439118. Two accessions IC554588 and IC554586 were confirmed containing high bacoside content (>3%) in dry herb by HPTLC consequently over the years. *Zingiber zerumbet* (RCM/PK/BR/39) wild collection from Malkangiri district of Odisha grown at NBPGR Regional Station Cuttack was validated for presence of high Zermbone content (~80.67%) in rhizome essential oil by GC/MS for four consequent harvest seasons.

4.8.5 Essential oil profiling of *Ocimum Species* germplasm collected from Cuttack

Chemical profiling of essential oil isolated from 25 accessions of six *Ocimum species* showed species-specific chemical variation in oil composition and different chemotypes were noted based on major aromatic compounds identified by GC/FID in essential oil. The major chemotypes present in essential oil of *Ocimum species* were: (1) Eugenol and Thymol rich in *O. gratissimum*; (2) Eugenol, (E)-β-Caryophyllene and β-Elemene rich in *O. tenuiflorum* ; (3) Camphor rich in *O. americanum* ; (4) (E)-Methyl cinnamate rich in *O. basilicum* ; (5) Geranial, Neral and Methyl chavicol rich in *O. citriodorum* and (6) Camphor rich in *O. killimandscharicum* as listed in Table 4.10.

4.9 Pre-breeding for genetic base enhancement

4.9.1 Study of mode of inheritance and proposed genotypes determining seed coat colour in Flax

Yellow seeded flax is often looked for introducing golden oil extraction and targeted in breeding programmes. Its wild progenitor, *L. bienne* (pale flax), has potential to broaden the narrow genetic base of flax. Study of mode of gene action for seed coat colour in the interspecific progeny of flax was done. Reciprocal interspecific

B’B’Y’Y’ (Very dark brown) X bbyy (Yellow)

↓

B’bY’y (Yellowish brown)

	B’Y’	B’y	bY’	by
B’Y’	B’B’Y’Y’ (Very dark Brown)	B’B’Y’y (Brown)	B’bY’Y’ (Brown)	B’bY’y (Yellowish brown)
B’y	B’B’Y’y (Brown)	B’B’yy (Medium yellow)	B’bY’y (Yellowish brown)	B’byy (Medium yellow)
bY’	B’bY’Y’ (Brown)	B’bY’y (Yellowish brown)	bbY’Y’ (Medium yellow)	bbyY’ (Medium yellow)
by	B’bY’y (Yellowish brown)	B’byy (Medium yellow)	bbY’y (Medium yellow)	bbyy (Yellow)

Fig. 4.13. Proposed genetic constitution of parental genotypes and the resultant interspecific progeny for brown and yellow seed coat colour categories in flax

Table 4.9: Phytochemical analysis of Medicinal and Aromatic Plants germplasm for quality traits

Plant name (Accessions) (Common name) Plant part analyzed	Quality traits	Range	Mean ± Stdev
Bacopa monnieri (31) (Brahmi) Dry herb powder	Extractive yield (%) Bacoside (%) Total flavonoids (mg/g) Total phenols (mg/g GAE) Tannic acid (%) Apigenin (mg/g) Luteolin (mg/g) Ash (%)	27.41 - 31.39 0.84 – 3.40 20.68 – 65.72 7.90 – 25.65 3.19 – 5.73 0.003 - 0.048 0.001 - 0.025 10.73 – 17.09	29.40 ± 2.81 1.76 ± 0.72 46.70 ± 7.21 15.64 ± 2.90 4.21 ± 0.13 0.012 ± 0.010 0.012 ± 0.006 14.10 ± 1.49
Moringa oleifera (19) (Moringa) Dry leaf powder	Extractive yield (%) Total flavonoids (mg/g) Total phenols (mg/g GAE) Tannic acid (%) Fixed oil (%)	14.50 - 18.05 12.79 - 21.13 6.14 - 12.40 1.10 - 1.53 3.98 - 6.92	16.28 ± 2.51 16.43 ± 2.45 9.36 ± 1.57 1.28 ± 0.10 5.43 ± 0.78
Costus speciosus (8) (Crepe Ginger) Dry rhizome powder	Extractive yield (%) Total phenols (mg/g GAE) Total flavonoids (mg/g) Total sugar (%) Tannic acid (%) Fixed oil (%) Diosgenin (%) Ash (%)	9.92 - 13.37 4.85 - 7.68 7.33 - 11.89 1.53 - 3.31 1.59 - 4.84 1.42 - 1.76 0.03 - 0.07 7.71 - 13.33	11.68 ± 1.16 6.27 ± 1.11 9.75 ± 1.73 2.21 ± 0.52 3.42 ± 1.11 1.56 ± 0.10 0.05 ± 0.02 10.00 ± 1.76
Zingiber zerumbet (1) (Wild/Shampoo ginger) Dry rhizome powder	Extractive yield (%) Essential oil (%) Total phenols (mg/g GAE) Total flavonoids (mg/g) Tannic acid (%) Ash (%) Dry matter (%) Zerumbone (Area %)	12.67 - 15.42 0.86 - 1.67% 5.51 - 5.65 17.51 - 18.87 2.16 - 2.31 8.42 - 11.23 20.78 - 21.32 79.34 – 82.00	14.05 ± 1.94 1.27 ± 0.57 5.58 ± 0.10 18.19 ± 0.96 2.24 ± 0.11 9.83 ± 1.9 21.05 ± 0.38 80.67 ± 1.88
Abelmoschus moschatus (2) (Muskdana) Dry seeds	Extractive yield (%) 100 seed wt (g) Mucilage (%) Total phenols (mg/g GAE) Total flavonoids (mg/g) Tannic acid (%) Ash (%) Fixed oil (%) Total sugar (%) Essential oil (%) Moisture (%)	18.31 - 21.76 1.35 - 1.36 11.50 - 14.65 5.02 - 6.75 12.44 - 12.84 3.18 - 7.99 5.08 - 5.67 17.21 - 17.91 3.06 - 3.92 0.20 – 0.28 6.01- 9.22	20.04 ± 2.44 1.35 ± 0.01 13.08 ± 2.23 5.89 ± 1.22 12.64 ± 0.28 5.58 ± 3.40 5.38 ± 0.29 17.56 ± 0.49 3.49 ± 0.61 0.24 ± 0.06 7.62 ± 2.27

Table 4.10: Chemical composition of essential oil of six *Ocimum* species

Ocimum **species (accessions)**	**Major aroma compounds identified**
O. americanum (1)	**Camphor,** α-Pinene, Camphene, 1,8-Cineole, Myrtenol, (E)-β-Caryophyllene, β-Selinene, α-Selinene, *epi*-β-Eudesmol
O. basilicum (4)	**(E) -Methyl cinnamate**, Linalool, (Z)- Methyl cinnamate, epi-α-Cadinol
O. tenuiflorum (6)	**Eugenol, (E)-β-Caryophyllene, β-Elemene**, (E)-β-Farnesene, , α-Selinene, Caryophyllene oxide, α-Humulene
O. citriodorum (5)	**Neral, Geranial, Methyl chavicol, Linalool,** epi-β-Eudesmol, *trans*-Linalool oxide, (Z)-α-Bisabolene
O. gratissimum (7)	**Eugenol**, **Thymol,** Linalool, Verbenone, Carvacrol, (E)-β-Caryophyllene, Germacrene D, Caryophyllene oxide, α-Thujene, Myrcene, Limonene, γ-Terpinene, β-Selinene
O. killimandscharicum (2)	**Camphor,** Camphene, δ-3-Carene, (E)-β-Caryophyllene

crosses were performed: T397 X EC993389 and T397 X EC993391, of which EC993389 and EC993391 were yellow seeded pale flax, and T397 is brown seeded cultivated flax. F_1 seeds within both crosses were identical to maternal parent, while F_2 resulted in an intermediate phenotype, consistent with the maternal effect. These assumptions were validated with all the seeds obtained by growing 50 F_1 plants (bearing F_2 seeds) with no segregation for seed colour. However, segregation was observed on 804 and 599 plants of $F_{2:3}$ seeds in crosses T397 X EC993389 and T397 X EC993391 in 9:7 expected ratio of two broad classes of brown and yellow colour, validated with chi-square test. Nature of gene action inferred with the help of measures of skewness (> 0) and kurtosis (< 3) indicated additive gene action with complementary epistasis. Such interaction adequately accounted for extracting desirable transgressive segregants for yellow seed coat colour. This is also proposed that the genes B′ and Y′ together are responsible to produce brown seed coat colour in flax that act in additive fashion where the donor for dark brown seed coat colour has B′B′Y′Y′ genetic constitution and for yellow seed coat colour has bbyy genetic constitution.

S. No.	Individual genotype	Seed coat colour	Major seed coat colour	Genetic ratio
1.	B'B'Y'Y'	Very dark to dark brown	Brown	
2.	B'-Y'Y' B'B'Y'-	Brown	Brown	
3.	B'bY'y	Yellowish brown	Brown	9
4.	B'-yy bb Y'-	Medium yellow	Yellow	
5.	bbyy	Yellow	Yellow	7

Fig. 4.14. Genetic constitution of various genotypes producing brown and yellow seed coat colour classes in interspecific progeny of flax

4.9.2 Inter and intraspecific hybridization in Brassica

Some of the inter/intraspecific crosses attempted to create genetic variability in brassica were also found tolerant to powdery mildew and rust. Details are given in Table 4.11.

4.10 Development of cryopreservation protocol in *Momordica dioica*

Seeds are not preferred propagules for conservation of *Momordica dioica* as they show dormancy, unpredictable sex ratio in seedling progenies, and loss in viability during storage. Hence, developing cryoprotocol would be helpful in long term conservation of the true to type propagules of superior genotypes of spine gourd germplasm. Efforts were made to conserve the vegetative propagules of *M. dioica* using *in vitro* derived shoot-tips in one accession (RMDSG/ 2020-2). Shoots were multiplied using the protocol standardized thus far. Axillary and apical shoots (1mm and 2mm) were isolated aseptically under a microscope. The shoots were inoculated in 0.3M sucrose for 0, 24 and 48 h followed by cryopreservation using droplet vitrification technique. The shoot tips were suspended in loading solution for 20 min. followed by dehydration with chilled PVS2 for 20, 40 and 60 min. Axillary shoots (2mm long) pre-treated with 0.3 M sucrose for 24 h showed maximum survival (80%) as compared to other treatments after LN treatment. The protocol will be further optimized and is reported for the first time in this species.

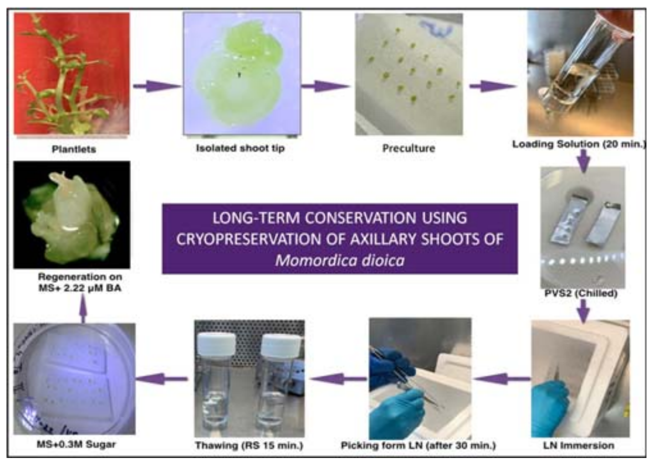


Fig. 4.15. Conservation of *Momordica dioica*

4.11 Establishment of multipurpose tree species in Field genebank

Collection and planting of under-utilised fruits, fodder trees, medicinal and aromatic trees, gum and resin yielding plants and RET species was continued in the year 2022-23 at Issapur farm of ICAR-NBPGR. Total number of species has now enhanced to seventy nine (79) belonging 38 families. Some of the important species are: *Santalum album, Syzygium cumini, Garcinia indica, Salvadora persica, Oroxylum indicum* etc. Maximum number of species belong to the family *Fabaceae* (13 species) followed by Rutaceae (6

Table 4.11: New interspecific crosses and generation advancement

Interspecific hybrid	Generation	Species	PM disease score
Powdery mildew resistance			
IC555891 X PJK	F_1	*B. carrinata* X *B. juncea*	<5
IC296828 X IC49624	F_1	*B. napus x B. juncea*	<5
White rust resistance			
IC265495 X RLM198	F_2	*B. juncea* X *B. juncea*	Delhi and Pantnagar
EC766148 X PJK	F_2	*B. juncea* X *B. juncea*	Delhi

species) and Myrtaceae (5 species). All the tree species that had been collected and planted have different uses such as fruits rich vitamins and minerals, medicinal trees, fodder and fuel wood trees etc. These are useful for nutritional, cultural and therapeutic needs of people (Table 4.12).

Table 4.12: Number of species having different use raised in the field genebank and biodiversity garden in the Issapur experimental farm of ICAR-NBPGR

SN	Economic Use	No of Species
1.	Underutilized fruits	36
2.	Medicinal trees	12
3.	Ornamental	4
4.	Fodder and fuel	7
5.	Vegetable	2
6.	Gums and resin	1
7.	Aromatic and essential oil	2
8.	Dye yielding	2
9.	Fat	1
10.	Katha	1
11.	Jigat for incense stick	1
12.	Timber	7
13.	Sports goods, walking stick	2

4.11.1 Monitoring of tree germplasm in field genebanks with the help of Passive RFIDs and Real Time Sensors (RTS)

Tree germplasm in Indian field genebanks are manually labelled, and tracked with the help of a field map/layout. Many a times these maps are lost, damaged and misplaced especially when the curators move out and a new person moves in. Most often, trees are wrongly labelled if any accessions are missing in between. Perennial germplasm requires periodic recording of observations, updating of database and compilation at the national level for access to the stakeholders such as students, researchers, academicians and policymakers. Manual operation of these activities from far off places is not only expensive, time consuming but also subjected to lots of error and mislabelling. Keeping this in view, a pilot project was initiated at 3 places such as ICAR-NBPGR, ICAR-CAFRI and ICAR-IIHR to monitor tree genebanks in real time as well as with a semi-automated system having passive RFIDs and interrogator. A mobile App and software to manage database in the server was developed for this purpose. Record of each accession can be uploaded with 10 images, 5 pdf documents, 3 audios and 3 videos.

4.11.2 RFID sensors and interrogator/reader

Thirty seven (37) passive RFID Tags were fixed on different tree species in the field genebank at Issapur, ICAR-NBPGR, New Delhi. Each record was configured to contain 10 basic information such as common name, scientific name, accession number, unique trait, health status (disease, insect pest, physical damage etc), year of plantation, age, place from which collected, latitude, longitude, name of location of the field genebank. RFIDs were placed at three different orientation (Fig. 4.16) i.e. (horizontal, vertical and inclined) on the tree trunk as shown in the figure. They were interrogated at every 1ft away from the tag upto 8ft. It was observed that vertical tags were better interrogated than the horizontal and inclined tags. Maximum average distance of scanning was 4ft in case of vertical placement followed by horizontal (2 ft) and inclined (1.5 ft).

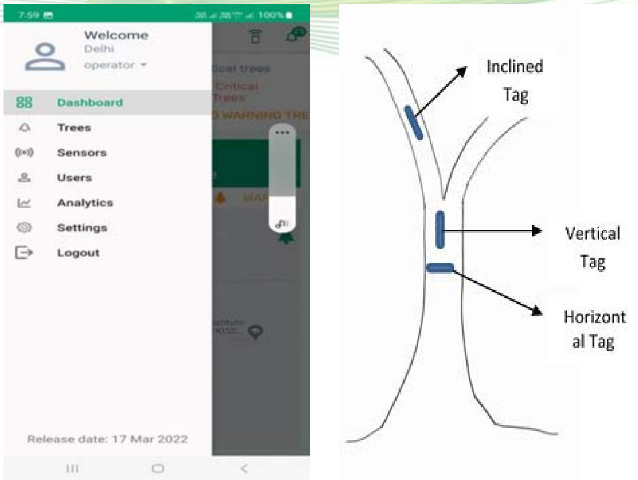


Fig. 4.16. Orientation of RFID tags on trees

Efficiency in terms of accuracy and time was also measured by locating trees on the field with the help of guide maps only. Respondents were given accession numbers randomly in 10 paper slips along with a layout/guide map. Accuracy percent varied from 20 to 100 percent depending upon acquaintance of the respondent with the field genebank. A person having very recent exposure to the genebank has the lowest accuracy and higher time to complete the work. Whereas with the help of RFID scanner, accuracy was 100 percent with an average time of 5 minutes to scan 10 trees.

Table 4.13: Interrogation distance of scanner from tags

SN	Direction	Avg distance (ft)
1.	Horizontal	2.0
2.	Inclined	1.5
3.	Vertical	4.0

4.11.3 Rear Time Sensors (RTS)

Fifty one real time sensors were installed on the trees. The chips are programmed with algorithms to detect any disturbance such as breaking, cutting which is alerted as shown in (Fig. 4.17). This would facilitate monitoring the status of tree germplasm of the field genebanks at a centralized facility and initiate corrective measures immediately. Some more features are being added to enhance performance of the system.

4.12 Germplasm supply and seed multiplication

4.12.1 Germplasm supply

During 2022, a total of 6,243 accessions of various crops, *viz*. wheat (966), barley (782), maize (149), linseed (169), brassica (339), sesame (311), pulse germplasm including chickpea, mungbean, urdbean and ricebean (3,527 accessions) were supplied to 54 indenters belonging to ICAR institutes, SAU and other research organisations engaged in crop improvement programmes. In addition, 501 accessions were sent for evaluation of wheat germplasm under CRP on Agro-biodiversity PGR management-component III.

RTS on a Ber tree

RTS on a Aonla tree

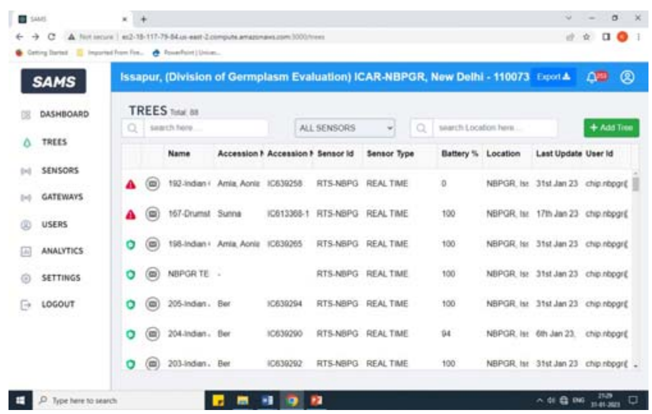


Fig. 4.17. Alerts in red mark for the trees that are threatened by external damage

4.12.2 Seed multiplication

A total 6 accessions of wild *Linum* sp. were multiplied and conserved under long term storage facility of National genebank, while 700 accessions of barley germplasm and 2,700 accessions of linseed were multiplied and conserved in medium term storage.

Research Programme (**Code:** Title, **Programme Leader**)
PGR/GEV-BUR-DEL-01.00 Characterization, evaluation and documentation of genetic resources of agri-horticultural crops (**R K Gautam**)
Research Projects (**Code:** Title, **PI**, Co-PIs and Associates)
PGR/GEV-BUR-DEL-01.01 Characterization, evaluation and documentation of wheat, barley and triticale germplasm (**Jyoti Kumari**, Sandeep Kumar, Sundeep Kumar, Vikender Kaur, Ruchi Bansal (till march 31, 2022), SK Kaushik and Pardeep Kumar and YS Rathi)
PGR/GEV-BUR-DEL-01.02 Characterization, evaluation and documentation of maize germplasm (**Ashok Kumar**, Jyoti Kumari, Ishwar Singh and K S Hooda)
PGR/GEV-BUR-DEL-01.03 Characterization, evaluation and documentation of pulses germplasm (**Gayacharan**, Kuldeep Tripathi, Rakesh Bhardwaj, Z Khan, Jameel Akhtar, and Babu Ram)
PGR/GEV-BUR-DEL-01.04 Characterization, evaluation, and documentation of oilseeds germplasm (**Rashmi Yadav**, Sandeep Kumar, RK Gautam, Vijay Singh Meena, Vikender Kaur, Mamta Singh, Jameel Akhtar, Sapna and BL Meena)
PGR/GEV-BUR-DEL-01.05 Characterization, evaluation and documentation of vegetable and ornamental crop germplasm (**Vinod Kumar** (w.e.f. August, 2022), SK Yadav, Pragya, Raj Kiran, Vijay Singh Meena, Bharat Gawde and Pooja Kumari)
PGR/GEV-BUR-DEL-01.06 Biochemical evaluation of field and vegetable crops germplasm (**Rakesh Bhardwaj**, Sandeep Kumar, Manjusha Verma, Vijay Singh Meena, Sapna, Nand Lal Meena)
PGR/GEV-BUR-DEL-01.07 Characterization and evaluation of medicinal and aromatic plants germplasm (**Archana P Raina,** Ashok Kumar, Ishwar Singh, KP Mahapatra, Rakesh Singh, RC Misra and BS Panwar)
PGR/GEV-BUR-DEL-01.09 Evaluation for abiotic tolerance in field crops germplasm stress (**Ruchi Bansal** (till march 31, 2022), Vikender Kaur, Jyoti Kumari, Rashmi Yadav, Gayacharan, Kuldeep Tripathi, Mamta Singh, MC Yadav and Nand Lal Meena)
PGR/GEV-BUR-DEL-01.10 Characterization of wild species and pre-breeding in selected crops (**Vinod Kumar**, Gayacharan, Kuldeep Tripathi, Mohar Singh, KS Hooda, MK Rana, M Latha, and R Gowthami, Celia Chalam and Era V Malhotra)
PGR/GEV-BUR-DEL-01.11 Characterization, evaluation and documentation of underutilized crops germplasm (**SK Kaushik**, Ishwar Singh, Sandeep Kumar, Rahul Chandora, Mohar Singh, SB Choudhary, Mamta Arya, Vartika Srivastava and Anuradha Agrawal)
PGR/GEV-BUR-DEL-01.12 Application of statistical techniques in management of information on plant genetic resources (**Hanuman Lal Raiger**)
Externally Funded Projects
"Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery" funded by DBT, GoI (PI: Rashmi Yadav)
"Leveraging genetic resources for accelerated genetic improvement of linseed using comprehensive genomics and phenotyping approaches" funded by DBT, GoI (PI: Vikender Kaur)
"Characterization of Chickpea Genetic Resource to Accelerate Genomics-assisted Crop Improvement" funded by DBT, GoI (PI: Gayacharan)
"Pre-breeding for genetic enhancement of chilli, beans & peas using crop wild relatives" funded by Alliance of Bioversity-CIAT (PI: Vinod K Sharma)
"Identification of indica and japonica sub-species of rice in the Indian national genebank for enhanced utilization" funded by Alliance of Bioversity-CIAT (PI: R K Gautam)
"Mainstreaming underutilized multipurpose tree species and fodder crops in semi-arid region of India" funded by Alliance of Bioversity-CIAT (PI: K P Mohapatra)
"National Mission for Sustaining the Himalayan Ecosystem: Agriculture" funded by DST, GoI (PI: K P Mohapatra) funded by Alliance of Bioversity-CIAT (PI: K P Mohapatra)
"Pilot the solutions of chip-based technology for real time and RFID passive monitoring of field genebank and agroforestry species for scaling up" funded by CIFOR-ICRAF (PI: K P Mohapatra)
"Tapping the potential of wild Vigna for cultivated Vigna improvement Programme" funded by Alliance of Bioversity-CIAT (PI: Kuldeep Tripathi)
"US Testing of Fababean" funded by PPV&FRA (PI: S K Kaushik)

5 DIVISION OF GENOMIC RESOURCES

कुल 16 कृषि–बागवानी फसलों के इक्यावन (51) नमूनों के लिए डीएनए फिंगरप्रिंटिंग सेवा प्रदान की गई थी। नोवेल जीनोमिक संसाधन सीसम, केसर, डोलिकोस बीन आदि जैसी फसलों में विकसित किए गए थे। एसएनपी जीनोटाइपिंग डेटा का उपयोग करके डुप्लिकेट जननद्रव्य की पहचान के लिए एक वेब सर्वर विकसित किया गया और कई प्रजातियों में मान्य किया गया। एसएसआर मार्करों का उपयोग करके ब्राउनटॉप बाजरा, छोटे बाजरा, कोदो बाजरा, चावल, गेहूं और अमरेन्थ सहित फसलों में आनुवंशिक विविधता अध्ययन किए गए थे। सुगंधित चावल भूभागों के विविधता विश्लेषण से उच्च स्तर के बहुरूपता का पता चला। सेसम और केसर में मानकीकृत नेक्स्ट–जेनरेशन सीक्वेंसिंग–आधारित जीनोटाइपिंग प्रोटोकॉल का मानकीकरण किया गया। कैप्सूल विकास के विभिन्न चरणों के दौरान कम और उच्च तेल–सामग्री जीनोटाइप पर ट्रांसक्रिप्टोमिक विश्लेषण किया गया था, जिसने उच्च तेल संचय प्राप्त करने के लिए बीज विकास के दौरान तेल जैव संश्लेषण की लंबी अवधि के महत्व को रेखांकित किया। जीनोम–वाइड एसोसिएशन अध्ययनों से अलसी में चावल और बीज वजन में पौधे की ऊंचाई के लिए जीनोमिक क्षेत्रों का पता चला। ओरिजा अल्टा में ड्राफ्ट स्तरीय क्लोरोप्लास्ट और पूरे जीनोम असेंबली तैयार की गई। गर्मी सहिष्णुता के लिए द्विदलीय और एमएजीआईसी आबादी के गेहूं के संकर अगली पीढ़ियों के लिए उन्नत किए गए। भारत की वन्य और खेती वाली मूसा प्रजातियों का लक्षण वर्णन प्लॉयडी और आण्विक डीएनए सामग्री के लिए प्रवाह साइटोमेट्रिक विश्लेषण के आधार पर की गई। एनआईआर–आधारित पूर्वानुमान मॉडल को खेत और सब्जी फसलों के जननद्रव्य में चीनी और स्टार्च सामग्री के आकलन के लिए विकसित किया गया। गेहूं के तीन आनुवंशिक स्टॉक विभिन्न वांछनीय लक्षणों के लिए पंजीकृत किए गए। अराबिडोप्सिस थैलियाना (3 नमूने) और मेडिकागो ट्रंकुलेटा (7 नमूने) सहित आयातित ट्रांसजेनिक खेपों के दस नमूनों का पीसीआर/रीयल–टाइम पीसीआर जांच को नियोजित करने वाले विशिष्ट आनुवंशिक तत्वों के लिए परीक्षण किया गया। इसके अतिरिक्त, आईएसओ/आईईसी17025:2017 मान्यता प्राप्त जीएम डिटेक्शन रिसर्च फैसिलिटी द्वारा कपास, पपीता, अरहर मटर और सोयाबीन की 23 खेपों के 54 नमूनों के लिए जीएमओ परीक्षण सेवाएं प्रदान की गईं। वास्तविक समय लूप–मध्यस्थ आइसोथर्मल एम्प्लिफिकेशन (एलएएमपी)– आधारित जीएम डायग्नोस्टिक्स विकसित किए गए और पिनII टर्मिनेटर अनुक्रम के तेजी से ऑन–साइट पता लगाने के लिए मान्य किए गए।

Summary: DNA fingerprinting service was provided for fifty-one (51) samples of 16 agri-horticulral crops. Novel genomic resources were developed in crops such as *sesamum*, safflower, dolichos bean etc. A web server for the identification of duplicate germplasm using SNP genotyping data was developed and validated in multiple species. Genetic diversity studies were undertaken in crops including, browntop millet, little millet, kodo millet, rice, wheat and amaranth using SSR markers. Diversity analysis of aromatic rice landraces revealed a high level of polymorphism. Next-generation sequencing-based genotyping protocols standardized in *Sesamum* and safflower. Transcriptomic analysis was performed on the low and high oil-content genotypes during the different stages of capsule development which underscored the importance of the longer duration of oil biosynthesis during seed development to obtain higher oil accumulation. Genome-wide association studies revealed genomic regions for plant height in rice and seed weight in linseed. Draft-level chloroplast and the whole genome assemblies were constituted in *Oryza alta*. The biparental and MAGIC populations crosses of wheat for heat tolerance were advanced to the next generations. Wild and cultivated *Musa* species of India were characterized based on flow cytometric analysis for ploidy and nuclear DNA content. NIR based prediction models were developed for the estimation of sugar and starch contents in field and vegetable crops germplasm. Three genetic stocks of wheat were registered for various desirable traits. Ten samples of imported transgenics consignments including *Arabidopsis thaliana* (3 samples) and *Medicago trunculata* (7 samples) were tested for specific genetic elements employing PCR/ real-time PCR assays. Additionally, GMO testing services were provided for 54 samples of 23 consignments of cotton, papaya, pigeon pea and soybean by ISO/IEC17025:2017 accredited GM Detection Research Facility. Real-time Loop-mediated isothermal amplification (LAMP)-based GM diagnostics developed and validated for rapid on-site detection of *pinII* terminator sequence.

5.1 DNA fingerprinting of crop varieties

Fifty-one (51) samples of 19 agri-horticultural crops, namely, buckwheat, chenopodium, chilli, cotton, fababean, horsegram, linseed, mung bean, mustard, oats, paddy, pea, soybean, taramira, wheat and urd bean were DNA profiled during the period under report for various public and private sector organizations. The DNA profiling was done using mostly mapped Simple Sequence Repeats (SSRs) markers except in few cases where SSR markers were not available. The crop-wise details for the number of samples are provided in the Table 5.1. By rendering DNA fingerprinting services, resources to the tune of Rs. 3,36,300.00 were also generated.

5.2 Development of a web server for the identification and removal of duplicate germplasm using SNP genotyping data

A germplasm duplicate identification and removal tool (G-DIRT) (http://webtools.nbpgr.ernet.in/gdirt/) were developed to identify and remove the duplicates based on genotypic information (Fig. 5.1). The duplicate identification can be carried out based on total genotypic difference and homozygous difference. An option for generating clusters based on selected distance matrix has been also incorporated. The clusters can be generated in 3 formats i.e., rectangular, triangular and circular. The web server also allows data pre-processing based on minor allele frequency, missing genotype data, linkage disequilibrium pruning, Hardy Weinberg's equilibrium, marker heterozygosity and monomorphic SNPs. G-DIRT has been validated for duplicate identification in many crops based on identity-by-state analysis using SNP genotyping data. Specifically, it has been extensively tested on wheat cultivars including 95 genotypes of *Triticum aestivum*, 173 genotypes of *Triticum dicoccum*, 1,011 genotypes of *Triticum durum* and 1,854 genotypes of tetraploid wheat subspecies from worldwide domestication and cultivation areas (*T. durum, T. dicoccum, T. dicoccon, T. turanicum, T. polonicum, T. turgidum, T. carthlicum, T. dicoccoides, T. aethiopicum, T. petropavlovskyi, T. ispahanicum, T. karamyschevii*). The tool has detected the wheat duplicate germplasms with a high accuracy of ~95% at 0.1% of homozygous genotypic difference.

5.3 Genetic relatedness among browntop millet genotypes based on SSR profiling

SSR profiling data of 57 browntop millet genotypes from Karanatka (Chitradurga,

Table 5.1: Details of samples DNA fingerprinted during 2022

S. No.	Crop	Scientific Name	Number of Samples
01	Buckwheat	*Fagopyrum esculentum*	1
02	Chenopodium	*Chenopodium sp.*	1
03	Chilli	*Capsicum annum*	1
04	Cotton	*Gossypium sp.*	5
05	Fababean	*Vicia faba*	1
06	Horsegram	*Macrotyloma uniflorum*	4
07	Linseed	*Linum usitatissimum*	1
08	Mungbean	*Vigna radiata*	7
09	Mustard	*Brassica sp.*	7
10	Oats	*Avena sativa*	4
11	Paddy	*Oryza sativa*	1
12	Pea	*Pisum sativum*	3
13	Soybean	*Glycine max*	2
14	Taramira	*Eruca sativa*	1
15	Wheat	*Triticum aestivum*	1
16	Urdbean	*Vigna mungo*	11
		Total	**51**

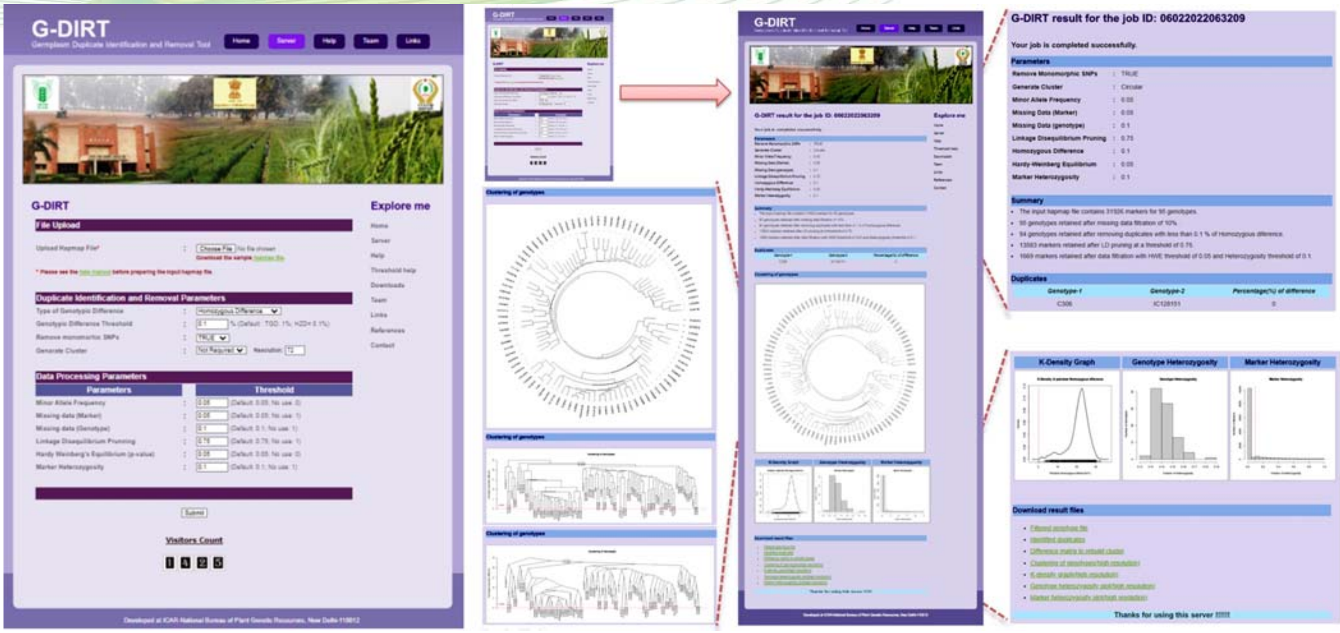


Fig. 5.1. The G-DIRT job submission page and visualization of the result of a G-DIRT job showing summary, duplicates, k-density plot, heterozygosity graphs and genotype cluster

Tumakuru, Haveri, Bijapur), Andhra Pradesh (Ananatapur, Nandyal), Gujarat and Odisha were scored and analysed. A total of 75 SSR primer pairs were used for analysis and an average of 5.42 alleles per locus was observed. Cluster analysis revealed different sub-groups (Fig. 5.2). Most of the genotypes from Karnataka were grouped together (I), similarly most of the genotypes from Andhra Pradesh were clustered (II). Genotypes from Gujarat, Odisha and of unknown origin were grouped in a different cluster (III) and these regions need to be explored thoroughly to collect more diverse germplasm of browntop millet.

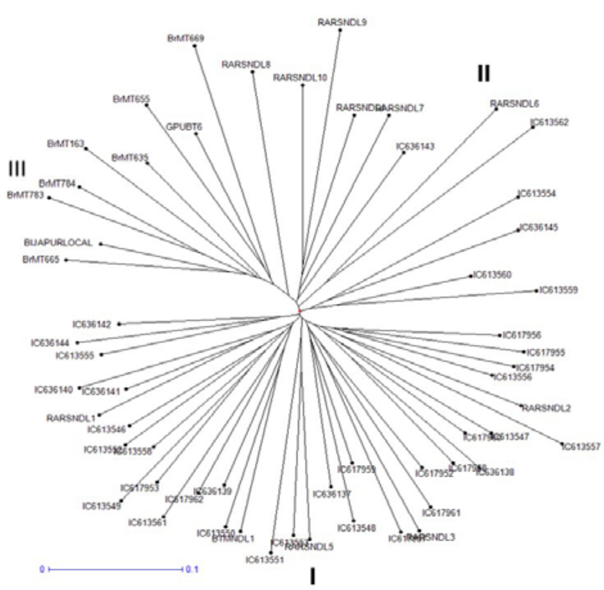


Fig. 5.2. Phylogenetic tree showing genetic relationship among 57 genotypes of browntop millet based on SSR profiling

5.4 Genetic relatedness among accessions of little millet (*Panicum sumatrense* Roth. Ex Roem. & Schult) based on SSR profiling

Allele scoring and data analysis of ninety-six accessions of little millet exhibiting variation for various traits including days to 50% flowering (39 to 118 days), thousand grain weight (1.12 to 3.487g) etc. was completed and 0/1 data matrix was subjected to DARwin 6.0 to construct a phylogenetic tree (Fig. 5.3). Close groupings of accessions having thousand grain weight more than 3.0 g in different sub-clusters were observed. Accessions having thousand grain weight less than 2.4 g were also closely grouped in different sub-clusters. Accessions showing days to 50% flowering between 97-112 days were closely placed and some of the early flowering accessions were also closely grouped.

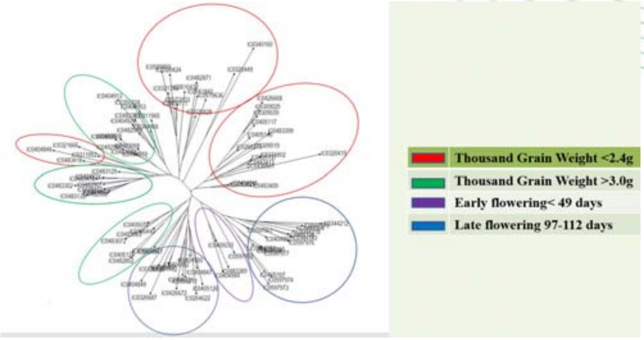


Fig. 5.3. Phylogenetic tree showing genetic relationship among 96 accessions of little millet based on SSR profiling

5.5 Genetic relatedness among accessions of kodo millet (*Paspalum scrobiculatum*) based on SSR profiling

A total of 74 diverse accessions with its diverse origin from 12 states of India were selected out of 2,397 accessions of kodo millet available at NGB, ICAR-NBPGR. These accessions were characterized using 39 In-house developed genic-SSRs loci and generated an average of 4.82 alleles per locus showing significant variation in the germplasm studied. Allelic data was converted to 0/1 data matrix and subjected to statistical analysis using unweighted neighbor-joining method of DAR win 6.0 to generate phylogenetic tree. Two major clusters (I and II) (Fig. 5.4) were observed, most of the accessions from Tamil Nadu were placed in cluster I with accessions from Andhra Pradesh, Maharashtra, Madhya Pradesh and Gujarat as outliers. Accessions from Uttar Pradesh, Chhattisgarh, Bihar, Kerala, West Bengal and Odisha, were present only in Cluster II. Accessions from Bihar were closely grouped with accessions from Chhattisgarh. All the accessions from Uttar Pradesh were closely grouped. Loose groupings based on geographical origin/ biological status were observed.

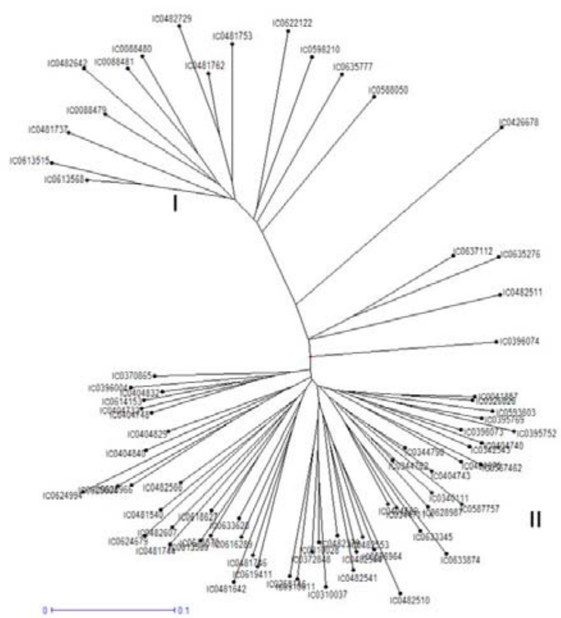


Fig. 5.4. Phylogenetic tree showing genetic relationship among 74 accessions of kodo millet based on SSR profiling

5.6 Genetic diversity and population structure study in grain Amaranth (*Amarthus hypochondriacus*) using genome wide novel SSR markers

The genetic diversity and population structure of 94 accessions of grain amaranth was studied using 57 genomic SSR (g-SSR) markers that were developed in-house. A total of 138 alleles were amplified across 36 g-SSR markers, with a mean value of 3.83 alleles per locus. The major allele

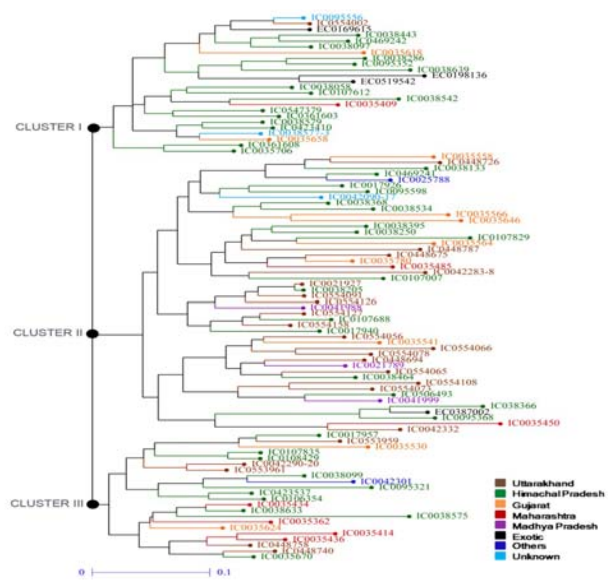


Fig. 5.5. Neighbor-Joining tree analysis across 94 accessions of grain amaranth. Three major clusters were observed. Different colors denote the accessions belonging to different states

frequency showed a range of 0.28 to 0.98 with an average of 0.63. The gene diversity (expected heterozygosity) calculated among 36 g-SSR loci varied from 0.03 to 0.81, with a mean of 0.46 per locus. To further investigate the genetic relationships among the studied amaranth accessions, a neighbor-joining tree was constructed based on 36 g-SSR loci. The results based on genetic distance as observed in the N-J tree clustered 94 amaranth accessions into three major genetic clusters (Fig.5.5). The model-based population structure analysis of the 94 studied accessions revealed the presence of two different genetic populations. Population I contained 46 accessions and population II comprised of 48 accessions without any admixture. In this study, no separate groups were observed based on geographical origin. The lack of significant association between genetic divergence and geographical diversity denotes that factors other than geographical origin contribute to genetic diversity. The diversity indices represented a substantial amount of molecular diversity among 94 accessions with the in-house developed g-SSR markers. Thus, these markers could be added as new desirable genomic tools for further studies related to characterization of germplasm banks and future breeding programs.

5.7 Genetic diversity assessment in bread wheat accessions using SSR markers

Molecular analysis of a select sub-set of 96 accessions drawn from a large set of trait-specific germplasm for heat-stress tolerance of bread wheat was carried out using hypervariable set of 25 SSR markers (Fig. 5.6). Twenty-five SSR loci amplified a total 263 alleles with 10.52 alleles per locus. The high values of Shannon's information index (av. 1.99) and PIC (av. 0.69) revealed high extent of genetic diversity in bread wheat germplasm. Average expected heterozygosity value of 0.81 indicated the presence of very high genetic divergence between sub-populations. Similarly, high estimates of gene flow (mean 2.38) revealed the presence of high extent of genetic variation between different accessions. However, F_{ST} showed the presence of moderate levels of molecular diversity between 96 accessions of bread wheat. UPGMA dendrogram separated the clusters at 0.30 Dice's similarity. 96 accessions were grouped into six major clusters. Clusters-I and -II consisted of 22 accessions each, cluster-III comprised of 16 accessions, cluster-IV had 15 accessions and cluster-V grouped 17 accessions, whereas cluster-VI was the smallest cluster containing only 4 accessions.

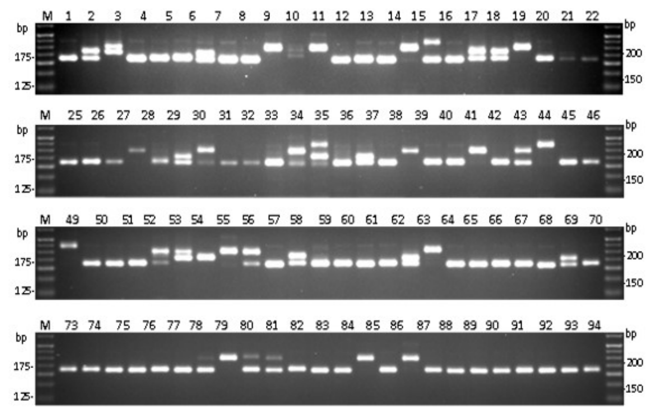


Fig. 5.6. Molecular profiles of 96 accessions of bread wheat amplified using primers for microsatellite locus wmc773 located on chromosomes 5B and 6D

5.8 Development of MAGIC populations in bread wheat

Progenies of bi-parental and MAGIC populations were sown during third week of January 2022 for exposing the breeding materials to high temperature (35-38°C) during grain filling and to impart adaptation to heat-stress. From 8-way crosses, 4020 plant progenies were harvested as 2nd cycle self-seeds and 1940 progenies of 4-parental and 5-parental MAGIC harvested as 4th cycle of self-seeds during *Rabi* 2021-22. A total of 680 plant progenies of two crosses and 440 plant progenies of three crosses between terminal-heat stress tolerant and susceptible lines were advanced to obtain F_9 and F_8 seeds (Fig. 5.7). Two bread wheat accessions namely IC534929 and IC449061 were selected for early maturity trait. The wheat field trial was monitored by ADG (AAF &CC), ICAR, New Delhi (Fig. 5.8).

Fig. 5.7. Field view of bi-parental and MAGIC populations developed for heat-stress grown in 2021- 22 *Rabi* (A). Bread wheat accessions IC534929 and IC449061 with early-maturity trait identified (B, C)

Fig. 5.8. Dr. S. Bhaskar, ADG (AAF & CC) visited ICAR-NBPGR NICRA wheat trial on 07-04-2022 and interacted with NICRA team members and other scientists

5.9 Molecular characterization of aromatic rice germplasm of Indo-Gangetic Plains of India

Ninety-two accessions of aromatic landrace germplasm collected from Indo-Gangetic region including 10 popular aromatic landraces of other states of India were characterized using 26 morphological characters. Landrace accessions displayed significant variation for plant height, culm length, flag-leaf length, panicle length, panicle exsertion, panicle bearing tillers, grain size, husk colour, pericarp colour and 1000-grain weight. First four principal components contributed 79% of phenotypic variation. Molecular analysis using 48 hypervariable microsatellite loci revealed the amplification of 11.0 alleles per locus, which clearly showed that a high level of DNA polymorphism exists between landrace accessions. The structure analysis showed the presence of four subpopulations in 96 accessions with numerous accessions showing allele sharing with other groups (Fig. 5.9). The gene diversity analysis revealed the presence of high amount of expected heterozygosity (0.83), Shannon's Information index (1.99) and high gene flow (1.51). This was also supported by high polymorphism information content (0.806). The landraces revealed the presence of private alleles. The unique and rare alleles could be used for DNA fingerprinting and differentiation of genotypes.

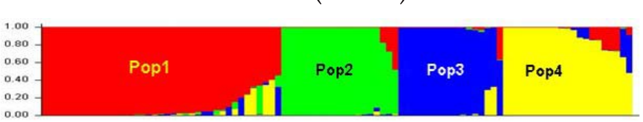


Fig. 5.9. Population structure of 96 aromatic rice accessions generated using STRUCTURE 2.3.4 software with K = 4

5.10 Development of EST-SSR in dolichos bean (*Lablab purpureus* L.)

Using a total 1129 unique ESTs of dolichos bean available in public domain, a total of 83 SSRs were identified. Among these EST-SSRs, tri-nucleotide repeats were most abundant (37) followed by tetra-nucleotide repeats (18) and di-nucleotide repeats (15). Ten of the identified SSRs were validated by successful PCR amplification in nine dolichos bean varieties (Fig. 5.10). The novel EST-SSR markers are expected to be helpful in genetic diversity studies as well as for varietal DNA fingerprinting.

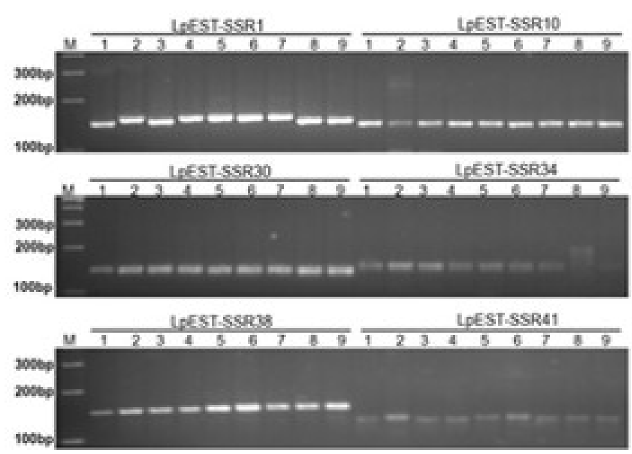


Fig. 5.10. Validation of EST-SSR markers on dolichos bean varieties

5.11 Genotyping of sesame germplasm using high throughput genomics

Initially, a set of 48 phenotypically diverse sesame accessions were subjected to single- and double- digest based genotyping through sequencing was performed utilizing the RAD strategy. The SNP call density across the 13 linkage groups of the sesame genome suggested for the uniform distribution of SNPs across the genome with few genomic regions in most of the linkage groups exhibiting SNP dense regions (Fig. 5.11). The comparison between these two datasets for an overall analysis result and the methodologies involved in generating data to decide the method of choice indicated for the double-digest based genotyping strategies that is being followed for the complete set of sesame genotypes.

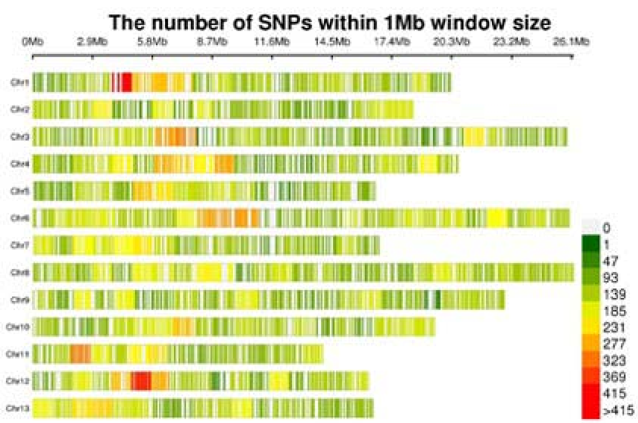


Fig. 5.11. SNP call density across the sesame genome comprising 13 linkage groups

5.12 Transcriptome analysis between high and low oil-yielding sesame genotypes

Publicly available transcriptome datasets for high- (ZZM4728) and low- (ZZM3495 and ZZM2161) oil yielding sesame genotypes at different developmental stages (10, 20, 25 and 30 dpa) of capsule development was used to understand the key regulatory genes and molecular mechanism underlying the high oil yielding nature, for sesame improvement program. Of the 501 genes that are significantly differentially expressed between high- and low-oil yielding genotypes, 27 genes were found to be associated with oil biosynthesis. Our study underscored the importance of the longer duration of oil biosynthesis during seed development to obtain higher oil accumulation and hence yielding higher oil content within the existing productivity limits (Fig. 5.12).

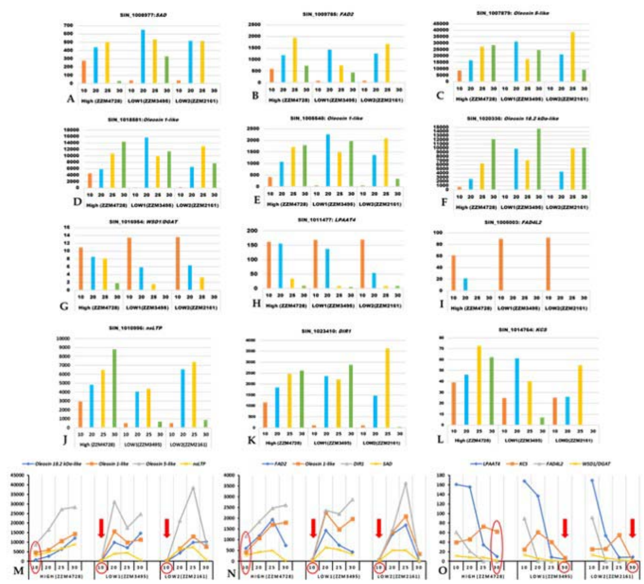


Fig. 5.12. Expression profiles (in FPKM values, Y-axis) for key regulatory genes of oil biosynthesis in sesame using the transcriptome dataset of Wang et al. (2019). The X-axis represents the developmental stages in days post anthesis (DPA). (A): *Sad*; (B): *Fad2*; (C): *Oleosin 5-like*; (D): *Oleosin 1-like*; (E): *Oleosin 1-like*; (F): *Oleosin 18.2 kDa-like*; (G): *Dgat*; (H): *Lpaat4*; (I): *Fad4L2*; (J): *nsLTP*; (K): *DIR1*; (L): *KCS*; (M,N): Set of genes that are expressed significantly less at 10 DPA in both of the low oil yielding genotypes (indicated with a red colored down arrow at 10 DPA); (O): Set of genes that are significantly less expressed at 30 DPA in both of the low oil yielding genotypes (indicated with a red colored down arrow at 30 DPA).

5.13 Genome-wide association study to identify QTLs for plant height in rice

A subset of 198 rice accessions from 3K rice genome (RG) panel were obtained from IRRI South Asia Regional Center, NSRTC campus, Varanasi, Uttar Pradesh, India. These rice accessions were from 32 countries and were used as the materials in our study. This panel consisted of four types of populations, including

Xian(indica) (171), aus/boro (22), tropical Geng (japonica) (3), intermediate type (2) and two semi-dwarf varieties Pusa 1121 and Lalat as checks. Phenotyping of these accessions were done at NBPGR, New delhi during Kharif 2020 and 2021. The genotypic data of 198 accessions were taken from the 3K RG panel and used in GWAS study.

The genome wide association analysis of 198 rice accessions identified seven new QTLs designated as qPH1-1, qPH1-2, qPH1-3, qPH2-1, qPH3-1, qPH4-1 and qPH8-1 on chromosomes 1,2,3,4 and 8 and two novel MTAs (MTA4-1 and MTA6-1) on chromosome 4 and 6 respectively (Fig. 5.13). Among them, qPH1-1, qPH3-1, qPH4-1 and qPH8-1 were identified to regulate plant height negatively. The MTAs (MTA4-1 and MTA6-1) were identified as positively regulating plant height. We identified different allelic groups (whole population and indica subspecies) and showed that multiple alleles can be pyramided to attain statistically significant effect on plant height of rice. The markers in the vicinity of QTLs/MTAs identified in the study can be used directly in marker-assisted breeding.

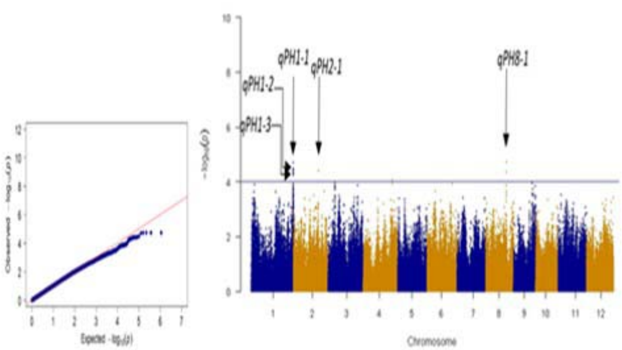


Fig. 5.13. Manhattan and Quantile-quantile plots of GWAS for rice plant height in 198 rice accessions

5.14 Genetic dissection of test seed weight (TSW) in Linseed (*Linum usitatissimum* L.)

Multi-locus Genome Wide Association Study (ML-GWAS) was performed to identify associated markers/quantitative trait nucleotides (QTNs) for test seed weight (thousand seed weight) trait in linseed. Field evaluation was carried out in five environments in multi-year-location trials in year 2017-18, 2018-19, and 2019-20 at NBPGR research farm at Akola and Delhi. SNP genotyping information of the AM panel of 131 accessions comprising 68,925 SNPs were employed for ML-GWAS. Six ML-GWAS methods: FASTmrEMMA, FASTmrMLM, ISIS EM-BLASSO, mrMLM, and pLARmEB were employed for detection of QTNs of which, five methods identified total 84 unique significant QTNs for TSW. QTNs identified in ≥2 methods/ environments were designated as stable QTNs. Accordingly, 30 stable QTNs have been identified for TSW accounting up to 38.65% trait variation. The Manhattan plot showing SNPs associated with TSW is given in Fig. 5.14. Alleles with positive effect on trait were analyzed for 12 strong QTNs with $r^2 \geq 10.00$ which showed significant association of specific alleles with higher trait value in three or more environments (Fig. 5.15). Putative candidate genes have been identified for TSW which included B3 domain-containing transcription factor, SUMO-activating enzyme, protein SCARECROW, shaggy-related protein kinase/protein BRASSINOSTEROID INSENSITIVE 2, ANTIAUXIN-RESISTANT 3, RING-type E3 ubiquitin transferase E4, auxin response factor, WRKY transcription factor, and CBS domain-containing protein.

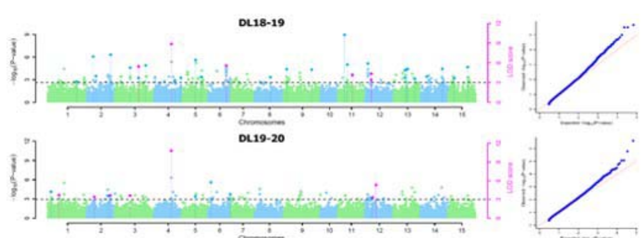


Fig. 5.14. Combined Manhattan plots and respective quantile-quantile plots of five ML-GWAS methods for test seed weight trait in two representative environments at Delhi during 2018-19 (DL18-19) and, 2019-20 (DL19-20). LOD threshold score of 3.0 is indicated as dashed line in Manhattan plots. Dots above the threshold line represent significant QTNs, whereas QTNs identified in ≥ 2 methods are depicted in pink colour

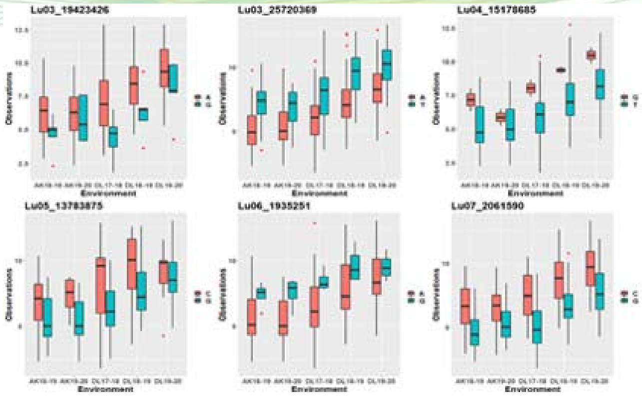


Fig. 5.15. Representative box plot showing positive effect of alleles of robust QTNs (r^2 e″ 10.0%) on TSW trait values in five studied environments at Akola (2018-19 & 2019-20) and New Delhi (2017-18, 2018-19 and, 2019-20)

5.15 Phylogenetic relations of *Piper nigrum* with other taxa based on the protein coding genes of chloroplast

The chloroplast genome studies have proved to be useful in evolutionary, phylogenetic and molecular systematic studies. The protein coding genes identified from the elucidated chloroplast genome of *Piper nigrum* have been used for phylogenetic analyses with 37 taxa, comprising 34 angiosperms and three gymnosperms. Maximum likelihood analysis resulted in single tree with higher bootstrap values (Fig. 5.16). Twenty eight out of 35 nodes showed 100% bootstrap value. The 100% bootstrap value strongly supports the monophyly of Magnoliids. Magnoliids with 100% support value forms two distinct clades one with Canellales and Piperales and other Magnoliales and Laurales. Piperales with four species of *Piper* got further divided into two clades with 100% bootstrap value. *P. nigrum* is positioned with *Piper kadsura* in one clade and *Piper auritum* and *Piper cenocladum* were observed to be more similar.

5.16 Generation of draft chloroplast and whole genome assemblies of *Oryza alta*

Short-read and long-read data using Illumina and PacBio platform, respectively was generated using the genomic DNA extracted from the wild rice species *Oryza alta*. Using these datasets, a chloroplast and whole genome draft assembly was made. The chloroplast genome assembly consisted of a single circular contig of 135, 175 bp (Fig. 5.17) The annotation of this chloroplast assembly revealed the presence of 173 mRNA, 34 tRNA and 4rRNA genes. Regarding the draft genome assembly, the genome size estimates had revealed for the presence of repeats for nearly

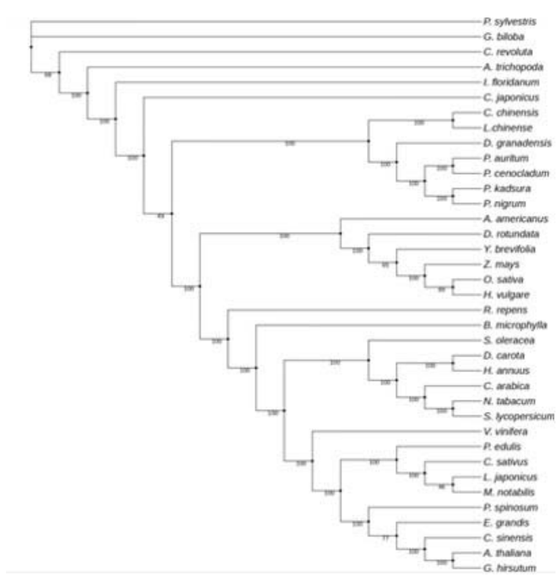


Fig. 5.16. Phylogenetic tree of 37 different species based 58 chloroplast protein-coding genes

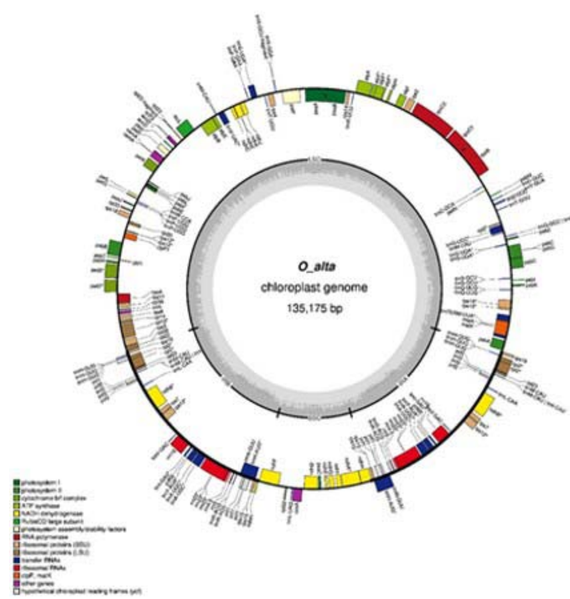


Fig. 5.17. Chloroplast genome assembly of *Oryza alta*

29% of the genome and the expected genome size after accommodating repeats and heterozygosity is estimated to be 930.702294 Mbp. Chromosome-scale draft genome assembly of 848.811314 Mbp (of which, 831.173153 Mbp were of 24 chromosomal level super-scaffolds) was made using short- and long-read data. An N_{50} scaffold length of 35.650855 Mbp was achieved. Further strategies were in progress to develop a chromosome-scale reference genome assembly.

5.17 Comparative studies on sequence based genotyping methods for molecular characterization of safflower (*Carthamus tinctorius* L.) germplasm

For genotyping two main approaches are available either PCR based markers or sequence-based approach. PCR based markers generate data with relatively small numbers of loci and oligonucleotide libraries significantly add more to overall costs as compared to genome-wide sequencing approaches that deliver large number of loci and reducing the overall cost in a single run. Lack of prior studies in Safflower on genotyping by sequencing, leads to optimization of method and finding the suitable set of Restriction enzymes (REs) for the RAD seq (Restriction Site-Associated DNA Sequencing) experiment. In present study total diverse 48 accessions from safflower germplasm were used for single (ApeK1), double-digest RAD seq (NlaIII-MseI and EcoR1-Msel), for library preparation and sequencing. The single RE (ApeKI) enzyme generated on 1387415 average raw reads per sample, whereas among the double digest the NlaIII+MseI pair generated more reads than (10146613) EcoR1+MseI (5499049). Average mapping percentage for reads from selected restriction enzymes were 25.05%, 92.21%, 92.89% for ApeKI, NlaIII+MseI and EcoR1+MseI respectively. However, the representation of variants (≥ 0.05 minor allele frequency) among the genotypes (90%) were drastically different between the two combinations. Hence, genotyping of safflower germplasm for molecular characterisation was carried out with, the ddRAD with enzyme combination EcoR1+MseI.

5.18 Identification of trait specific germplasm by biochemical phenotyping of representative set of kodo millet (*Paspalum scrobiculatum* L.) for protein content

A representative subset of 102 accessions (Fig. 5.18) belonging to 12 states (Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Uttar Pradesh, Gujarat, Chhattisgarh, Bihar, Odisha, West Bengal, Kerala, Andhra Pradesh) of India was procured from NGB. This set comprises of released varieties, landraces, elite lines, primitive cultivars, breeding line and was used to estimate protein content by Dumas method. A wide range of variability (7.34 to 16.72%) was observed in this subset and 20 potential lines having more than 13% protein content were identified and will be evaluated at multi-locations to find the promising lines stable across locations/ environments. Accessions with highest protein content were from Tamil Nadu and Karnataka. Accession with highest protein content was a Breeding line from Tamil Nadu and accession with lowest protein content was a released variety from Madhya Pradesh. Landraces showed high range of protein content (9.94 to 16.26%). This study further emphasizes the necessity to characterize the whole set of kodo millet germplasm available at NGB to identify sufficient number of promising accessions for protein content as well as for other traits. Regions showing accessions with high protein content must be explored thoroughly for collecting more such germplasm. Kodo millet accessions viz. IC0622122, IC0613570, IC0598210 and IC0567409 showed more than 14% protein content.

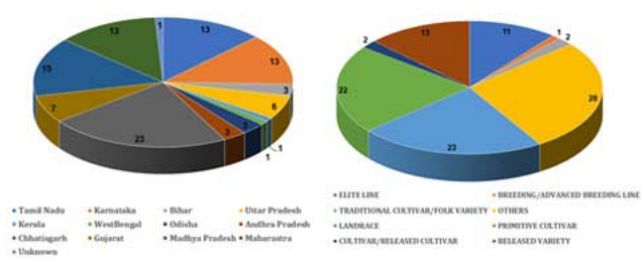


Fig. 5.18. Distribution of kodo millet accessions used for protein estimation

5.19 Development of prediction machine learning models for sugar and starch contents in field and vegetable crops germplasm

Five Near-Infrared spectroscopic machine learning algorithms measure chickpea crop sugar and starch contents. The data generated under the project "Biochemical evaluation of field and vegetable crops germplasm (PGR/DGE-BUR-DEL-01.06)" was used for this analysis. Total 237 chickpea raw spectra were present in this data set. The spectral dataset has 1050 wavelength bands (400-2498 nm) with 2 nm differences. Laboratory measurements of two chickpea crop components are used to validate and evaluate models.

For chickpea sugar prediction, Interval Partial Least Square Regression (*i*PLS) suggests the 1800–1938 nm wavelength range. Pre-processing reduces noise with a moving average at four points, the second derivative approach, and Savitzky-Golay (polynomial: 3; window size: 5) to smooth the spectrum. Before modelling, 80% of the data was calibrated and 20% validated. Linear Regression (LR), Artificial Neural Network (ANN), Random Forest (RF), Support Vector Regression (SVR), and Decision Tree Regression (DTR) algorithms were used to create prediction models. Root Mean Square Error (RMSE), Residual Standard Error (RSE), R^2, Adjusted R^2, and Residual Prediction Deviation (RPD) are used to evaluate model performance. The SVR model has the lowest RSE value (0.043), highest R^2 value (0.968), and highest adjusted R^2 value (0.968). All models had RMSE values between 0.043 and 0.074 and RPD values over 4.1. RSE values for all models are 0.045–0.076. Adjusted R^2 values range from 0.906 to 0.968. All models predicted the sugar component well on validation data, with bias values from 0.007 to 0.009. All models have lower evaluation parameter efficiency than the LR model. The LR model was validated with RMSE and RSE values of 0.039 and 0.04, respectively. Adjusted R^2 is 0.974 and 0.975, respectively.

One hundred ninety six, out of 237 samples have NIR starch component reflectance. IPLS recommends chickpea starch prediction at 2360-2498 nm. Preprocessing involves moving average noise reduction (10 points), smoothing by third derivative and Savitzky-Golay (polynomial:5; window size:3) and scatter correction by MSC. The LR model had the lowest RSE value (0.027), greatest R^2 value (0.965), and greatest adjusted R^2 value (0.964). All models predict starch well with RPD values over 4.1. All models have RMSE values of 0.027–0.04. RSE values for all models are 0.028–0.041. R^2 values are 0.926–0.965, while corrected values are 0.924–0.964. High-end models were validated using validation data. All models performed well for starch prediction on validation data, with bias values between 0.002 and 0.007. Across all evaluation parameters, the LR model performed best. LR model RMSE and RSE values of 0.017 and 0.018 proved its accuracy. R^2 and Adjusted R^2 values are 0.99.

5.20 Characterization of wild and cultivated *Musa* species of India based on flow cytometric analysis of ploidy and nuclear DNA content

The In Vitro Gene Bank at ICAR-NBPGR has conserved most of the wild species and cultivated *Musa* distributed in India as in vitro cultures, whole seeds and/or excised embryos, depending on the species. The knowledge of total nuclear DNA content in terms of genome size is absolutely important in evolutionary and genomic studies especially in *Musa* where variation in ploidy is well-known. A total of 29 *Musa* accessions consisting of 19 species and 3 cultivars were used for estimating DNA content and ploidy level using flow cytometry method with *Raphanus sativus* as internal standard. For the first time the DNA content of 3 triploid cultivars and 8 wild species were estimated and reported. In section *Eumusa*, lowest nuclear DNA content was observed in the diploid species *Musa balbisiana* (1C= 459 Mb), while highest was recorded for the triploid cultivar *Meitei-hei* (1C=886Mb). Under the section *Rhodochlamys* with all diploid species the lowest nuclear DNA content was recorded in species

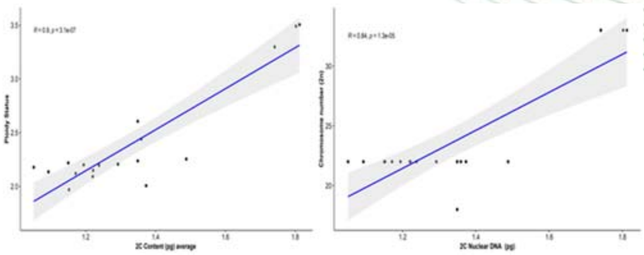


Fig. 5.19. Relationship between nuclear 2C DNA content, ploidy status and chromosome number of the *Musa* accessions

Musa rosae (1C= 584Mb) and the highest in *Musa velutina* (1C=702Mb). The ploidy of plants with large chromosomes can easily be determined by chromosome counting but bananas present a challenge due to its small chromosomes which are always hard to spread out during squash preparations. Hence, the difference in genome sizes between species of *Musa* containing diploid, triploid, and tetraploid edible banana cultivars permit the use of flow cytometric analysis for rapid identification of ploidy level. Based on the DNA content the ploidy level of 26 accessions of diploid *Musa* under section *Eumusa* and *Rhodochlamys* and three accession triploids in the section *Eumusa* (2n=33) were confirmed from In Vitro Gene Bank (Fig. 5.19). Further, a tree of the 26 accessions was also constructed, based on the Nuclear DNA content (2C), ploidy status, and chromosome number (Fig. 5.20).

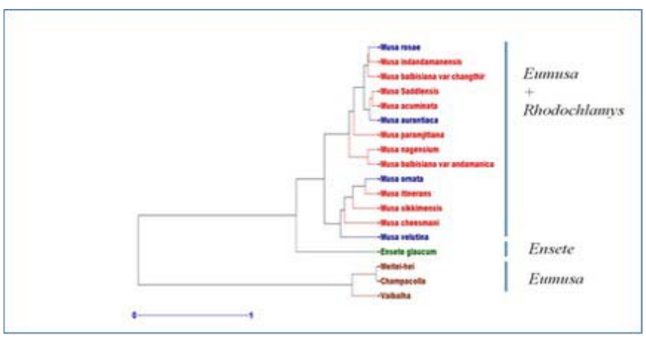


Fig. 5.20. Tree of *Musa* accessions based on Hierarchical clustering of Nuclear DNA content (2C), ploidy status and chromosome number

5.21 Network of genes influencing flowering and yield

The MYB associated genes in a network of 113 MYB genes have a close relationship with a set of flowering and energy genes. Key genes like BT, CO, COP1, LFY, HFR1, NPH4, and many others regulate flowering through cross-talk. In silico analysis revealed 76 non-coding mRNAs from 150 gene sequences, with 11 pre-miRNA and 22 mature miRNA obtained. 22 putative miRNAs and their targets were identified, some of which could also act as phasiRNA. Target prediction listed 15 targets for the miRNAs. A co-expression network of genes was generated from experimental gene function, co-occurrence, and co-expression, revealing the regulatory role of genes (Fig. 5.21) in the flowering process and photomorphogenesis in *A. thaliana, Glycine max,* and *Cajanus cajan*. Four major clusters and some minor clusters were found, indicating the epistatic interaction of major genes involved in flowering.

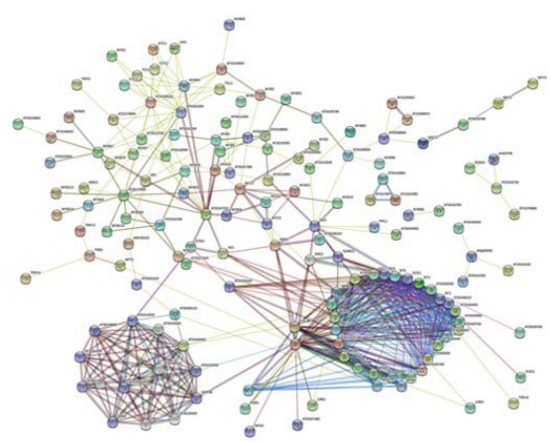


Fig. 5.21. Network of genes directly correlated with yield and drought tolerance traits

From our previous MYB network and flowering gene networks, we have identified genes that are closely linked and co-expressed for flowering and yield-related traits. Semi-quantitative expression analysis revealed that the GCL-2 lanc-like protein, which contributes to drought stress tolerance, is expressed and contributes to disease resistance (Fig. 5.22). Additionally, MYB-linked BTB/POZ genes were found to contribute to high yielding in pigeonpea. These genes were expressed together in drought-tolerant, high-yielding pigeonpea lines previously reported by our team. We also reported on the

MYB-linked expression of BTB/POZ genes. These genes, selected from our previous network analysis, were identified, PCR amplified, and sequenced. From the gene sequences, we predicted the protein structure and validated it. The Lan C protein was found to be associated with our co-expression analysis, confirming that these genes directly contribute to stress tolerance and high yielding traits.

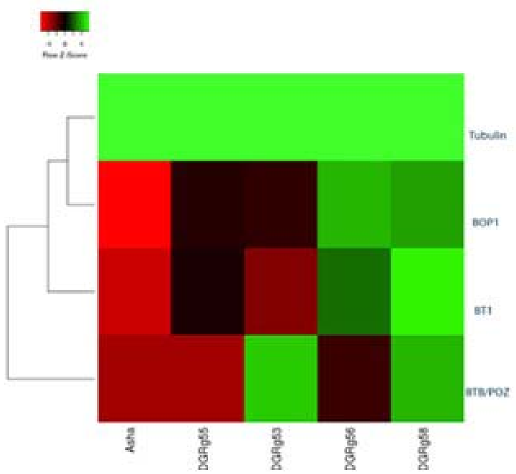


Fig. 5.22. Heatmap depicting differential expression of genes contributing to yield and flowering

5.22 Generation of new set of markers in pigeonpea

The decoding of the pigeonpea genome and the creation of molecular markers provide valuable resources for improving pigeonpea. 21434 transcripts were collected from online databases, and after filtering out poor quality sequences using stringent criteria, 1699 high quality mRNAs were obtained. Additionally, 95 lincRNAs and 385 lncRNAs were identified (Fig. 5.23). The non-coding and weak-coding sequences were analyzed for miRNAs using secondary structure analysis, resulting in the prediction of both conserved and novel miRNAs. The targets for these miRNAs were also predicted through de-novo annotation. In total, 624 miRNAs were identified, with 73.61% potentially functioning by cleaving their targets and 26.38% by inhibiting translation.

Fig. 5.23. The lncRNA map of pigeonpea

5.23 Genetic stock registered

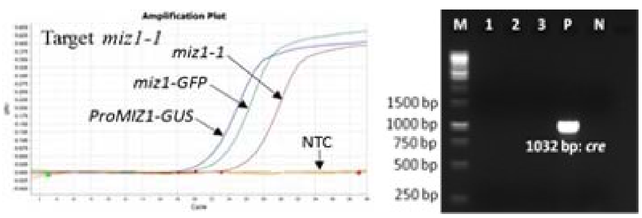
IC128335 (INGR22116): IC128335 has low drought sensitivity index (-1.7 and -2.81) and less reduction (%) in thousand grain weight (-49.9 and 14.4). The germplasm line was found to be highly tolerant to drought stress (DSI = 0.45). The germplasm line is characterized with higher antioxidant activity (1.8fold), total phenolic content (1.6 fold), proline content (2.4 fold) and higher SOD activity and higher upregulation of transcription factors (qTaWRKY2 – 3.49 fold and qTaNAC2a – 2.31 fold). Therefore, this genotype can be used as a donor for enhancing drought tolerance in wheat.

HW-5074 (INGR-22068) : Stable and high yielding line selected at BC4F7 generation, showed resistance to the stem rust, leaf rust and powdery mildew pathotypes prevailing in India. Stem rust, leaf rust and powdery mildew resistance genes, Sr2/Lr27/Yr30, Sr24/Lr24 and Sr36/Pm6 were pyramided in the background of HD2833 cultivar through marker assisted backcross approach. Presence of the resistance genes were carried out using molecular markers, gwm533 (Sr2+) (Spielmeyer et al., 2003), Sr24#12 (Sr24/Lr24) (Mago et al., 2005) and stm773-2 (Sr36/Pm6). Hence, it can be considered a promising multiple disease resistant germplasm.

IC73591 (INGR22073) : A potential genetic resource for stripe rust resistance. Showed the presence of leaf rust resistance genes, *Lr34+* (*Lr34/Yr18/Sr57/Pm38*), *Lr46+* (*Lr46/Yr29/Sr58/Pm39*) and *Lr67+* (*Lr67/Yr46/Sr55/Pm46/Ltn3*) also showed yield stability in above said four different locations may be considered promising multiple disease resistant germplasm and could be included in breeding program as parents for developing new durable multiple rust resistant cultivars.

5.24 Molecular testing of imported transgenic seeds

Ten samples of two consignments of imported transgenics of *Arabidopsis thaliana* (3 samples, IQ 173/2022) and *Medicago truncatula* (7 samples, IQ 208/2022) were received and tested for specific genetic elements employing PCR/ real-time PCR assays, as well as for ensuring the absence of embryogenesis deactivator gene employing PCR. Real-time PCR profile for confirming the presence of *miz1-1* gene in the *MIZ1* mutant lines (miz1-1 (G704A), miz1-1/proMIZ1:MIZ1-GFP and Col-0/proMIZ1:GUS) of *A. thaliana* is shown in Fig. 5.24a. The samples were also tested for ensuring the absence of embryogenesis deactivator gene employing PCR specific for *cre* recombinase gene. None of these samples showed presence of terminator gene technology (Fig. 5.24b).



(a) (b)

Fig. 5.24. (a) Real-time PCR amplification profile for *miz1-1* in imported *MIZ1* mutant lines of *A. thaliana* (b) PCR profile for ensuring absence of *cre* gene in *A. thaliana* mutant lines (1-3) (M:1kb DNA Ladder; P: positive control; N: negative control)

5.25 Initiative to keep the inventory of imported transgenics for traceability

As an initiative to keep the inventory of imported transgenics, the research activity at the importer's site was monitored. For tracking the consignment of GM soybean (IQ 46/21) imported by Dr. Akshay Talukdar, Principal Scientist, ICAR-IARI, New Delhi, a visit was made at National Phytotron Facility, ICAR-IARI where imported GM soybean was being utilized for the development of herbicide (glyphosate) tolerant soybean genotypes in the controlled environmental condition (Fig 5.25). The leaves (experimental material) of both the donor variety, *viz*, S14-9017(GM parent) and the recipient variety (non-GM parent) along with the F1 generation (samples F1-A and F1-B) were collected and F1 generation was screened for the transgenic trait. The presence of *cp4-epsps* transgene for Roundup Ready® trait in donor GM parent and F1 was confirmed using real-time PCR (Fig. 5.26).

Fig. 5.25. Visit at the importer's site (National Phytotron Facility, IARI, New Delhi) to track the research activities for use of imported consignment of GM soybean (IQ 46/21)

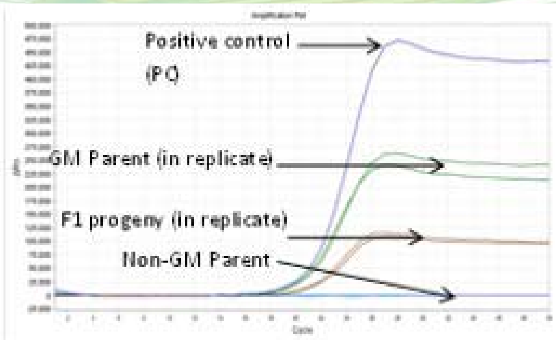


Fig. 5.26. Real-Time PCR amplification profile for *cp4-epsps* gene in GM parent, non-GM parent and F1 progeny

5.26 Real-time loop-mediated isothermal amplification (LAMP)-based GM diagnostics developed and validated for rapid on-site detection of *pinII* terminator sequence

Proteinase inhibitor (T-pinII) has been employed as terminator sequence in 25% of globally approved GM crops (maize, potato, tobacco) and some of the indigenously developed GM crops. Real-time LAMP-based GM detection technology targeting *pinII* terminator sequence was developed with acceptable specificity and sensitivity. Specificity was confirmed using a set of 17 samples including GM events of three GM crops, namely, maize, soybean and cotton along with the non-GM counterpart as respective targets and non-targets (Fig. 5.27). The assay was found sensitive enough to detect as low as 7 target copies within 40 minutes. Practical applicability of the assay was assessed using the maize test samples of Proficiency Programs organized by United States Department of Agriculture Agricultural Marketing Service/ Federal Grain Inspection Service (USDA-AMS-FGIS) in 2019-2021. The assay can be utilized for on-site GMO screening in the farmers' fields, ports of entry or at plant quarantine offices.

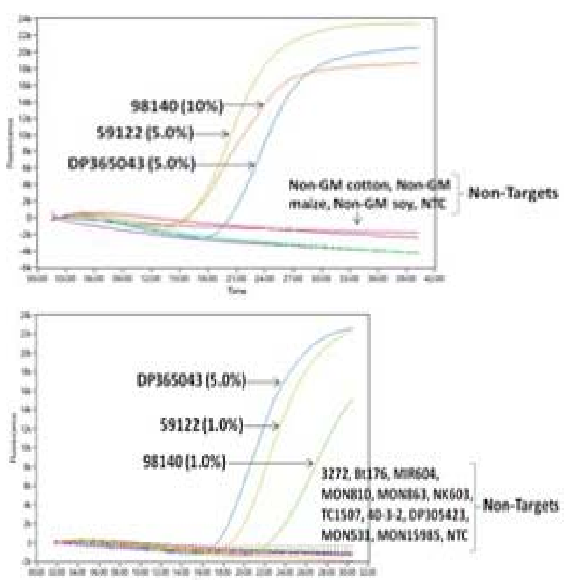


Fig. 5.27. Amplification profile for real-time LAMP targeting *T-pinII* terminator sequence

5.27 Validation and conservation of the voucher samples of indigenously developed GM events

GM seeds of 22 GM events of brinjal (10 events), wheat (8 events) and tobacco (4 events) for nematode resistance were received from Division of Nematology, ICAR- IARI, New Delhi. Prior to conservation, these events were validated using the protocols provided by the developer (Fig. 5.28).

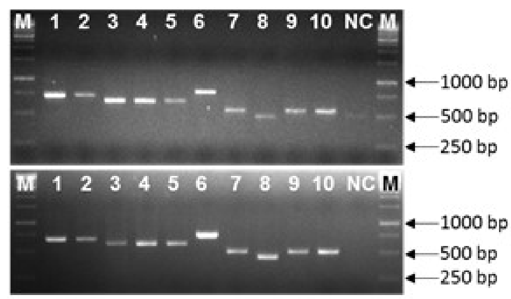


Fig. 5.28. PCR profile for checking the presence of transgene(s) in GM brinjal events having different nematode resistance genes (a) *P35S-attB2*, (b) *t35S-attB2* (M: 1 kb ladder; 1, 2: events 3 and 13 with *msp1* gene; 3, 4: events 18.3 and 18.4 with *msp 18* gene; 5, 6: events 20.3 and 20.7 with *msp 20* gene; 7, 8: events S.1 and 24.2 with *flp14* gene; 9,10: events 8 and 21 with *flp18* gene; NC: non-GM brinjal; NTC: non-template control

5.28 Utilization of GM diagnostics for checking the GM status of food products

One hundred and fifty five (155) samples of 17 food products or derivatives (as mentioned in Table 5.2) were tested in 2-3 replications with appropriate positive and negative controls using

Table 5.2: Summary of GMO testing of food products/ derivatives

S. No.	Food derivatives*	No. of samples	Targets screened	Results
	Bakery & confectionery products (70)			
1.	Fruit cakes	10	*P-35S, T-nos, pFMV, cp4-epsps*	Absent
2.	Biscuits/ Cookies	25		Absent
3.	Breads	05		Absent
4.	Cake mix	05		Absent
5.	Bread crumbs	05		Absent
6.	Chocolates	15		Absent
7.	Candy slice	05		Absent
	Soup (30)			
8.	Corn/ Sweet corn/ vegetable soup	15	*P-35S, T-nos*	Absent
9.	Tomato soup	10		Absent
10.	Curry paste	05		Absent
	Packed rice grains and rice products (50)			
11.	Packed Rice	20	*P-35S. T-nos, pat, cry1Ac*	Absent
12.	Poha	5		Absent
13.	Rice Idli Mix	5		Absent
14.	Rice Dosa Mix	5		Absent
15.	Murmure (Puffed Rice)	5		Absent
16.	Noodles and Pasta	10	*P-35S. T-nos*	Absent
	Oil (05)			
17.	Canola (3), Cottonseed (1), Soybean (1)	05	*P-35S. T-nos*	Absent

**Well-defined DNA extraction protocols were optimized and validated for Bakery and Confectionery products as well as rice products. For rest of the products, previously in house validated protocols were used.*

PCR/ real-time PCR tests. Before conducting the GMO tests, the amplifiability of DNA extracts was confirmed using *cp-tRNA* specific PCR/real-time PCR. Based on the tests conducted, none of the samples were found positive for GM targets screened.

Research Programme (Programme Code, Title, **Programme Leader)**
PGR/GRD-BUR- DEL-01.00: Development of genomic tools for identification, protection and enhanced utilization of PGRs **(Gurinderjit Randhawa Until 31 August 2022); MC Yadav (from 1st September 2022)**
Research Projects (Code & PI, Co-PIs 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 fibre crops (**Rajesh Kumar,** J Radhamani, JK Yasin, DP Wankhede, Rashmi Yadav, S Rajkumar and R Parimalan)
PGR/GRD-BUR- DEL-01.02: Development of genomic tools for enhanced utilization of cereals (**Rakesh Singh**, MC Yadav, Sundeep Kumar, AK Singh, R Parimalan and Sheel Yadav)
PGR/GRD-BUR- DEL-01.03: Development of genomic tools for enhanced utilization of millets (**Lalit Arya**, Monika Singh (till 19 Dec. 2022), Mamta Singh)
PGR/GRD-BUR- DEL-01.04: Development of genomic tools for enhanced utilization of horticultural crops (**AB Gaikwad**, M. Verma, S Archak, K Joseph John and *Dikshant Gautam*)
PGR/GRD-BUR- DEL-01.05: Development of genomic tools for species delineation and genetic erosion studies in selected crops (**MC Yadav**, S Rajkumar, S Marla, J Radhamani, DR Pani, N Dixit and M Latha)
PGR/GRD-BUR- DEL-01.06: Establishment and maintenance of national genomic resources repository and bioinformatics facility. (**Sundeep Kumar,** MC Yadav, MK Rana, Lalit Arya, M Verma, S.RajKumar, Rajesh Kumar, AK Singh, JK Yasin, R Parimalan, Sheel Yadav, DP Wankhede, Monika Singh, Rekha Chaudhury and *SK Singh*)
PGR/GRD-BUR- DEL-01.07: Development and utilization of GM diagnostics for detection of genetically engineered plant derivations (**Monika Singh,** Gurinderjit Randhawa (Until 31 August 2022), AK Singh (wef 19 Dec. 2022)
PGR/GRD-BUR- DEL-01.08: Development of unique identity system for cultivars and genetic stocks for IPR protection (**MK Rana,** AB Gaikwad, Rakesh Singh, Lalit Arya, M Verma, Sundeep Kumar, Rajesh Kumar, S Rajkumar, R Parimalan, AK Singh, Sheel Yadav, DP Wankhede, JK Yasin and *SK Singh*)

6 DIVISION OF GERMPLASM CONSERVATION

सारांशः राष्ट्रीय जीन बैंक में दीर्घकालिक संरक्षण के लिए विभिन्न कृषि–बागवानी फसलों की कुल 6,561 जननद्रव्य एक्सेशन प्राप्त हुए। इन्हें जीनबैंक मानकों के बाद संसाधित किया गया, संग्रह में विभिन्न कृषि–बागवानी फसलों की 5,932 एक्सेशन शामिल किए गए, जिससे कुल जननद्रव्य बढ़कर 4,63,130 हो गये। संरक्षित एक्सेशनों में से, 4176 नए थे और 1,756 एक्सेशन पुनर्जन्म के बाद प्राप्त हुए। भंडारित जननद्रव्य (6,367 एक्सेशन) में अंकुरण और बीज की मात्रा की निगरानी और लक्षण वर्णन/मूल्यांकन/ पुनर्जनन/अनुसंधान के लिए वितरण (47,859) अन्य प्राथमिकता गतिविधियां थीं। आपूर्ति किए गए जननद्रव्य में एग्रोबायोडायवर्सिटी पर कंसोर्टियम रिसर्च प्रोजेक्ट (सीआरपी–एबी) के तहत वृद्धि और विशेषता के लिए भेजे गए जननद्रव्य शामिल हैं। सहायक अनुसंधान के तहत जीनोम–वाइड एसोसिएशन स्टडीज (जीडब्ल्यूएएस) का उपयोग करके सीडिंग स्थापना लक्षणों जैसे बीज वजन, कोलियोप्टाइल लंबाई, रूट लेंथ, रूट एंगल और रूट नंबर के लिए 145 गेहूं एक्सेशन (लैंडरेस, एलाइट लाइन, जारी किस्में और एक्सोटिक एक्सेशन सहित) का विश्लेषण किया गया। दो नमी (4% और 7%) पर संग्रहीत और बीज सूखे वजन (विग इंडेक्स II) के आधार पर अंकुरण प्रतिशत, अंकुरण की गति और विगर इंडेक्स पर तीन स्थितियों (LTS, MTS और Ambient) पर बीजों के प्रभाव का अध्ययन करने के लिए ग्यारह अलग–अलग फसलों सहित एक दीर्घकालिक प्रयोग (पचास वर्षों के लिए) शुरू किया गया। राष्ट्रीय जीन बैंक में विभिन्न कृषि–बागवानी फसलों के बीजों का दीर्घकालिक भंडारण (एलटीएस), (–18°C), और मध्यम अवधि के भंडारण (एमटीएस, +4°C) शामिल किए गए एक्सेशन के संदर्भ में नमूने लिए गए। इसके अलावा, फसल सुधार कार्यक्रमों में जननद्रव्य के उपयोग को सुविधाजनक बनाने के लिए, रिलीज और अधिसूचना के लिए राष्ट्रीय कृषि अनुसंधान प्रणाली के तहत पहचानी गई संभावित मूल्यवान विशेषता–विशिष्ट जननद्रव्य का पंजीकरण और जारी की गई किस्मों और जेनेटिक स्टॉक का संरक्षण, अन्य महत्वपूर्ण गतिविधियां हैं। भौतिक सत्यापन के बाद कुल 17,226 एक्सेशनों के साथ एलटीएस एक्सेशनों की बारकोडिंग शुरू की गई।

Summary: A total of 6,561 germplasm accessions of various agri-horticultural crops were received for long-term conservation in the National Genebank. These were processed following genebank standards, adding 5,932 accessions of different agri-horticultural crops to the collection thereby raising the total germplasm holding to 4,63,130. Of the conserved accessions, 4,176 were new and 1,756 accessions were received after regeneration. Monitoring of germination and seed quantity in stored germplasm (6,367 accessions) and distribution (47,859) for characterization/evaluation/regeneration/research were the other priority activities. The germplasm supplied includes those sent for multiplication and characterization under the Consortium Research Project on Agrobiodiversity (CRP-AB). Under supportive research 145 wheat accessions (including landraces, elite lines, released varieties and exotic accessions) were analyzed for seedling establishment traits *viz*., seed weight, coleoptile length, root length, root angle and root number, using Genome Wide Association Studies (GWAS). A long-term experiment (for fifty years) including eleven different crops was initiated to study the effect of seeds stored at two moistures (4% and 7%) and at three conditions (LTS, MTS and Ambient) on Germination percentage, speed of germination and Vigour index based on seedling dry weight (Vigour Index II). Long-term storage (LTS) of seeds of various agri-horticultural crops in the National Genebank, (at -18°C), and medium-term storage (MTS, at +4°C) of reference samples of introduced accessions was carried out. In addition, the registration of potentially valuable trait specific germplasm and conservation of released varieties and genetic stocks identified under the National Agricultural Research System for release and notification, are the other important activities, to facilitate utilization of germplasm in crop improvement programmes. Barcoding of LTS accessions was initiated a total of 17,226 accessions were barcoded after physical verification.

6.1 Germplasm augmentation

A total of 5932 germplasm accessions of various agri-horticultural crops were added for long-term conservation in the National Genebank and were conserved at – 18 ± 2°C as base collections. Of the conserved accessions, 4,176 were new and 1,756 accessions were received after regeneration (Table 6.1). A total of 629 accessions were rejected during quarantine examination. Accessions which did not qualify the genebank standards in terms of seed quantity were stored in MTS and will be multiplied subsequently for further long-term conservation.

Table 6.1: Status of germplasm holdings in the National Genebank (as on December 31, 2022)

Crop Groups/Crop Name	No. of Accessions conserved during (1st January 2022 to 31st December 2022)			Total no. of Species	Present Status (As on 31st December 2022)
	Regenerated	New Accessions	New Species Added		
Cereals	89	1597	2	148	1,73,487
Millets	622	209	0	31	60,222
Forages	306	79	7	228	7,477
Pseudocereals	0	80	0	57	8,097
Grain legumes	512	628	6	117	68,465
Oilseeds	0	299	0	88	63,260
Fibre	58	153	1	81	16,920
Vegetables	46	487	0	222	28,679
Fruits & nuts	0	2	1	72	300
Medicinal & aromatic plants	120	420	19	707	9,146
Ornamental	2	47	6	134	734
Spices, condiments and flavour	1	159	0	28	3,641
Agroforestry	0	16	1	195	1,696
Duplicate safety samples	0	0	0	0	10,235
Trial material (Wheat, Barley)	0	0	0	0	10,771
Total	1,756	4,176	43	2,108	4,63,130

Among the new accessions added to the genebank, cereals (1,597), legumes (628), vegetables (487), medicinal aromatic plants (420), oilseeds (299) and millets (209) comprised a major portion of germplasm followed by spices & condiments (159), fibres (153), pseudo-cereals (80), forages (79), ornamentals (47), agroforestry (16) and fruits and nuts (2). The total germlasm holdings in the National Genebank representing 2,108 species has increased to 4,63,130. Accessions received after regeneration (1,756) belonged to millets (622), grain legumes (512), forages (306), medicinal and aromatic plants (120), cereals (89), fibre (58), vegetables (46), ornamentals (2) and spices & condiments (1) crop groups (Table 6.1).

6.2 Monitoring of germplasm

Germplasm conserved in the long-term storage condition for >10 years (6,361accessions) were monitored for seed viability and seed quantity, to ensure the status of the conserved germplasm as per the genebank standards (Table 6.2). The accessions showing less than 85% of the initial germination will be regenerated to replace low viability seeds in genebank.

6.3 Distribution of germplasm

A total of 47,859 accessions were supplied for utilization by different stakeholders. Most of the accessions were distributed for research, regeneration, characterization (under CRP on Agro-biodiversity) and evaluation. The details are given in Table 6.3.

6.4 Supportive research for conservation

6.4.1 Marker trait association studies

145 wheat accessions (including landraces, elite lines, released varieties and exotic accessions) which were conserved in NGB and multiplied at 3 locations – Delhi, Ludhiana and Pune, were

Table 6.2: Details of the monitoring of viability of germplasm conserved in LTS

Crop	Number of accessions tested for viability	Initial viability	Present viability	No. of accessions with viability <85%
Paddy	1402	85-100	85-100	-
Maize	346	90-100	80-100	-
Barley	109	80-100	70-100	-
Wheat	482	94-100	80-100	-
Cluster bean	415	90-100	80-100	06
French bean	316	90-100	80-100	07
Cucumber	350	70-100	70-90	-
Ridge gourd	135	70-100	70-90	-
Brinjal	300	70-100	70-90	-
Muskmelon	39	70-100	70-100	-
Okra	60	70-100	70-100	-
Sponge gourd	38	70-100	70-100	-
Watermelon	50	70-90	70-90	–
Yardlong bean	15	70-90	70-90	-
Broccoli	07	70-90	70-90	-
Sorghum	45	85-100	85-100	-
Kenaf	16	85-100	85-100	-
Avena	13	85-100	85-100	-
Napier grass	52	20-100	20-100	-
Guinea grass	144	20-100	20-100	-
Chilli	210	70-100	70-100	60
Chenopodium	03	100	100	-
Buckwheat	53	96-100	80-100	05
Amaranth	214	100	100	
Medicinal	507	70-100	50-100	208
Spices	184	70-100	70-100	40
Ornamental	56	80-100	80-100	24
Groundnut	13	80-100	80-100	-
Safflower	17	80-100	80-100	-
Sunflower	7	80-100	80-100	-
Sesame	453	80-100	80-100	-
Linseed	7	80-100	80-100	-
Mustard	222	80-100	80-100	4
Soybean	66	80-100	80-100	6
Niger	1	80-100	80-100	-
Pongamia	7	80-100	80-100	-

Table 6.3: Distribution of germplasm of different crops for various purposes

Crop	Purpose	Total
Sorghum (24,950), Paddy (7,000), Brinjal (1,000), Pigeon pea (1,200), Cucumber (987), Maize (812), Okra (266), Kodo millet (102), Isabgol (71),Babchi (50), Periwinkle (23)	CRP (AB)	36,461
Cotton (691), Sesame (648), Mustard (535),Soyabean (404), Watermelon (52), Maize (50), Castor (33), Forages (22) Yard long bean (15), Sunflower (15), Round gourd (05), Sesbania (02)	Regeneration and/ or evaluation	2,472
Wheat (1,236), Paddy (906), Ridge gourd (235), Luffa species (96), Sponge gourd (38), Melon (07), Barley (02)	Multiplication	2,520
Chilli (1,567), Triticale (1099), Forages (22)	Characterization	2,688
Maize (316),Paddy (247), Wheat (240), Snake gourd (213), Jute (201), Triticale (85), Watermelon (52), Cumin (65), Coriander (50) *Cucumis* species (12), Pumpkin (10), Cauliflower (09), Bottle gourd (08), Beet root (07), Broccoli (07), Snap melon (05), Lablab bean (04), Radish (03), Solanum (02), Tomato (02)	Research	1,538
Wheat (2,180)	Safety duplicate at Svalbard	2,180
	TOTAL	**47,859**

analyzed for seedling establishment traits *viz.*, seed weight, coleoptile length, root length, root angle and root number, using Genome Wide Association Studies (GWAS). In the marker-trait association analysis (MTA) for seed weight trait four significant MTAs with regards to seed weight were identified, two on chromosome 3B and one on 6A and 7D chromosomes. The MTA identified on chromosome 7D (TraesCS7D02G48900) is a novel locus governing seed weight. In the case of root angle, a significant MTA marker-trait association involving SNP AX-94414610 was identified and 53 genes were marked using the wheat genome browser. TraesCS6A02G405800 which is 245Kb upstream from the SNP is the potential candidate gene with major role in root angle. A candidate gene TaNFYA-9 which is a transcription factor gene, was identified as the potential candidate gene with a major role in coleoptile length. For plant height, a highly stable marker-trait association was identified in all three locations (SNP AX-94547615) and *TraesCS4D02G032700* gene (TaNFYA-1) which is 7.8Kb downstream from SNP is the potential gene with a major role in plant height. The information generated in this study could be of potential value for conservation agriculture and resilience breeding in wheat, for improving the genetic base of seedling establishment traits, using marker assisted selection.

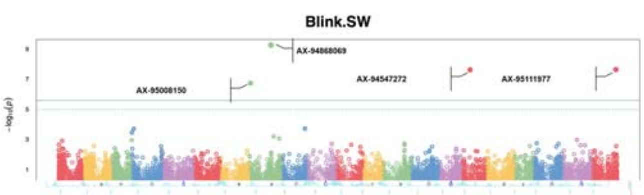


Fig. 6.1. Four significant SNPs were identified that were associated with seed weight

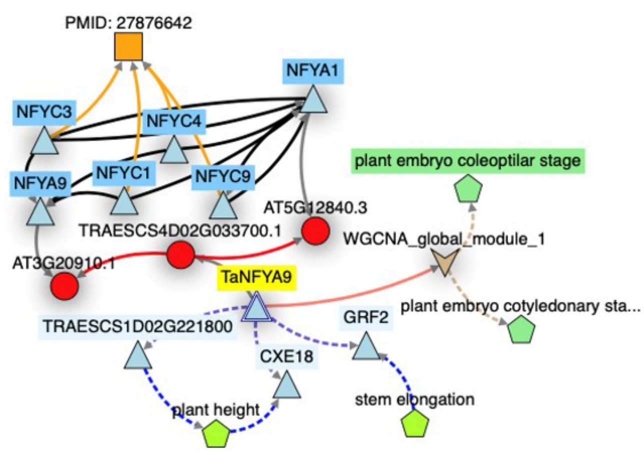


Fig. 6.2. Candidate gene TaNFYA-9 was identified as the potential candidate gene with a major role in coleoptile length

6.4.2 Development of seed germination protocols and seed storage behaviour in indigenous medicinal plants

Studies were initiated in *Euryale ferox* Salisb., an annual aquatic herb, is the only species within the genus Euryale within the family *Nymphaeaceae* and locally as Makhana. It was found that submergence method significantly reduces germination time and enhances germination percentage. There is evidence of mechanical as well as physiological dormancy, which can be removed by scarification and chemical and hormonal treatments. Both KNO3 and GA3 helps in enhancing germination speed in makhana seeds. Makhana seeds can tolerate desiccation level of 6-7 % with storage condition of -18°C which indicates its orthodox storage behavior.

6.4.3 Long term experiments

A long term experiment (for fifty years) including eleven different crops was initiated. Seeds will be stored at two moistures (4% and 7%) and at three conditions (LTS, MTS and Ambient). Data will be recorded on Germination percentage, speed of germination and Vigour index based on seedling dry weight (Vigour Index II).

6.5 Plant germplasm registration

Three Plant Germplasm Registration Committee (PGRC) meetings (47th, 48th, 49th) were conducted online through GRIS (Germplasm Registration Information System). The meetings were held at ICAR-NBPGR, New Delhi on March 29, 2022; July 08, 2022 and December 08, 2022 respectively under the Chairmanship of Dr TR Sharma, DDG (CS) ICAR, New Delhi. Out of the 375 proposals submitted, 240 were considered for registration. Finally, 189 proposals belonging to 59 species were approved for registration.

6.5.1 Some notable registered Genetic stocks are

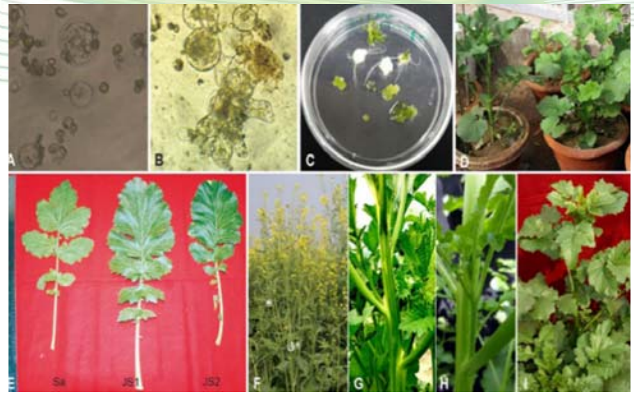
Rice with low phytic acid in grain (0.83g/100g) and high zinc content in grain (59.1 mg/kg); Wheat with Gigas plant type with reduced number of tillers (69 Tillers/m row) and long spike (12 cm); Six rowed barley with high bold grain proportion with higher 1000 g weight and bold grains percentage (76.7%); Barnyard Millet with early flowering (42 days) and early maturity (85 days); Finger millet with longer finger length

Table 6.4: Crop-group and meeting wise germplasm registered

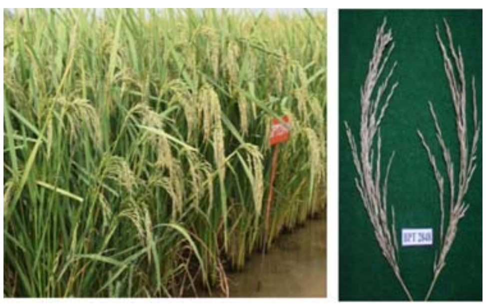
Crop group	Current status	No. of acc. Jan 01, 2022 - Dec 31, 2022	March 29, 2022 47th PGRC	July 08, 2022 48th PGRC	Dec 08, 2022, 49th PGRC
Cereals and Pesudocereals	731	65	20	12	33
Millets	142	31	14	4	13
Fibre and Forages	127	3	1	-	2
Grain Legumes	209	24	11	3	10
Vegetables	134	14	3	7	4
Oilseeds	254	17	3	6	8
Commercial Crops	119	5	-	-	5
M & AP & Spices and Masticatory	130	8	3	2	3
Fruits and Nuts	66	13	5	2	6
Tubers	55	3	2	-	1
Ornamentals	91	6	1	-	5
Narcotic/Beverages	8	-	-	-	-
Agro-forestry	8	-	-	-	-
Grand Total	**2,074**	**189**	**63**	**36**	**90**

Lisianthus (*Eustoma grandiflorum*) (IC0646867; INGR22178), with violet rose shaped double flower, producing more than 24 flowers per plant having long sturdy stem of >82 cm, suitable for cut flower production

Jackfruit (*Artocarpus heterophyllus*) (IC438858;INGR22172), with highest number of fruits (107 fruits/tree)



Indian Mustard (*Brassica juncea*) (IC0643977; INGR22050) resistant against *Sclerotinia sclerotiorum*. Half yellow and half brown (mottle seed colour). High male and female fertility



Rice (*Oryza sativa*) (IC0645766; INGR22100), with High protein content (10.5%) in polished rice

Mango (*Mangifera indica*) (IC0646861; INGR22189), with high vitamin A content (11338IU) in comparison to most commercial varieties. Maximum 14 fruits per bunch with 232 grams average fruit weight. 2000 number of fruits/per plant in a year

Chrysanthemum (*Chrysanthemum morifolium*) (IC0645570; INGR 22181), germplasm for Flower Colour (RHS colour: 71B, Red-Purple Group, Fan 2). Early Flowering (66.52 days). Dwarf (30.17 cm)

Fig. 6.3. Some notable trait specific germplasm registered

(10.7 cm); Chilli tolerant to heat, can set fruits at maximum temperatures above 40^0C and night temperatures above 25^0C; Basil with unique dark purple leaf colour, maximum essential oil content (0.28 %), maximum eugenol content (60%), ß-caryophyllene (14%) and ß-elemene content (14%); Indian mustard with resistance to white rust disease caused by *Albugo candida*; Jackfruit with highest number of fruits bearing (107 fruits/tree); Jute with resistance to stem rot, *r*oot knot nematode and Bihar hairy caterpillar; Lisianthus with violet rose shaped double flower, producing more than 24 flowers per plant having long sturdy stem of >82 cm, suitable for cut flower production; Mango with high vitamin A content (11338IU) in comparison to most commercial varieties. Maximum 14 fruits per bunch with 232 grams average fruit weight and 2000 number of fruits/per plant in a year.

Programme (Programme Code: Title, **Leader)**
PGR/GCN-BUR-DEL-01.00: Ex situ conservation of Plant Genetic Resources of Agricultural and Horticultural Crops using Conventional Methods **(Veena Gupta, Anjali Kak (w.e.f 10/11/2022))**
Research projects (PI; Co PI; *Associate/s***)**
PGR/GCN-BUR-DEL-01.01: Management of Information and National Germplasm Conservation Network and associated research **(Anjali Kak,** J Aravind (w.e.f 28/10/2022), *Rajvir Singh, Rajiv Gambhir, SmitaLenka Jain, Satya Prakash and Nirmala Dabral***)**
PGR/GCN-BUR-DEL-01-02: Conservation of grain legume germplasm using conventional seed storage methods and associated research **(Neeta Singh, Padmavati Ganpat Gore (w.e.f 01/10/2022)** and Chithra Devi Pandey**)**
PGR/GCN-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods and associated research **(GD Harish,** Sherry Rachel Jacob, Badal Singh (w.e.f 01/10/2021), J Aravind (w.e.f 28/10/2022) and *AD Sharma***)**
PGR/GCN-BUR-DEL-01-04: Conservation of oilseed germplasm using conventional seed storage methods and associated research **(Badal Singh,** Neeta Singh, Sherry Rachel Jacob, G D Harish (w.e.f 01/09/2021) and J Aravind (w.e.f 28/10/2022)**)**
PGR/GCN-BUR-DEL-01-05: Conservation of cereal germplasm excluding paddy, using conventional seed storage methods and associated research **(Sherry Rachel Jacob,** Badal Singh (w.e.f 01/10/2021) and Padmavati Ganpat Gore**)**
PGR/GCN-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,** Anjali Kak and Padmavati Ganpat Gore**)**
PGR/GCN-BUR-DEL-01-07: Conservation of millets germplasm using conventional seed storage methods and associated research **(Sushil Pandey,**Chithra Devi Pandey and GD Harish (w.e.f 01/09/2021)**)**
PGR/GCN-BUR-DEL-01-08: Conservation of forage and fibre germplasm using conventional seed storage methods and associated research **(Anjali Kak** and Veena Gupta**)**
PGR/GCN-BUR-DEL-01-09: Conservation of vegetable germplasm using conventional seed storage methods and associated research **(Chithra Devi Pandey,** Neeta Singh and Sushil Pandey**)**

7 TISSUE CULTURE AND CRYOPRESERVATION UNIT

सारांशः विभिन्न पौधों की प्रजातियों के 1,962 एक्सेशनों की इन विट्रो संस्कृतियों को 8–25 डिग्री सेल्सियस के भंडारण तापमान पर इन विट्रो जीनबैंक (IVAG) में संरक्षित किया गया, जिसमें 1–24 महीने की उपसंवर्धन अवधि थी। क्रायोजीनबैंक में बीज, भ्रूण, पराग और 2,194 जीनोमिक संसाधनों के रूप में कृषि–बागवानी प्रजातियों की कुल 12,615 एक्सेशनों को संरक्षित किया गया। आईवीएजी में कुल 28 नई एक्सेशनों को जोड़ा गया और इन विट्रो बेस जीनबैंक (आईवीबीजी) में 13 प्राप्तियों को जोड़ा गया। इन विट्रो स्थापना और गुणन प्रोटोकॉल एलियम शोएनोप्रासम, आर्टोकार्पस लाकुचा, फ्रिटिलरिया सिरोसा, होमलोमेना एरोमेटिक, इपोमोइया बटाटास, मोमोर्डिका डियोका, पिपर निग्रम और जिंजिबर क्रिसंथेमम में विकसित किए गए। एलियम सैटिवम, ए. शोएनोप्रसूम, आर्टोकार्पस लाकूचा, हुमुलस लुपुलस, मोरस इंडिका, पिपर लोंगम, और विट्रिफिकेशन, ड्रॉपलेट विट्रिफिकेशन और वी और डी–क्रायोलाइट तकनीकों का उपयोग करके स्वरतिया चिरायीत में क्रायो संरक्षण प्रयोगों में सफलता की अलग–अलग डिग्री हासिल की गई। स्लो–ग्रोथ मीडिया हेडिकियम कोरोनेरियम और फ्रैगारिया एक्स अन्नासा में स्थापित किया गया। फलों, औद्योगिक फसलों, फलों, बाजरा, चरागाह, सब्जियों और जंगली प्रजातियों से संबंधित कुल 478 प्राप्तियों को बीज, भ्रूण कुल्हाड़ियों और पराग के रूप में संग्रहीत किया गया। कुल 14 प्रजातियों में फ्रीजिंग और डिसेक्शन अध्ययन किए गए। पिपर निग्रम (48 आईएसएसआर का उपयोग करके), इपोमेया बटाटा (48 आईएसएसआर मार्करों का उपयोग करके), एक्संथोसोमा सैजिटिफोलियम (40 आईएसएसआर मार्करों का उपयोग करके) में इन विट्रो उगाए गए पौधों की आनुवंशिक अखंडता के रखरखाव की पुष्टि की गई। टीसीसीयू की गतिविधियां एसडीजी 2, लक्ष्य 2. 5 (खाद्य उत्पादन में आनुवंशिक विविधता को बनाए रखना) का अनुपालन करती हैं।

Summary: *In vitro* cultures of 1,962 accessions of various plant species were conserved in the *In Vitro* Genebank (IVAG) at storage temperatures of 8-25°C, with subculture duration ranging from 1-24 months. A total of 12,615 accessions of agri-horticultural species in the form of seeds, embryonic axes, pollen and 2,194 genomic resources were conserved in the Cryogenebank. A total of 28 new accessions were added to the IVAG and 13 accessions were added to the *In Vitro* Base Genebank (IVBG). *In vitro* establishment and multiplication protocols were developed in *Allium schoenoprasum, Artocarpus lakoocha, Fritillaria cirrhosa, Homalomena aromatica, Ipomoea batatas, Momordica dioica, Piper nigrum,* and *Zingiber chrysanthum*. Varying degrees of success was achieved in cryopresevation experiments in *Allium sativum, A. shoenoprasum, Artocarpus lakoocha, Humulus lupulus, Morus indica, Piper longum* and *Swertia chirayita* using vitrification, droplet-vitrification and V and D-cryoplate techniques. Slow growth media was established in *Hedychium coronarium* and *Fragaria* x *annanasa*. A total of 478 accessions belonging to fruits, industrial crops, legumes, millets, forages, vegetables and wild species were cryostored in the form of seeds, embryonic axes and pollen. Freezing and desiccation studies were carried out in 14 species. Maintenance of genetic integrity of *in vitro* raised plants was confirmed in *Piper nigrum* (using 48 ISSR), *Ipomoea batatas* (using 48 ISSR markers), *Xanthosoma sagittifolium* (using 40 ISSR markers). The activities of TCCU comply with the SDG 2, Target 2.5 (maintain the genetic diversity in food production).

7.1 Conservation of vegetatively propagated crops

7.1.1 Germplasm maintenance, augmentation and addition

A total of 1,962 accessions of the mandated crops were conserved *in vitro* in the form of 37,800 cultures and/or *in vitro* cryopreserved meristems/shoot tips in the *In Vitro* Active Genebank (IVAG) or *In Vitro* Base Genebank (IVBG). Cultures in IVAG are normally conserved at 25±2°C and 16 h photoperiod, and in some species at low temperature (5-10°C, in dark). The average subculture period under these conditions varied from 1-24 months, depending on the species/genotype and the conservation strategy employed (Table 7.1).

A total of 157 accessions of different horticultural crops were received/procured and processed for *in vitro* establishment for its conservation in *In Vitro* Active Genebank (IVAG). This includes *Aconitum heterophyllum* (1), *Acorus calamus* (1), *Angelica gluaca* (1), *Ainsliae aptera* (1), *Arnebia benthamii* (1), *Hedychium spicatum* (1),

Table 7.1: Status of *in vitro* conserved germplasm in IVAG (as on December 31, 2022)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)	No. of accs added during 2022	Major collections(no. of accessions)
Tropical fruits	3	18	9,500	**449**	5	*Musa* spp. (443), *Garcinia gummi-gutta (1), Garcinia indica (4),Syzygium cumini (1)*
Temperate and minor tropical fruits	10	42	8,500	**382**	2	*Actinidia* spp. (11), *Aegle marmelos* (2), *Artocarpous* spp. (2), *Fragaria* x *ananasa* (81), *Malus domestica* (35), *Morus* spp. (61), *Prunus* spp. (29), *Pyrus communis* (76), *Rubus* spp. (62), *Vaccinium* spp. (21), Vitis (2)
Tuber crops	6	14	7,500	**527**	1	*Alocasia indica* (4), *Colocasia esculenta* (96), *Dioscorea* spp. (153), *Ipomoea batatas* (263), *Xanthosoma sagittifolium* (10), *Smallanthus sonchifolius* (1)
Bulbous and other crops	5	13	4,000	**177**	6	*Allium* spp. (161), *Dahlia* sp. (6), *Gladiolus* sp. (8)
Medicinal and aromatic plants	30	40	4,000	**198**	13	*Bacopa monnieri* (31) *Coleus forskohlii* (14), *Plumbago zeylanica* (15), *Rauvolfia serpentina* (16), *Tylophora indica* (10), *Valeriana wallichii* (18)
Spices and industrial crops (jojoba)	8	26	4,300	**229**	1	*Arundo donax* (1), *Curcuma* spp. (109), *Elettaria cardamomum* (5), *Humulus lupulus* (8), *Piper* spp. (7), *Simmondsia chinensis* (12), *Stevia rebaudiana* (1), *Zingiber* spp. (81), *Vanilla planifolia* (4)
TOTAL	**62**	**153**	**37,800**	**1,962**	**28**	

Dioscorea deltoidea (1), *Picrorhiza kurroa* (1), *Polygonatum verticillatum* (1), *Podophyllum hexandrum* (1), *Rheum australe* (1), *Saussurea costus* (1), *Selenium vaginatum* (1,) *Trillium govanianum* (1), *Valeriana jatamansi* (1) from ICAR-NBPGR, RS, Shimla; *Bacopa monnieri* (10) from ICAR-NBPGR, RS Thrissur; *Kaempgeria galanga* (25), *Kaempferia rotunda* (2) from ICAR-NBPGR, RS Shillong; *Homalomena aromatica* (1), *Kaempferia galanga* (1), from Division of exploration; *Kaempferia parviflora* (1) from ICAR RC NEH Mizoram. Also augmented one exotic species *Duboisia* sp. (3) received from Australia. *Curcuma* spp. (2) namely, *Curcuma amada* and *Curcuma aeruginosa* from ICAR RC NEH Region Mizoram Centre Kolasib were augmented for conservation. Twenty diverse accessions of *Allium strachei* (2), *A. przewalskianum* (1), *A. negianum* (1), *A. schoenoprasum* (2), *A. carolinianum* (1), *A. tuberosum* (2), *A. hookeri* (3), *A. sativum* (6), *Lilium polyphyllum* (1), and *Gladiolus hybridus (1)* were augmented. Fruits of *Musa balbisiana* (2) collected from wild Koloriang, Arunachal Pradesh; and male bud of banana (KP/PR/22-86) collected from Chhindwara, MP. Two accessions of traditional banana cultivars (*Musa* spp.) viz., Muzuzu (AAB) and Matooke (AAA) were received as voucher samples from Maua Mazuri Tissue Culture Products Ltd. Tanzania. Apple (1) from Jammu; *Malus* and *Prunus* (38) from RS Shimla; kiwifruit (4) from GEPU, were received in the form of cuttings or bud wood. *Dioscorea esculenta* (1) was augmented from Exploration Division and NBPGR Regional Station, Shimla. For introduction in IVAG, plants were initially established in the pots from tubers of collection received in *Dioscorea alata* (2) and *Dioscorea esculenta* (1). Nodal explant/ shoot tips were taken from the pot-grown tubers and surface sterilized. Clean cultures have been established on MS medium supplemented with BAP and NAA.

Based on the collections received, 28 accessions were added to the IVAG. These were *A. sativum* (3), *A. schoenoprasum* (1), *Bacopa monnieri* (11), *Chlorophytum borivilianum* (1), *Fritillaria roylei* (1), *G. indica* (4); *Gladiolus hybridus* (1), *Kaempferia galanga* (1); *Syzygium cumini* (1); *Smallanthus sonchifolius* (1); *Vitis vinifera* (2), *Zingiber neesanum* (1) in the *In Vitro* Genebank (IVGB).

7.1.2 *In vitro* cryobanking

Based on protocols developed earlier, cryobanking was done in 11 new accessions. This includes three accessions of *Allium sativum* (IC639637, IC639638, IC643872), two accessions of *Bacopa monnieri* (IC321278, IC256496), three accessions of *Colocasia esculenta* (IC0636541, IC0636542, IC0636543), one accession of *Morus indica* (IC313679) and four accessions of *M. bombycis* [EC49378550, cv. Almora local (IC313680), cv. S-13 (IC313971) and cv. T-1 (IC313838)] using shoot tips. Two accession of *Musa* (IC250668, IC250501) were cryobanked. The status of germplasm cryobanked in the IVBG is given in Table 7.2.

Table 7.2: Status of germplasm cryobanked in the IVBG (as on December 31, 2022)

Crop/Species	Acc. added during 2022	Total no. of accessions	Technique(s)*	Explant (s)#
Allium sativum	3	137	V, DV	ST
A. albidum	0	1	V, DV	ST
A. chinense	0	8	V, DV	ST
A. hookeri	0	2	V, DV	ST
A. fistulosum	0	1	V, DV	ST
A. lineare	0	1	V, DV	ST
A. ramosum	0	1	V, DV	ST
A. scorodoprasum	0	1	V, DV	ST
A. tuberosum	0	4	V, DV	ST
Bacopa monnieri	2	8	V, DV	ST
Colocasia esculenta	3	5	DV	ST
Dioscorea bulbifera	0	2	V	ST
D. deltoidea	0	12	V	ST
D. floribunda	0	1	V	ST
Ensete glaucum	0	2	AD	ZE
Fragaria x ananassa	0	1	ED	ST
F. chiloensis	0	1	ED	ST
Garcinia indica	0	1	DV	ST
Gentiana kurroo	0	3	DV	ST
M. indica	1	1	V, DV	ST
M. bombycis	4	4	V, DV	ST
Musa spp.	0	74	DV, V, AD	SM, ECS, ZE
M. acuminata	0	7	DV	SM, ZE
M. balbisiana	0	8	AD, DV	SM, ZE
M. cheesmanii	0	2	AD	ZE
M. inandamanesis	0	2	AD	ZE

Crop/Species	Acc. added during 2022	Total no. of accessions	Technique(s)*	Explant (s)#
M. itirenans	0	2	AD	ZE
M. ornata	0	1	AD	ZE
M. puspanjaliae	0	1	AD	ZE
M. textilis	0	1	DV	SM
M. velutina	0	2	AD	ZE
Rubus hybrid	0	6	ED	ST
Vaccinium ovatum	0	7	ED	ST
Total	**13**	**310**		

*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

7.1.3 *In vitro* germplasm supply and hardening

Total forty six accessions of different crops were supplied to the indenters for research purposes during the year. A total of 28 accessions of banana were supplied viz., NRC Banana, Trichy (19 acc.), Dept. of Botany, Gargi College, New Delhi (3 acc.); Deptt. of Biotechnology Chandigarh University, Mohali, Punjab (2 accessions); Deptt. of Botany, Gargi College, New Delhi (3 acc.) and National Agro-food Biotechnology Institute, Department of Biotechnology, Punjab (1 acc.). Among medicinal crops, 18 accessions were supplied viz., *Centella asiatica* (8), *Dioscorea deltoidea* (7) to DTU, Delhi and *Swertia chirayita* (1) and *Valeriana wallichii* (2) to V.G. Shivdare college of Arts, Commerce and Science, Solapur, Maharashtra. Sixty four accessions (exotic) of *in vitro* collection of *Rubus* spp. (41 acc.) and *Vaccinium* spp. (23 acc) were hardened for field transferred to RS Srinagar/ and RS Shimla. *Rubus* acc. transferred to RS Regional station in March 2021 which subsequently established well in the field genebank. Ten accessions out of those showed very good fruit bearing.

7.2 Supportive research

7.2.1 *In vitro* shoot multiplication/ micropropagation protocols

***In vitro* shoot multiplication of *Artocarpus lakoocha* IC612468- an underutilized fruit crop of India:** Shoot tips (1-1.5 cm) were excised from *A. lakoocha* cultures and multiplied on media supplemented with different concentrations of BAP [0.2, 0.5 and 1 mg/l]. Shoot parameters, *i.e.*, number of shoots, shoot length and number of nodes were recorded after four weeks. Amongst the tested media, B5 (0.5 mg/l BAP) was adjudged the best (Fig. 7.1).

***In vitro* multiplication of *Piper nigrum*:** A micropropagation protocol was developed in *Piper nigrum* (IC85371) for multiplication of elite genotypes. A total of 24 media combinations comprising of MS and WPM medium along with growth regulators BAP and kinetin were tested to optimize the best medium for shoot multiplication using nodal segments as explants. The highest shoot multiplication was recorded on MS medium supplemented with 0.5 mg L^{-1} BAP. The multiplied shoots were rooted on MS medium containing 2.0 mg L^{-1} IBA (Fig. 7.2).

***In vitro* aseptic culture establishment in *Homalomena aromatica*:** Experminents were initated in *H. aromatica* to establish aseptic *in vitro* cultures. Sterilization protocol was successfully standardized to establish aseptic shoot cultures using rhizome buds explants. Experiments were conducted to induce multiple shoots on MS medium supplemented with different concentrations of cytokinins, BAP and Kn. Aseptic cultures were obtained on MS + BAP (5.0 mg/l). Experiments are underway to standardize complete and repeatable protocol of *in vitro* propagation

***In vitro* establishment of *Zingiber chrysanthum*:** One accession a CWR of ginger, namely, *Z. chrysanthum* (Collector No. KP-PR-21-03)

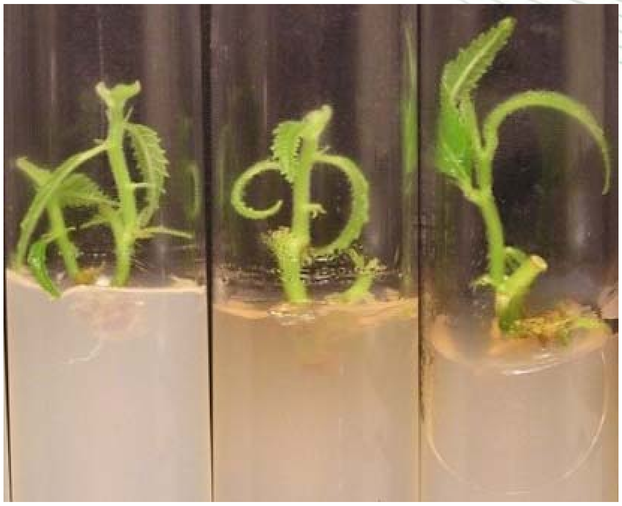


Fig. 7.1. Shoot multiplication of *A. lacucha*

Fig. 7.2. *In vitro* multiplied plants of *P. nigrum*

Fig. 7.3. Culture establishment of *Z. chrysanthum*

collected from Valmiki Tiger Reserve, West Champaran Dist., Bihar was established *in vitro* using rhizome buds as explants. Extracted buds were surface sterilized using 0.2% bavistin for 30 min followed by 0.05% mercuric chloride for 30 min. Explants were cultured onto MS medium supplemented with 11.11 µM BAP and aseptic plantlets were successfully established *in vitro* (Fig 7.3).

Aseptic cultures of *Allium schoenoprasum* established: *In vitro* cultures of *A. schoenoprasum* (IC0645159), collected from Kullu, Himachal Pradesh were established using basal portion of plant as explants. Healthy explants were successfully established after surface sterilization with 70% ethanol for 5 minutes, 1.0% cetrimide + 0.1 % streptomycine + 0.5 % bavistin for 20 minutes and 0.1 % $HgCl_2$ for 12 minutes. Among the tested 35 media combinations, highest number of shoots *i.e.* 5.5 shoots/explant were observed on MS medium supplemented with BAP (0.5 mg/l) + NAA (0.1 mg/l) with 30 g/l sucrose.

Aseptic cultures of *Fritillaria cirrhosa* established: Bulbous *Fritillaria cirrhosa* D. Don (Synonym: *Fritillaria roylei* Hook.) is a critically endangered medicinal herb and found in Himalayan region of India. Aseptic cultures were successfully established on MS + 0.1 mg/L NAA + 0.02. mg/L 2iP and multiple shoots (3-4 shoots/explant) was achieved.

***In vitro* mass multiplication and field acclimatization of spine gourd *(Momordica dioica)*:** As the traditional methods of spine gourd (*Momordica dioica* Roxb.) propagation have several limitations; efficient clonal propagation to aid in the production of high-quality planting material in genotype (RMDSG/2020-2) was developed through axillary shoot proliferation from nodal segments using shoot-tip explants derived from the tubers sprouted in the pot. Shoot induction was obtained on Murashige and Skoog's (MS) medium supplemented with 0.88 µM 6-benzyladenine (BA) while maximum shoot proliferation of 6±1.2 shoots per explants was recorded on MS medium supplemented with 2.22 µM BA. Profuse rooting was observed on half-strength MS medium containing 4.9 µM indole-3-butyric acid as well as on media containing half-strength MS salts with 5.71 µM indole-3-acetic acid. The roots were thick and short on media supplemented with IBA while roots were long and slender in IAA supplemented media. Successful hardening of the plantlets was recorded in potting mix containing soil: sand: vermiculite (3:1:1).

***In vitro* clonal propagation protocol for sweet potato:** Efforts were made to develop an improved *in vitro* clonal propagation protocol for sweet potato. A single nodal explant derived from 12 weeks old *in vitro* maintained plantlets was cultured on basal MS medium and MS medium supplemented with 12 different concentrations of meta-topolin along with fixed concentrations of NAA (0.54 µM) and GA_3 (0.09 µM). Optimum shoot multiplication response with highest number of shoots (7.26±0.17) and axillary nodes (65.254±1.82) was achieved on MS medium with 8.29 µM meta-topolin. Regenerated shoots exhibited 100% rooting response with an average 9.75±1.21 roots on ½-MS basal medium supplemented with 0.49 µM Indole-3-butyric acid (IBA). Sweet potato plantlets with well-developed shoot and root systems were successfully hardened with an average survival of 90.48±0.38% (Fig 7.4).

In vitro* rooting in *Xanthosoma: Experiments were conducted for optimization of *in vitro* rooting protocol in *Xanthosoma sagitifolium* (Fig 7.5). Single shoots (>2 cm) were inoculated on 12 different media containing various concentrations of auxins IAA, IBA and NAA. Hundred percent root induction was observed on IBA. In terms of root numbers, 1.0 mg/L IBA was found to be the best (13.94±0.46 roots).

7.2.2 *In vitro* slow growth conservation

***Hedychium coronarium* J. Koenig:** *In vitro* cultures of one accession (IC628130) were subjected to various slow growth conservation strategies and subculture duration was extended up to 3 years on MS medium supplemented with low concentration of BAP alone (0.5 to 1.0 mg/l) (50 %), on MS basal media (45 %) and on MS basal media under dark incubation (38 %) at standard culture room conditions. Upon shifting to fresh multiplication medium, 100% regrowth was observed from the 3 years conserved plants.

Fragaria* x *ananassa: 23 accessions of *Fragaria* x *ananassa* were conserved under normal growth condition and slow growth conditions (low temperature/ dark). Observation was recorded after six and nine months. Under normal growth condition, 88.68% cultures kept standard culture room condition (SCC) showed survival after six months while only 59% survived after nine months. At low temperature (~4°C) 100% cultures were green and healthy up to nine months and no contamination was observed. Experiment was continued (Fig 7.6).

7.2.3 *In vitro* cryopreservation protocols

***Alliums*:** Cryopreservation experiments were conducted for *A. sativum* using DV technique (pre-culture for three days on MS + 0.3 M sucrose and PVS3: 150 minutes). Post-thaw survival of shoot tips (isolated from cloves), ranged from 40-90% and shoot regrowth varied from 20-70%. Cryopreservation experiments were continued in *A. schoenoprasum* using DV protocol. Shoot tips (1.0-1.5 mm) were isolated from stock cultures pre-grown of on MS + 0.1 NAA + 0.5 BAP for 9 weeks (25°C for 4 week and 22/5°C for 5 week) followed by pre-culture of shoottips for four days on MS + 0.3 M sucrose, loading solution treatment for 30 minutes, PVS2 dehydration for 45 min, post-thaw regrowth of 60% was obtained.

Fig. 7.4. *In vitro* multiplied, hardened plantlets of sweet potato

Fig. 7.5. *In vitro* rooting response in *Xanthosoma sagitifolium*

Fig. 7.6. Conservation of *Fragaria* x *ananassa* under normal growth

Hops (*Humulus lupulus*): Cryopreservation experiments were carried out in hops (EC452695) using droplet-vitrification (DV) technique. Shoot tips isolated from stock cultures were pre-grown on MS medium supplemented with 0.3M sucrose overnight. Explants were then osmotically dehydrated in loading solution for 20 min and subjected to cryoprotectant treatment for 10, 20, 30 and 40 min at room temperature. After freezing in LN the explants were thawed rapidly and cultured on regeneration medium. Data on shoot tip survival and shoot regeneration was recorded. Cryoprotection of 30 min was found to be optimal with 50% post-thaw shoot tip survival and regeneration (Fig 7.7).

Artocarpus lakoocha: Experiments continued to standardize cryopreservation protocol for *A. lakoocha* (IC612468) using vitrification (V) technique and Droplet vitrification (DV) technique. 1 wk and 2 wk cold acclimation of cultures at alternate temperature of 22 and 5°C was tested. Shoot tips excised from cold acclimated plants, were pre-cultured on 0.5 M sucrose and treated with PVS2 for 20, 30 and 40 min at 0°C. In 1 wk cold acclimated shoot tips, 20% survival was observed after 40 m PVS2 treatment (-LN). 20% post-thaw survival (+LN) of shoot tips was recorded using droplet vitrification. Shoot tips excised from 2 wk cold acclimation cultures showed 10-30% survival after PVS2 treatment (-LN). However, no regrowth was observed in cryopreserved shoot tips.

Morus indica: Cryopreservation experiments were carried out in mulberry using Vitrification (V) & droplet vitrification (DV) techniques. On comparison of shoot tips isolated from 3-week-old cultures growing in standard culture-room condition (SCC) and shoot tips isolated from 1-week cold acclimated cultures, it was found that cryopreserved shoot tips isolated from plants growing under SSC gave rise to high regrowth per cent PVS2 20 min at 0°C (above 60%), while 40-50% regrowth was observed in cryopreserved shoot tips isolated from cold-acclimated plants in both technique (Fig 7.8).

Piper longum: Experiments were carried out on desiccation and freezing tolerance of shoot tips of *P. longum* using the D-plate method of cryopreservation. Shoot tips isolated from one month old cultures were precultured on high osmoticum medium (MS containing 0.3M sucrose). These shoot tips were then loaded onto wells of aluminium cryo-plates containing sodium alginate solution, followed by the addition of calcium chloride which led to polymerization of calcium alginate matrix coating the precultured shoot tips. These plates were treated with loading solution containing 2M glycerol and 0.4M sucrose for 20 min. The treated shoot tips were air dehydrated for different time durations (1.5 h, 2 h, 2.5 h and 3 h) in a laminar air flow and then frozen in LN. The shoot tips were recovered by thawing them in an unloading solution containing 1.2M sucrose and re-cultured on the regeneration medium. Data was recorded for shoot tip survival and regeneration. Control shoot tips in all the experimental set-ups showed 80-90% survival, while only the shoot tips dehydrated for 1.5 h before cryopreservation were observed

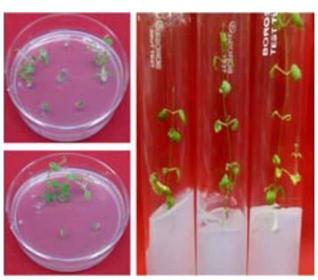


Fig. 7.7. Post-thaw survival, shoot regeneration and plantlet formation in explants cryopreserved by DV by different duration of PVS2 exposure

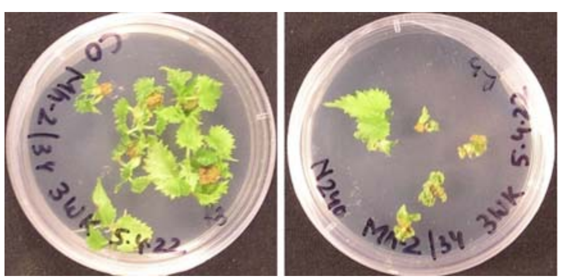


Fig. 7.8. Cryopreservation of *M. indica*: (a) Control and (b) cryopreserved shoot tips

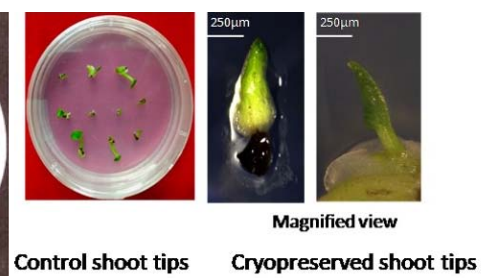


Fig. 7.9. Survival of air desiccated (a) control and (b) cryopreserved shoot tips

to show post-cyro recovery (10%) and regeneration (Fig 7.9)

Swertia chirayita (Roxb.) H.Karst.: *Swertia chirayita* (Roxb.) H.Karst. 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 Murashige and Skoog (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 dehydrated with Plant Vitrification Solution 2 (PVS2) (10 to 40 min) and cryoconserved using vitrification and droplet-vitrification (DV) technique. Shoot tips subjected to PVS2 solution for 20 min reported high post-thaw regeneration using DV (44.44 %) in comparison to 21.67 % using V.

7.2.3 Genetic stability analysis of conserved germplasm

Piper nigrum: Genetic stability assessment of micropropagated plants of *P. nigrum* was carried out using 48 ISSR markers. Banding profiles of mother cultures were compared to those of plants multiplied on the multiplication medium. No significant variation was observed between the mother plants and the clonally multiplied plants indicating no loss of genetic stability (Fig 7.10).

Sweet potato: Genetic integrity of sweet potato plants multiplied on different concentrations of phytohormone meta-topolin was analyzed using 48 ISSR primers. The amplification profiles of plants multiplied on low, optimal (yielding best multiplication rate) and high concentrations were compared with mother plants. Out of 48 ISSR primers tested, 32 gave scorable amplification (66.67%). Analysis revealed 100% similarity among all the *in vitro* multiplied plants and mother plants.(Fig 7.11).

***Xanthosoma sagittifolium*:** The genetic uniformity of *in vitro* induced meristematic clumps and regenerated plantlets of *X. sagittifolium* was analyzed using 40 ISSR primers. Out of 40 tested primers, 25 gave scorable amplification with a total of 91 monomorphic bands. Amplification profiles revealed 100% similarity of all the tested samples with mother plants thus indicating the genetic uniformity of *in vitro* plant material during all multiplication stages (Fig 7.12)

7.3 Cryopreservation of seed, pollen, dormant bud and genomic resources

7.3.1 Germplasm augmentation and cryostorage

A total of 12,615 accessions comprising non-orthodox (intermediate and recalcitrant) and orthodox seed species and 2,194 genomic resources are being conserved in the cryogenebank (Table 7.3). During the period, a total of 478 accessions of diverse germplasm comprising fruits & nuts, industrial crops, medicinal and aromatic plants, vegetables including wild species and wild relatives of crop plants were cryostored as seeds, embryonic axes and pollen at temperatures between -160°C to -180°C.

7.3.2 Studies on germplasm

Studies on desiccation and freezing sensitivity of seeds for developing cryopreservation protocol: A total of 14 diverse species were received during the period under report including *Aconitum heterophyllum* (1), *Angelica glauca* (1), *Catunaregam spinosa* (1), *Eriobotrya japonica* L. (53), *Garcinia pedunculata* (1), *G. xanthochymus* (1), *Hematocarpus validus* (1), *Morus* spp. (35), *Momordica subangulata* sub sp. *renigera* (1) and *M. subangulata* sub sp. *subangulata* (1), *Podophylum hexandrum* (1), *Rheum austral* (1),

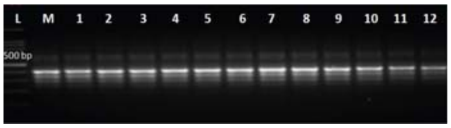


Fig. 7.10. Banding profiles obtained with ISSR primer IS8 of the mother plant and micropropagated plants (Ladder lane: 100 bp DNA marker, M- mother plant, 1-12: micropropagated plants)

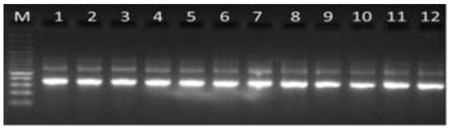


Fig. 7.11. ISSR profile UBC824; where M: 100 bp DNA ladder, 1-3: plantlets obtained on low mT, 4-6: plantlets obtained on optimal mT, 6-9: plantlets obtained on high mT, 10-12: mother plants

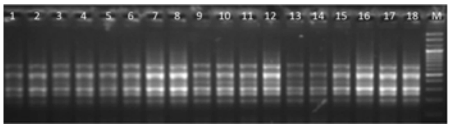


Fig. 7.12. ISSR profile of primer UBC 847; 1-3: mother plants; 4-6: calli regenerated plants, 7-12: meristematic clumps, 13-18: directly regenerated plantlets

Table 7.3: Status of cryopreserved germplasm (as on 31st December 2022)

Categories	No. of accessions added in 2022	Total Accessions (no.)
Recalcitrant & Intermediate		
Fruits & Nuts	411	4229
Spices & Condiments	15	238
Plantation Crops	0	121
Agro forestry & Forestry	0	1645
Industrial crops	10	1353
Medicinal & Aromatic Plants	2	50
Total	438	7,636
Orthodox		
Cereals	0	289
Millets and Forages	0	293
Pseudo-cereals	0	76
Grain Legumes	1	814
Oilseeds	0	682
Fibers	0	68
Vegetables	5	592
Medicinal & Aromatic Plants	6	1019
Narcotics & Dyes	0	35
Miscellaneous	2	80
Total	**14**	3,948
Dormant buds	0	**389**
Pollen grains	26	**642**
Total	**478**	**12,615**
Genomic resources	0	**2194**

Saussurea costus (1) and *Syzygium jambos* (6) for cryo-conservation studies. Desiccation and freezing sensitivity of the seeds revealed *A. heterophyllum*, *A. glauca*, *Morus* spp., *P. hexandrum*, *R. austral* and *S. costus* as orthodox seeded species while *C. spinosa*, *M. subangulata* sub sp. *renigera* (1) and *M. subangulata* sub sp. *subangulata* showed intermediate seed storage behavior. Seeds of *E. japonica*, *Garcinia* spp., *H. validus*, *S. jambos* showed recalcitrant storage behavior. Seeds of *G. pedunculata* and *G. xanthochymus* were devoid of any embryo like structure and showed viability loss with desiccation.

Desiccation and freezing sensitivity studies in (*Calophyllum inophyllum* L.): Seeds exhibited high oil content and short lived as they showed rapid loss in viability when desiccated slowly in silica as well as under air desiccation at room temperature. No germination was recorded when seeds are desiccated to MC 19% (after 5 months of desiccation at room temperature). The embryonic axis was not prominent in the seed, however, seed section containing protruding end (probable site of rooting) when used for cryopreservation, none of the inoculated seed sections showed germination under in vitro conditions.

Desiccation and freezing sensitivity studies in *Catunaregam spinosa* (Thunb.) Tirveng: The freshly extracted seeds of *C. spinosa* (KP/PR/21-05) with 29% moisture content showed 80% germination. The seeds showed freezing sensitivity below 15% moisture content [Critical moisture content (CMC)]. Seed germination at CMC was as high as 75% which dropped drastically (35%) at 10% moisture content after cryopreservation, indicating probable intermediate type of seed storage behaviour.

Recalcitrant seed storage behavior of *Hematocarpus validus*: Seeds of a critically endangered species (*H. validus*) commonly called as blood fruit, showed desiccation and freezing sensitivity. As the seeds were large and desiccation sensitive, the embryos were isolated aseptically from the seeds and desiccated under laminar air flow for conducting long-term conservation experiments. The critical moisture content was ~30% using air desiccation indicating its probable recalcitrant behavior in initial experiments. Hence, long-term conservation of embryos using new cryopreservation techniques need to be standardized in this species.

Seed desiccation and freezing tolerance in *S. jambos*: The seeds of *S. jambos* were studied for basic seed germination pre- and post-LN treatment using air desiccation and freezing in LN using vitrification and slow freezing method (using programmable freezer). Seeds were composite containing more than one embryo (1-3 embryo/seed) which are highly recalcitrant and looses viability below 26% moisture content. The embryos extracted aseptically from fresh seeds showed maximum seed germination (100%) in MS media supplemented with 2.22µM BAP. Maximum embryo germination (80%) after desiccation to 26% mc was observed. However, embryos could not survive LN exposure in either of the two methods tested.

Seed storage studies in *Momordica* spp.: Seeds of two species *M. subangulata* sub sp. *renigera* (JJK/Sel/I) and *M. subangulata* sub sp. *subangulata* (JRPH/15-128) were received for long-term conservation studies from regional station Thrissur, as viability loss was observed in MTS during storage in this species. Seeds at a mc 7-8% were stored at four temperature conditions viz., ambient room temperature (22-25ºC), refrigerated storage (5ºC), deep freezer storage (-20ºC) and in Liquid Nitrogen (-196ºC). Viability of seeds (TTC staining) after one, three, six months was recorded. It was observed that seeds loose viability quickly when stored at low temperature of -20ºC and -196ºC. Maximum viability after 6 months of storage at room temperature (40%) was observed as compared to the viability of seeds in refrigerated condition (20%).

Seed germination medium in *Fritillaria roylei* was standardized: *F. roylei*, a critically endangered herb growing well in Himalayan sub-alpine and alpine meadows is prized for its therapeutic potential. Seed germination experiment under aseptic conditions was performed as germination protocol was not available. MS media supplemented with various growth regulators viz., BAP, Kinetin, GA3 were tested for maximum germination in the seeds before and after LN treatments; The inoculated seeds were kept at two different temperatures for germination viz., 5±2ºC and 25±2ºC; The highest seed germination (30%) was observed in MS media in fresh seeds (not stored in LN) when kept at refrigerated conditions (5±2ºC); Maximum germination after LN treatment (10%) was observed in MS media supplemented with GA3 (0.5mg/L) and Kinetin (0.2 mg/L).

7.3.3 Testing health status and regeneration of cryostored germplasm

Pest free status of 179 accessions of 38 species was checked and only three were found infected. Fresh seed viability, pre- and post-cryo viability of desiccated seeds were tested for 190 accessions of fresh orthodox/ non-orthodox seed species including Citrus, *Aegle marmelos, Annona reticulata, Buchanania lanzan, Dillenia indica, Diospyros melanoxylon, Ficus palmata, Limonia ascidissima, Manilkara hexandra, Morus* spp., *Muntingia calabura, Phoenix sylvestris, Pithecellobium dulce, Pyrus* spp., *Rheum austral, Saussurea costus, Tamarindus indica* etc. to ensure their successful cryostorage (Fig. 7.13).

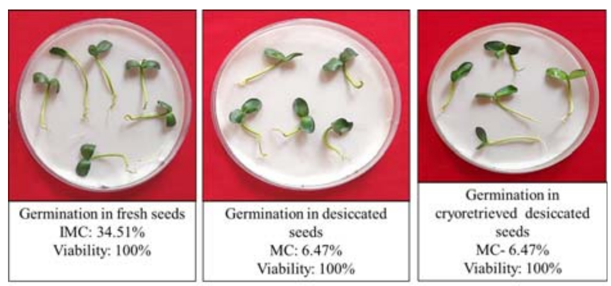


Fig. 7.13. Fresh seed viability, pre- and post-cryo viability of desiccated seeds of *Limonia ascidissima* (IC0645560)

Research programme (Code, Title, **Programme leader)**
Programme I: 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)**
Research project (Code, Title, **PI,** CoPIs & *Associates*)
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,** *DPS Meena*]
PGR/TCCU–BUR-DEL-01.06: *In vitro* conservation of temperate and minor tropical fruit crops [**Sandhya Gupta,** Narender Negi]
PGR/TCCU–BUR-DEL-01.07: Studies on genetic integrity of conserved germplasm [**Era V. Malhotra,** Sangita Bansal]
Programme II: 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**)
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]

8 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 तक आसान पहुंच की सुविधा प्रदान करना है। पीजीआर पोर्टल, एनबीपीजीआर का प्रमुख वेब–आधारित सूचना संसाधन, कई देशों के शोधकर्ताओं द्वारा प्रयोग में लाया गया। नए एप्लिकेशन विकसित किए गए और कुछ को सार्वजनिक उपयोग के लिए जारी किया गया। ट्विटर के माध्यम से पीजीआर गतिविधियों के बारे में जानकारी प्रसारित करने के एकेएमयू के प्रयास ने एनबीपीजीआर द्वारा निभाई गई भूमिका को लोकप्रिय बनाने वाले 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 Twitter has attracted many users popularizing the role played by NBPGR.

8.1 PGR Portal: Access to information uninterrupted

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 eight years. During 2022, PGR Portal had 69,129 page views. Google Analytics data show that 2,764 users clocked ~190 page views per day across 4,945 sessions. Increasing popularity of PGR Portal among researchers was evident as 66% users reached PGR Portal directly without any search engines. The PGR Portal was compatible across browsers and devices, and was accessed on mobile devices by 26% users.

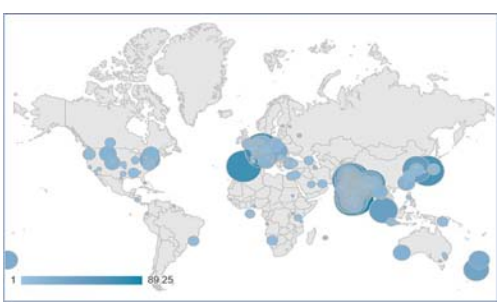


Fig. 8.1. Access to PGR Portal was from across the world throughout

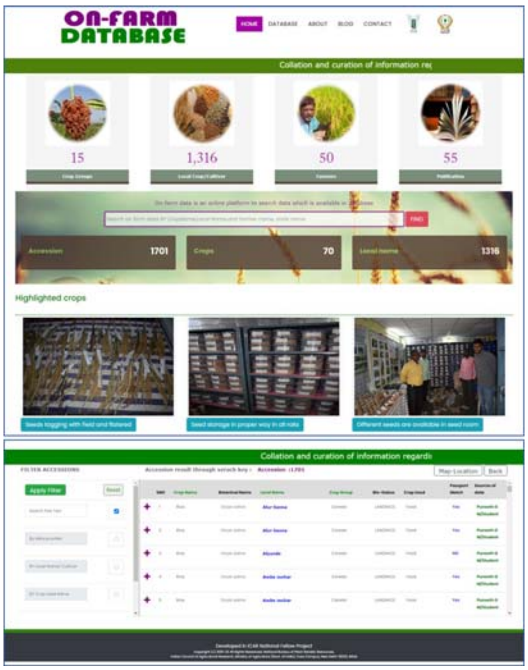
Source: Google Analytics

8.2 Plant Quarantine dashboard

The database for plant quarantine activities was developed in 2021. An application with dashboard was developed in 2022 for easy access, data updating and report generation by the nodal persons in the Division of Plant Quarantine.

8.3 On-Farm conservation database pilot project

Initiated work on development of a database and application covering on-farm conservation activities. With a focus on documenting germplasm outside genebank, on-farm database was designed with addition of pilot data. Web-app is ready with infographics, search and customized reports. Next year the application is expected to include more data from regional stations.

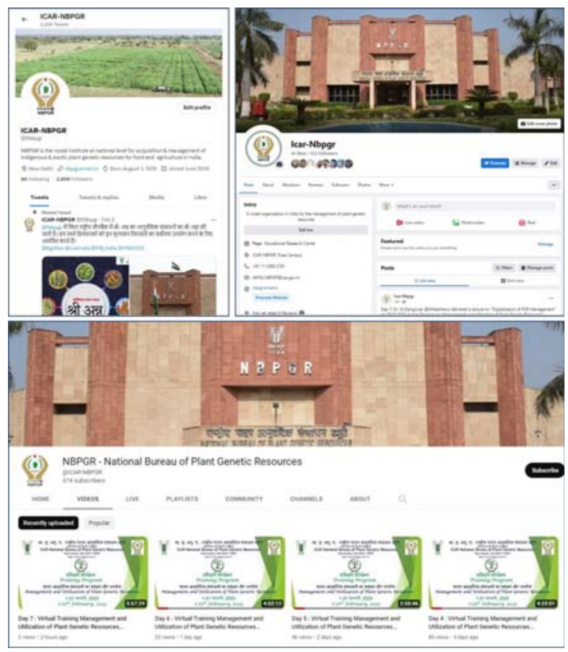


8.4 NBPGR on social media

NBPGR maintains a strong presence on the social media via the official twitter account @iNbpgr. During January 2022 to December 2022, NBPGR tweeted 394 information bits, which attracted as many as 259 K impressions, 131.9 K profile visited. By the end of 2022, NBPGR had 1,238 followers. NBPGR YouTube channel hoisted six events (four live) in January 2022 to December 2022. Institute Facebook page was opened on 5 Nov 2022. As many as 31 items were posted in 2022 (110 followers).

8.6 Virtual Platform

AKMU managed virtual meetings, webinars, interviews, events, etc. as well as NBPGR social media. During 2022, a total of 218 virtual engagements (meetings, interviews, IRC, RAC, trainings, seminars, viva, classes, etc.) were facilitated accounting for a total of 10,614 participants, 1,537 duration hours.



8.7 PGR Informatics activities

Table 8.1: PGR data status (number of accessions)

Information	Activity	Additions during 2022	Status as on 31-12-2022
Indigenous collections	IC number allotment	4,663	6,47,174
Exotic collections	EC number allotment	51,986	11,53,408
Genebank information	Data addition	5,927	4,18,821
Characterization data	Data porting	1,812	2,27,960
CryoBase	Data addition	423	10,738
Plant Germplasm Registration	Data addition	189	2,074

Table 8.2: 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
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/
MTS Application	pgrinformatics.nbpgr.ernet.in/mts/
Field Genebank	pgrinformatics.nbpgr.ernet.in/FGB/
Cryogene Bank	pgrinformatics.nbpgr.ernet.in /cryobank
National Genomic Resource Repository	www.nbpgr.ernet.in:8080/NGRR
Plant Quarantine Information System	pgrinformatics.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	pgrinformatics.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, IP PGR

8.8 Launch of PGR Informatics applications

Plant Quarantine Information System (1) and The National Genomic Resource Repository Application (2) were launched for public use on the occasion of 46th Foundation Day on 1 August 2022 by Dr PL Gautam and Dr SK Vasal respectively.

Research programme (Code, Title**, Programme leader)**
Programme: PGR informatics (Programme Leader: Sunil Archak)
IXX10707: PGR Informatics (**S Archak** and *Rajeev Gambhir* from AKMU) *[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)

9 REGIONAL STATION, AKOLA

सारांशः वर्ष के दौरान एक अन्वेषण और संग्रह कार्यक्रम शुरू किया गया और छत्तीसगढ़ राज्य में अचनकमार–अमरकंटक बायोस्फीयर रिजर्व और आसपास के क्षेत्रों से एगल मार्मेलो (35) और बुचनानिया लैंजन (15) सहित कुल 50 एक्सेशनों को एकत्र किया गया। कुल 4793 एक्सेशन, रबी 2021–22 के दौरान 3339 एक्सेशन, और खरीफ 2022 के दौरान 1454 एक्सेशनों का लक्षण वर्णन और मूल्यांकन किया गया। रबी 2021–22 के दौरान अलसी (2657), चना (200), और कुसुम (482) और खरीफ 2022 में मुंग बीन (598), होर्सग्राम (200), छोटे बाजरा (93), फॉक्स मिलेट (120), फिंगर मिलेट (92), तिल (151) और भिंडी (200) की विशेषता वाले फसल–वार एक्सेशनों का लक्षण वर्णन किया गया। भारत के भीतर उपयोगकर्ता एजेंसियों को अनुसंधान उद्देश्यों के लिए विभिन्न फसलों की 10459 एक्सेशनों की आपूर्ति की गई। रिपोर्टिंग अवधि के दौरान विभिन्न फसलों की 7279 जननद्रव्य एक्सेशनों का गुणन और रिजेनेरेट किया गया। विभिन्न फसलों/प्रजातियों के जननद्रव्य के कुल 20,838 एक्सेशन जिनमें तिलहन (10452), दलहन (4687), सब्जियां (2034), संभावित फसलें (1399), बाजरा (1536), और फसल पौधों की वन्य प्रजातियां (730) शामिल हैं, को अकोला क्षेत्रीय स्टेशन के मध्यम अवधि के भंडारण में नियंत्रित परिस्थितियों में रखा जा रहा है।

Summary: One exploration and collection programme was undertaken during the year and a total of 50 accessions comprising *Aegle marmelos* (35) and *Buchanania lanzan* (15) were collected from Achanakmar-Amarkantak Biosphere Reserve and surrounding areas in Chhattisgarh state. A total of 4793 accessions comprising 3339 accessions during *Rabi* 2021-22 and 1454 accessions during *Kharif* 2022 were characterized and evaluated. Crop-wise accessions characterized were Linseed (2657), chickpea (200) and safflower (482) during *Rabi* 2021-22 and mung bean (598), horse gram (200), little millet (93), foxtail millet (120), finger millet (92), sesame (151) and okra (200) in *Kharif* 2022. Supplied 10459 accessions of various crops for research purpose to user agencies within India. Multiplied and regenerated 7279 germplasm accessions of different crops during the reporting period. A total of 20,838 accessions of various crops/species germplasm comprising oilseeds (10452), pulses (4687), vegetables (2034), potential crops (1399), millets (1536) and wild relatives of crop plants (730) are being maintained under controlled conditions in the medium term storage of the Regional Station at Akola.

9.1 Exploration and collection of germplasm

As per the approved National exploration programme an exploration was undertaken for the collection of *Buchanania lanzan*, *Flacourtia indica*, *Manilkara hexandra*, *Aegle marmelos*, *Madhuca longifolia* var. *latifolia*, *Cordia macleodii*, *Phoenix acaulis*, *Zizyphus spp*. and *Andrographis paniculata* from Achanakmar-Amarkantak Biosphere Reserve (Chhattisgarh) from April 27th to May 4th, 2022. A total of 50 accessions were collected from 25 collection sites in Achanakmar-Amarkantak BR and surrounding areas (Fig. 9.1). These includes, the targeted species of *Aegle marmelos* (35) and *Buchanania lanzan* (15).

Out of 35 *bael* accessions, morphologically unique 21 accessions were analyzed for various traits (Fig. 9.2). The highest mean fruit weight was recorded in accession IC0645501 (2.54 kg) followed by IC0645463 (1.40 kg) while the accession IC0645480 exhibited the lowest average fruit weight (77.65g). The highest dry matter content was found in IC0645477 (50.53 %) and IC0645487 (48.46%). Whereas, IC0645499 recorded the lowest mean dry matter content (19.49 %). The highest pulp recovery was found in IC0645487 (71.22%) followed by IC0645499 (67.59%). Accession IC0645487 recorded the highest TSS content (54.16°Brix) and lowest TSS content was obtained in IC0645499 (26.81 °Brix) accession. Total carotenoid content was high in IC0645485 (6.21 µg/g) and the lowest was recorded in IC0645501 (0.62 µg/g) showing 9.5 fold variation for the trait. FRAP antioxidant activity ranged from 0.09502 to 0.20199 % GAE and the highest FRAP antioxidant activity (0.20199 % GAE) was recorded in the IC0645480 while the least antioxidant activity was observed in IC0645496 (0.09502 %GAE). Total phenolics in 21 *bael* accessions varied from 1.22 (IC0645501) to 2.27 % GAE (IC0645480).

9.2 Characterization and evaluation of germplasm

9.2.1 *Rabi* 2021-22

A total of 3339 accessions were characterized and evaluated during *Rabi* 2021-22 and Crop-wise accessions characterized were linseed (2657), chickpea (200), 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).

Chick pea: A total of 200 accessions of chick pea along with ten 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* 2021-22. Promising accessions were identified for days to 50% flowering were IC117804 and IC117807 (63 days); For primary branches per plant : IC117832 and IC117833 (6.0); for pods per plant: IC117844 (215) IC117798 and SAKI-9516 (210) and for 100 seed weight PKV Kabuli-4 (38.80g) and PKV Kabuli-2 (30.24g) were promising.

Linseed: Under DBT-linseed project a total of 2657 linseed accessions along with eight checks (T397, Shekhar, Sheela, Sharada, Kartika, JLS-95, JLS-67 and LSL-93) were characterized in ABD. High variation was observed for different qualitative and quantitative traits. Promising accessions identified for different traits were for days to 50% flowering IC0118906 (36days), EC0455084 and LSL93 (37days): for Plant height IC0498784 (76.0cm), IC629220 (71.4cm); for Primary branches per plant IC0499080 (15.4) and IC0585363 (15.2); Capsules per plant IC0499080 (270), IC096730 (248) and IC096731 (239); for seed yield per plant IC0499080 (9.68g) and IC0424874 (8.73g) and for 1000 seed weight accessions IC0564678 (10.42g) and IC0585287 (9.96g) were superior (Fig. 9.3).

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 and SSF-708) were evaluated in ABD during *Rabi* 2021-22. Earliness in 50% flowering was observed in IC527924 (64 days), IC442656 and IC511293 (75 days). For diameter of main capitula, the accessions IC0500180 (3.81cm), EC0159627-X (3.49cm) and EC182347 (3.44cm) were superior. Highest seed yield per plant was recorded in EC182247 (48.33g), EC0337351 (43.83g) and IC0337833 (41.98g) and for 1000 seed weight accessions IC0338249 (76.5g), IC0500180 (73.0g) and IC545062 (68.3g) were found promising (Fig. 9.4 – Fig. 9.5).

9.2.2 *Kharif* 2022

A total of 1454 accessions were characterized and evaluated during *Kharif* 2022. Crop-wise accessions characterized were mung bean (598), little millet (93), foxtail millet (120), finger millet (92), horse gram (200), sesame (151) 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).

Fig. 9.1. Chironji (*Buchanania lanzan*) fruits collected from Achanakmar-Amarkantak Bio-sphere Reserve

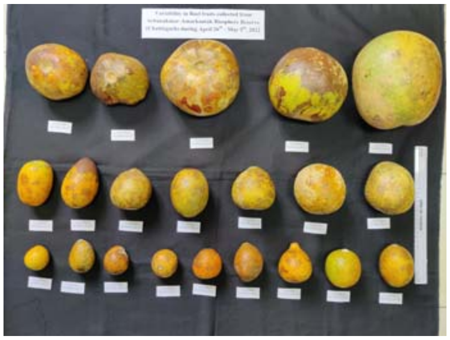


Fig. 9.2. Variability collected in Bael for fruit shape and size

Fig. 9.3. Linseed germplasm Characterization –Field View

Fig. 9.4. Safflower characterization- Variability for plant types

Fig. 9.5. Variation for flower colour in Safflower

Mung bean: Two hundred accessions of mung bean along with nine checks (AKM8802, BM2003-2, Green Gold, IPM02-3, IPM 02-14, MH-421, PDM 139, SMJ668 and Phule Chetak) were evaluated in ABD. Promising accessions were identified for different traits. For days to 50% flowering, IC39545, PLM-124 and PLM-76-1 (40 days); For plant height IC10179 (100.99cm), IC10492-2 (87.59cm) and IC11664 (82.09cm); For pod clusters per plant IC11088 (11.62), PLM-124 (11.16) and PLM-180 (11.16); For pods per plant IC10497-1 (33.69), EC314299-1 (33.14) and EC391021 (33.14); For number of seeds per pod IC39512 (15.72), IC39552-1 (15.32), IC39525 (15.12); Seed yield per plant IC39392 (8.66g), IC11469 (7.41g) and PLM-185 (6.54g); For 100 seed weight EC396520 (4.98g), IC11124 (4.64g) and EC314299-1 (4.56g) (Fig. 9.6).

Fig. 9.6. Mung bean characterization- field view

Mung bean core evaluation under DBT project:

A total of 398 accessions of mung bean and five checks (IPM02-3, IPM2-14, MH421, PDM139 and SML668) were evaluated in ABD. Promising accessions identified for various traits. For days to 50% flowering, PLM53 (27 days), PLM324 (31 days) and IC447908 (32 days); For plant height EC260603 (57.37 cm), EC249640 (56.19cm) and IC548268 (55.91cm); for number of seeds per pod, PLM897(15.91), IC336750 (15.77) and IC338883 (15.11); For pods per plant, IC436668 (50.22), IC343864 (45.62) and IC76482 (40.82); for yield per plant, PLM89 (10.4g), PLM169 (9.14g) and EC396141 (9.08gg); For 100 seed weight, EC396402 (6.88g), EC396122 (6.68g) and EC398884 (6.67g) (Fig. 9.7).

Fig. 9.7. Variation for pod length in mung bean core set

Horse gram: Two hundred accessions of horse gram along with five checks (AK-21, AK-38, HGGP, PHG-9 and Raigad Local) were evaluated in ABD. For trait days to 50% flowering check Raigad Local was early whereas for 80% maturity accessions IC49287 (108 days), IC53615 and IC55083 (110 days) were early. Higher number of pods per plant were recorded in IC435110 (320), IC43512 (225) and IC26136 (220). Accessions IC23493 (33.62g), IC47461 (33.42g), and IC23486 (31.35g) were best for seed yield per plant. High 100 seed weight was reported in check AK-21 (4.77g) (Fig. 9.8).

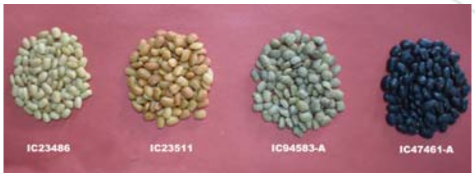


Fig. 9.8. Variation for seed colour in Horse gram germplasm

Fig. 9.9. Variation for panicle types in Foxtail millet germplasm

Fig. 9.10. Finger millet characterization- Variability in panicle types

Foxtail millet: A total of 120 accessions of foxtail millet and six checks (SIA-3156, Lepakashy, Prasad, Krishndevraya, Narsingraya and SIA-3088) were evaluated in ABD. Promising accessions identified for various traits. For days to 50% flowering, IC 120257, IC 326941, IC 325968 (44 days) and IC 406590 (46 days); For plant height, K-2660 (117.5 cm), K-2660C (117.5 cm) and IC 120179 (116.33 cm); For earhead length, IC 120183 (19.58 cm), IC 120237 (17.58 cm) and K-266 (17.42 cm); For number of productive tillers, IC 120183 (3.92), IC 120237 (3.52) and K-266 (3.48); For panicle length, IC 333326, IC 344714 (22.29 cm) and NIC 183182-2 (20.13 cm); For yield per plant, IC 120183 (10.64 g), IC 120244 (9.64 g) and NIC 183182-2 (8.39 g); For 1000 seed weight, IC 120403 (4.13 g), IC 120204 (3.77 g) and IC 120248 (3.75 g) (Fig. 9.9).

Little millet: A total of 93 accessions of little millet and three checks (JK- 8, DHLM 36-3 and BL-6) were evaluated in ABD. Promising accessions identified for various traits. For days to 50% flowering, JK-8 (45 days), IC 483399 (47 days) and IC 482803 (48 days); For number of basal tiller, IC 028415 (6.28), IC 404852 (6.28) and IC 482831 (6.15); For plant height, IC 405065 (159.88 cm), IC 482850 (154.88 cm) and IC 405063 (149.88 cm); For panicle length, IC 405065 (35.92 cm), IC 405071(34.92 cm) and IC 483165 (34.92 cm); For yield per plant, IC 483446 (5.41 g), IC 483062 (5.34 g) and IC 404852 (5.22 g); For 1000 seed weight, IC 482830 (3.93 g), IC 261432 (3.67 g) and IC 483042 (3.61 g).

Finger millet: A total of 29 varieties of finger millet were evaluated in RBD. Promising accessions identified for various traits were for days to 50% flowering KMR 660 (83 days),VL 376 (79 days), RAU8 (76.5 days) ; For plant height, MR1 (88.3 cm), KMR 301(82.3 cm), MR 6 (84.4 cm); for Ear head length, KMR-301 (9.2 cm), GPU 48 (9 cm), MR-6 (8.9 cm); For productive tillers, GPU 26, GPU 67 ad VL376 (3.5); For yield per plant, VR 762 (13g), VR 936 (11.8g), VL 379 (10.9g); for 1000 seed weight, GPU 28 (3.11g), VR 988 (3.32g) and MR 6 MUTANT (3.2g).

White Finger millet Characterization: Sixty-three accessions of white seeded finger millet along with their seven checks (PR 202, GPU67, KMR 340, OUAT 2, VL 352, VL376, and GN5) were evaluated in RBD. Promising accessions identified for various traits were for days to 50% flowering IC0474356 (84 days), IC0475624 (85 days), IC0065595 (90 days); For plant height, IC0473972 (100.3cm), IC0473959 (93 cm), IC0473957(91.2cm) ; For Ear head length, IC0473986 (8.8cm), IC0065595(8.4cm), IC0474228(8.4cm); For productive tillers, IC0475624 (5.6), IC0473970 (4.5), IC0474356(4); For yield per plant, IC0474356 (13.3g), IC0475624 (10.4g), IC0065595 (10.4g), IC0473858 (9.3g) ; For 1000 seed weight, IC0473992 (3.29g), IC0474356 (3.22g), IC0065595 (2.95g) and IC0473986 (2.73g) (Fig. 9.10).

Okra: A total of 200 accessions of okra and five checks (Arka Anamika, Parbhani Kranti, Pusa A-4, Arka Abhay, Phule Vimukta) were evaluated in ABD. Promising accessions identified for various traits. For days to 50% flowering, IC 12933 (49 days), EC 169340 (50 days) and IC 18073A (50 days); for fruit length at marketable stage IC 10265 (11.04 cm), IC 18073A (10.57 cm) and IC 15537 (10.07 cm); For fruit number of locules, IC 31033B (9.4), IC 6952 (8.57) and IC 29110 (8.5); For number of branches, IC 29359C (6.04), IC 31033A (6.04) and IC 27875A (5.94); For length of physiologically mature fruit, EC 102605 (20.98 cm), IC 13999B (20.41 cm) and EC 169331 (20.28 cm) (Fig. 9.11).

Screening of sesame germplasm for water-logging tolerance

Sesame germplasm comprising of 151 accessions and six checks (RT-346, PB TIL-2, GT10, TMV-7, VRI-1 and VRI-2) were screened in control and water-logging condition in Augmented Block Design). The water-logging tolerant accessions were identified on the basis of foliar damage score and chlorophyll Index. A total of 20 accessions which produced effective capsules per plant exhibiting some degree of tolerance against water-logging were identified (Fig. 9.12).

9.3 Regeneration and Multiplication of Germplasm

A total of 7279 accessions consisting of safflower (4655), niger (1824) and chick pea (200) in *Rabi* 2021-22 and mung bean (200), horse gram (200) and okra (200) in *Kharif* 2022 were regenerated (Fig. 9.13 –Fig. 9.14).

9.4 Germplasm Exchange

Supplied 10459 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.* mung bean (563), black gram (19), pigeon pea (2), grain amaranth (799), linseed (5326), niger (1323), okra (446), safflower (1694), sesame wild (18), winged bean (132), small millets (136), *Simarouba glauca* (1). Received 2492 accessions/ varieties of germplasm *i.e.* grain amaranth (250), mung bean (8), horsegram (1), black gram (8), linseed (1432), niger (379), sesame (271), soybean (60), spine gourd (8), wild linseed (6), winged bean (25), small millets (19), job tears (25) from different agencies.

9.5 Medium term storage of germplasm

A total of 20,838 accessions of various crops/ species comprising oilseeds (10452), pulses (4687), vegetables (2034), potential crops (1399), millets (1536) and wild relatives of crop plants (730) are being maintained under controlled conditions in the medium term storage of the station at Akola.

9.6 Field Gene Bank

A total of 75 accessions consisting of *Aloe vera* (05), wild foxtail millet (08), soybean wild (03), West Indian cherry (01), *Simarouba glauca* (01), *Gymnema sylvetre* (05), *Bael* (22) and Drumstick (30) are being maintained at field gene bank of Regional Station, Akola.

Fig. 9.11. Variation for pods in Okra

Fig. 9.12. Sesame screening for water-logging tolerance- field view

Fig. 9.13. Safflower regeneration and purification experiment- field view

Fig. 9.14. Purification and multiplication of Niger germplasm

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 (**Dinesh Chand (upto 08.08.2022) Sunil S. Gomashe (*w.e.f.* 09.08.2022)**.

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) (Dinesh Chand (up to 08.08.2022) and (*w.e.f.* 09.08.2022 **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** and Dinesh Chand (up to 08.08.2022)

10 REGIONAL STATION, BHOWALI

सारांशः आईसीएआर–एनबीपीजीआर क्षेत्रीय केंद्र, भोवाली अपने पांच अधिदेशों के साथ उत्तराखंड राज्य के पौधों की जैव विविधता की खोज, संरक्षण और उपयोग से संबंधित सभी गतिविधियों को सुनिश्चित करता है। रिपोर्टिंग अवधि के दौरान एक राष्ट्रीय अन्वेषण योजना में 26 विभिन्न संग्रह किए गए। विभिन्न क्षेत्रों, बागवानी, डब्ल्यूईयूपी फसलों की कुल 1687 एक्सेशनों को एमटीएस बीज प्रतिस्थापन के लिए लक्षण वर्णन, गुणन और कायाकल्प किया गया। विभिन्न फसल जननद्रव्य की कुल 1517 एक्सेशनों को एमटीए के तहत देश भर के शोधकर्ताओं के साथ साझा किया गया। एमटीएस में कुल 11,786 एक्सेशन और फील्ड जीन बैंकों में 1017 एक्सेशन भी बनाए रखे जा रहे हैं। कई अन्य गतिविधियां जैसे किसान मेला और प्रशिक्षण का आयोजन भी किया गया। इस अवधि के दौरान स्टेशन के वैज्ञानिकों ने विभिन्न बैठकों, प्रशिक्षण कार्यक्रमों, सेमिनारों और सम्मेलनों में भी भाग लिया। कृषि उपज की बिक्री के माध्यम से रु. 2,80,540/– का सृजन किया गया।

Summary: ICAR-NBPGR RS Bhowali with its five mandates ensures all the activities related to exploration, conservation and utilization of plant biodiversity of Uttarakhand state. During the reporting period 26 different collections were made in one national exploration plan. Total 1,687 accessions of various field, horticultural, WEUP crops were characterized, multiplied and rejuvenated for MTS seed replacement. Total 1,517 accessions of various crop germplasms were shared with researchers across the country against MTA. A total of 11,786 accessions in MTS and 1,017 accessions in field gene banks are also being maintained. Several other activities were also undertaken like 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 2,80,540/- was generated through sale of farm produce.

10.1 Germplasm exploration and collection

One exploration was undertaken during September 2022 in the high altitude of Gangotri and Nelang area of Uttarkashi, Uttarakhand for the collection of wild temperate fruits, *Allium* spp., MAP and ornamental species. A total 26 accessions were collected comprising wild fruit crops (13), wild *Allium* spp. (05), MAP (03) and ornamental species (05) (Table 01). One set of the ornamental species were supplied to the ICAR-DFR, Pune for conservation and their utilization in rose breeding. Wild *Allium* germplasm and MAP were dispatched to Tissue Culture Unit, NBPGR, New Delhi for *In-vitro* conservation.

Table 10.1: Details of exploration undertaken

S. No.	Crop/Crop group	Period	Team	Collaborative institute	Areas Explored	Germplasm collected				
						MAP	WEUP	Fruits	Orna-mental	Total
	Under National exploration Plan									
1	Crop specific (Wild temperate fruits, MAP and other economically useful species)	02nd Sept. to 15th Sept., 2022	Dr. K.M. Rai, Dr. P.K. Kannaujia & Mr. Anuj Sharma	ICAR-DFR, Pune	Gangotri and Nelang Valley of Uttarkashi	03	05	13	05	26
					Total	**03**	**05**	**13**	**05**	**26**

Fig. 10.1. Diversity of wild temperate fruit crops collected during expedition

10.2 Germplasm characterization/ evaluation/ multiplication

- A total of 470 accessions of various *Rabi* season 2021-22 crops *viz.*, faba bean (71), mustard (46), *Triticum* spp. (106), barley (69), wheat (59), coriander (31), fenugreek (20), pea (65), lentil (03) were grown for characterization, evaluation and initial seed increase.
- A total of 603 accessions of various *Kharif* season 2022 crops viz., paddy (156), buckwheat (17), kakrol (04), cucumber (01), pumpkin (01), hemp (01), okra (02), finger millet (34), horse gram (198), french bean (63), perilla (11), soybean (16), maize (09), blackgram (05), amaranth (15), sesame (04), adzuki bean (01), prosomillet (02), pearlmillet (01), rice bean (02), cowpea (02), radish (02), ground nut (07), buckwheat (49) were grown for characterization, evaluation and initial seed increase.
- Temperate horticultural crops viz., peach (34), plum (11), apricot (14), kiwi (05), Nectarine (09), Rubus species (08) persimmon (03) and Malta (12) were characterized for different qualitative and quantitative characters.
- 14 species of wild *Allium* viz., *Allium perzewaskianum, Allium negianum, Allium stracheyi, Allium tuberosum, Allium wallichii, Allium hookerii, Allium chinense* etc. were characterized for the morphological trait like vegetative growth, flowering character and seed setting behavior.
- A total of 504 accessions of germplasm comprising Chilli (490) and Sembean (14) were multiplied/ regenerated at Bhowali station for initial seed increase or replacement of old MTS seed material.

10.3 Germplasm conservation and maintenance

A total of 11,786 accessions in MTS and 1017 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., *Allium stracheyi, Allium negianum, Citrus medica, Prunus cornuta, Prunus jacquemontii, Prunus mira, Rubus nepalensis, Ribes alpastre, Ribes himalense, Thymes lineris* etc are being maintained in the field gene bank for future research purposes.

10.4 Establishment of minor /wild fruit germplasm in FGB

A total of 45 accessions of different wild temperate fruit crops germplasm comprising

Fig. 10.2. Distribution of inputs under SCSP program

Fig. 10.3. Agro-biodiversity conservation fair at Sitarganj, U.S. Nagar, Uttarakhand

Rubus spp. (25), Wild Apple (12), *Prunus mira* (02), *Prunus armeniaca* (06) were established in FGB.

10.5 Germplasm supply under MTA

A total 1517 accessions of various crops consisting Chilli, Ridge gourd, Strawberry and other horticultural crops were supplied to various indenters as per the MTA (Table 10.2). 13 accessions of wild *Allium* were supplied to Dr. S. Chandra, TCCU, ICAR-NBPGR, New Delhi.

Table 10.2: List of germplasm supplied as per MTA

S. no.	Germplasm number	Crop name	Indenters
1.	02	Sponge gourd	Dr. P. Anitha KAU, Thissur.
2.	1230	Chilli	Dr. S.K. Sharma, ICAR-NBPGR, New Delhi.
3.	03	Chilli	Dr. Ashutosh Trimbak PC (Breeding) Mansoon Crop Science Nashik (MH).
4.	20	Ridge gourd	Dr. A M Bhosale, VNMKU Prabhani (MH).
5.	40	Chilli	Smt. V. Krishna Veni, SKLTSHU Rajendranagar.
6.	33	Strawberry, Passion fruit	Dr. Avikal Kumar, KVK, Rudraprayag, GBPUA&T, Pantnagar (U.K.).
7.	01	Wild *Allium*	Dr. Vijay Laxmi, HNBGU, Srinagar, Uttarakhand
8.	50	Chilli	Dr. M. Pazhanisamy, Annamalai University (T.N.).
9.	30	Chilli	Dr. G.R. Lavanya, SHUATS, Prayagraj (UP).
10.	20	Chilli	Mr. Sobha Singh, Khalsa College Amritsar (Punjab).
11.	01	Strawberry	Dr. Ratna. GBPUA&T, Pantnagar (U.K.)
12.	40	Strawberry	Dr. Renu KVK Almora, GBPUA&T, Pantnagar.
13.	30	Strawberry	Dr. S. Tiwari Graphic Era Hill University, Bhimtal.
14.	17	Strawberry, Kiwi & Peach	Dr. T.P. Bisht, HNBGU, Srinagar, Uttarakhand
Total	**1517**		

Projects (Code: Title, **PI,** Co-PIs and *Associates*)
PGR/PGC-BHO-01.01: Management of genetic resources of field crops with emphasis on ethno botanical aspects **(PI: Dr. Mamta Arya, Scientist (Plant Genetics).**
PGR/PGC-BHO-01.02: Management of genetic resources of temperate horticultural crops **(PI: Dr. K.M. Rai, Scientist (Fruit Sci.), Dr. Mamta Arya, Scientist (Plant Genetics)** *Associates: Mr Anuj Kumar Sharma, Technician.*
PGR/PGC-BHO-01.03: Management of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species **(PI: Dr. K.M. Rai, Scientist (Fruit Sci., since 29.6.2017) and Dr. A. Raina, Pr. Sci. (Biochem.),** Co-PI: Dr. Mamta Arya, Scientist (Plant Genetics) *Associates: Mr Anuj Kumar Sharma, Technician.*
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: Dr. Mamta Arya, Dr K.M. Rai.

11 BASE CENTRE, CUTTACK

सारांशः तीन अन्वेषण मिशन और एक सहयोगात्मक कार्यक्रम किए गए और डलमा–चांडिल वन्यजीव अभयारण्य (झारखंड), अजोध्या हिल्स (पश्चिम बंगाल), ओडिशा, महाराष्ट्र और पश्चिम बंगाल से वन्य चावल, वन्य फसल प्रजातियां, कुकरबिट, दलहन, गुलाब सेब और मूल्यवान एम एंड एपी सहित 227 एक्सेशन एकत्र किए गए। महत्वपूर्ण जननद्रव्य संग्रह में एटायलोसिया, एबेलमोस्चस, अमरांथस, कुकुरबिट्स, कॉर्कोरस, डायोस्कोरिया, सोलानम, विग्ना और एम एंड एपी जैसे ओसिमम एसपीपी, दतुरा एसपीपी, कॉस्टस एसपी, इपोमोइया एसपीपी, सेना एसपीपी, लियोनोटिस नेपेटाइफोलिया, एक्सनथियम इंडिकम आदि की वन्य प्रजातियां शामिल हैं। वन्य बेसल अर्थात ओसिमम अफ्रीकन लोर ओडिशा में पहली बार रिपोर्ट किया गया और पूर्वी भारत के लिए एक नया वितरण रिकॉर्ड बनाया। कुल 1884 एकड़ फसलों और वन्य प्रजातियां का गुणन/पुनर्जीवित किया गया और 385 एक्सेशनों में खेती किए गए चावल (220), वन्य चावल (56), ओसीमम एसपीपी (48), हिबिस्कस सबदरीफा (22), एबेलमोकस एसपीपी (34), लुफा एजिप्टियाका (5) को विभिन्न कृषि रूपात्मक और आर्थिक लक्षणों के लिए विशेषता थी। ओसिमम एसपीपी (48) का मूल्यांकन किया गया और उच्च जड़ी बूटी उपज और आवश्यक तेल उत्पादनध्संयंत्र के लिए 11 बेहतर जीनोटाइप की पहचान की गई। वन्य भिंडी की तीन वर्गीकरण किस्में अर्थात एबेलमोशस एंगुलस वार, ग्रैंडीफ्लोरस, ए. ट्यूबरकुलेटस वार, डेल्टोडाइफोलियस और ए, ट्यूबरकुलेटस वार ट्यूबरकुलेटस को स्कैनिंग इलेक्ट्रॉन माइक्रोस्कोप के माध्यम से बीज माइक्रो–मॉर्फोलॉजी का विश्लेषण करके मान्यता दी गई। अबेलमोशस एसपीपी ओडिशा से एकत्र किए गए (34) को रेजेनेरेट किया गया, वर्गीकरण रूप से गणना की गई और दस टैक्सा की पहचान की गई। कई लक्षणों के लिए हिबिस्कस सबदरिफा की चार आशाजनक एक्सेशनों की पहचान की गई। ओसिमम बेसिलिकम (26 एसी) में आनुवंशिक परिवर्तनशीलता का आकलन किया गया और 6 वर्गीकरण किस्मों की पहचान की गई। वन्य चावल और खेती किए गए चावल के पांच बेहतर जीनोटाइप में से प्रत्येक को क्रमशः जलमग्नता सहिष्णुता और कई लक्षणों के लिए पहचाना गया। तीन हेडिकियम एसपीपी के राइजोम से निकाला गया आवश्यक तेल अस्थिर तेल घटकों और पहचाने गए विशिष्ट रासायनिक मार्करों में उच्च अंतर–विशिष्ट भिन्नता प्रदर्शित की। ओसीमम (25), हेडिकियम एसपीपी (3) के पत्तों का आवश्यक तेल और कोस्टस स्पेसस (8), जिंजिबर जीरमबेट (1) के राइजोम और अबेलमोशस मोचौटस (2), हिबिस्कस सबदरिफा (21) के पत्ते और कैलिक्स पाउडर बायोकेमिकल घटकों के मूल्यांकन के लिए डीजीई को आपूर्ति की गई। अनुसंधान उद्देश्यों के लिए आईसीएआर संस्थानों को वाइल्ड राइस (29) और प्लांट पार्ट्स (39) की आपूर्ति की गई थी और उगाए गए चावल (905) को पुनर्जनन और संरक्षण के लिए आईसीएआर–एनबीपीजीआर से प्राप्त किया गया था। राष्ट्रीय जीन बैंक में एलटीएस के लिए खेती योग्य चावल (697), वन्य चावल (17) और फसल वन्य प्रजातियां और अन्य फसलें (52) जमा की गईं; एनआरआरआई, कटक में 29 एक्सेशन को एफजीबी 28 एक्सेशन को एसीसी में जोड़ा गया। एफजीबी/प्रायोगिक भूखंड में एम–एपी, सीडब्ल्यूआर, कंद फसलों और बागवानी फसलों सहित कुल 595 एक्सेशन का रखरखाव किया जा रहा है और कुल 1480 हर्बेरियम नमूनों को संरक्षित किया जा रहा है। तीन खोजों से संबंधित पासपोर्ट डेटा और वन्य अबेलमोशस, एटायलोसिया, कॉर्कोरस, ककरबिट्स, सोलानम, डायोस्कोरिया सहित वन्य पत्तेदार सब्जियों और अन्य एम एंड एपी के पारंपरिक उपयोगों पर जानकारी एकत्र और प्रलेखित की गई। एससीएसपी और टीएसपी के तहत ओडिशा के 75 एससी किसानों और 35 आदिम आदिवासी किसानों के लिए दो व्यावहारिक प्रशिक्षण कार्यक्रम और तीन फील्ड प्रदर्शन आयोजित किए गए। अंतर्राष्ट्रीय सम्मेलन और स्थापना दिवस में स्टेशन गतिविधियों और राज्य की फसल विविधता प्रदर्शित करने वाले दो प्रदर्शनी स्टॉल आयोजित किए गए। ''आईसीएआर–एनआरआरआई, कटक में सह–संगठित ''चावल जर्मप्लाज्म फील्ड डे''।'' आमंत्रित वक्ता के रूप में भाग लिया और वैज्ञानिकों/कृषि अधिकारियों के प्रशिक्षण कार्यक्रम में व्याख्यान (2) दिया और ओडिशा में पीजीआर प्रबंधन पर टीवी समाचार कार्यक्रम में भाग लिया। ओडिशा रेनफेड कृषि मिशन और ओडिशा मिलेट मिशन के लिए विशेषज्ञ सदस्य (जैव–विविधता) के रूप में नामित और टीएसपी के आयोजन के लिए एससी एंड एसटी विभाग से सराहना प्राप्त की। संगोष्ठियों/ कार्यशाला/बैठकों में भाग लिया (7) और प्रदर्शनियों (2) में भाग लिया। अनुसूचित जाति के किसानों (75) और आदिम जनजातीय किसानों (35) के बीच बाजरा, सब्जियां, फल और एम एंड एपी के छोटे कृषि उपकरण और बीज वितरित किए गए। संयंत्र सुरक्षा उपायों, खरपतवार प्रबंधन और जैव–कम्पोस्ट के उपयोग के लिए एमजीएमजी गांवों के किसानों को नियमित सलाहकार सेवाएं प्रदान की गई।

Summary: Three exploration missions and one collaborative programme were undertaken and 227 acc comprising wild rice, wild crop relatives, cucurbits, pulses, rose apple and valuable M&AP were collected from Dalma-Chandil wildlife sanctuary (Jharkhand), Ajodhya hills (West Bengal), Odisha, Maharashtra and West Bengal. Significant germplasm collections include wild relatives of *Atylosia*, *Abelmoschus*, *Amaranthus*, cucurbits, *Corchorus*, *Dioscorea*, *Solanum*, *Vigna* and M&AP like *Ocimum* spp., *Datura* spp., *Costus* spp., *Ipomoea* spp., *Senna* spp., *Leonotis nepetifolia*, *Xanthium indicum* etc. Occurrence of wild basil viz. *Ocimum africanum* Lour. was reported first time from Odisha and form new distributional record for Eastern India. A total of 1884 acc of crops and wild relatives was multiplied/regenerated and 385 accessions comprising cultivated rice (220), wild rice (56), *Ocimum* spp (48), *Hibiscus sabdariffa* (22), *Abelmoschus* spp (34), *Luffa aegyptiaca* (5) was characterized for different agro-morphological and economic traits. Three taxonomic varieties of wild okra viz. *Abelmoschus angulosus* var. *grandiflorus*, *A. tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* were recognized analyzing the seed micro-morphology through scanning electron microscope. *Abelmoschus* spp. (34) collected from Odisha were regenerated, taxonomically enumerated and ten taxa were identified. The genetic variability in *Ocimum basilicum* (26 acc) was assessed and 6 taxonomic varieties were identified. A total of 595 acc comprising M&AP, CWR, tuber crops and horticultural crops are being maintained in the FGB/ experimental plot and a total 1,480 herbarium specimens are being preserved. Organised two hands-on training programmes and three field demonstrations for 75 SC farmers and 35 primitive tribal farmers of Odisha under SCSP and TSP.

11.1 Exploration and germplasm collection

Three exploration missions were undertaken and 217 acc comprising wild rice, wild relatives of vegetable crops *Atylosia, Abelmoschus, Amaranthus, Cajanus,* cucurbits, *Dioscorea, Solanum, Vigna, Corchorus,* and valuable M&AP such as *Ocimum* spp., *Abutilon, Datura, Senna, Ipomoea, Leonotis nepetifolia, Xanthium indicum* etc were collected from Sundargarh (Odisha), Ajodhya hills (West Bengal), Dalma sanctuary & Chandil forest areas (Jharkhand) and Maharashtra. Wide range of inter- and intra-specific variability was recorded among collected the germplasm accessions such as *Abelmoschus* spp., *Cucumis* spp, *Luffa aegyptiaca*, *Solanum* spp. and M&AP (*Ocimum* spp.) etc for various morpho-agronomic traits. The details of exploration and germplasm collection are given in Table 11.1.

11.1.1 Exploration and germplasm collection of crop wild relatives (*Cajanus, Vigna,* cucurbits) and M&AP from Jharkhand

First exploration mission was undertaken for germplasm collection of wild relatives of *Cajanus*, cucurbits, *Vigna* and M&AP germplasm from Dalma wildlife sanctuary & Chandil forest areas of Jharkhand and Ajodhya hill ranges of Puruliya district (West Bengal) during 31st Jan. to 11th Feb. 2022 in collaboration with ICAR-IIPR, Kanpur. A total of 61 acc comprising *Atylosia* and *Cajanus* spp. (13), *Luffa* spp. and other cucurbits (24), *Vigna* spp. (5), *Solanum* spp. (2), *Macrotyloma uniflorum* (3), *Ocimum* spp. (5), *Dioscorea* spp. (2), *Senna* (3), 1 acc each of *Abrus precatorius, Cissus quadrangularis, Leonotis nepetifolia* and *Brassica campestris* was collected. Significant germplasm collections include diversity of wild relatives of Cajanus, *Luffa* and M&AP like *Ocimum* spp., *Senna hirsuta, Leonotis nepetifolia* and *Cissus quadrangularis*. A wide range of variability in morphological traits such as colour and size of flowers, fruits and seeds of *Luffa* and *Solanum* was recorded.

11.1.2 Exploration and germplasm collection of wild rice

The second exploration mission was undertaken during 13-23 November,2022 and 31 accessions comprising 29 wild rice viz. *Oryza rufipogon* (05), *Oryza nivara* (08), *O.sativa* var *spontanea* (16) and one acc each from *Abelmoschus tetraphyllus* and *Corchorus olitorius* were collected from 27 collection sites from Raigad, Ratnagiri and Sindhudurg districts of Maharastra. The district wise collections include 12 from Raigad, 9 from Ratnagiri and 10 from Sindhudurg. The significant germplasm collections include *Oryza*

Table 11.1: Crop-wise exploration and germplasm collection mission during 2022

Crops/Species	Areas	Collaboration	Period of collection	No. of spp.	No. of acc
Crop wild relatives (*Atylosia, Cajanus, Vigna,* cucurbits & M&AP)	Dalma wildlife sanctuary & Chandil forest areas of Jharkhand and Ajodhya hill ranges of Puruliya district (West Bengal)	ICAR-IIPR, Kanpur	31st Jan. to 11th Feb. 2022	26	61
Wild rice (*O. rufipogon*, *O. nivara* and *O. sativa* var. *spontanea*)	Raigad, Ratnagiri and Sindhudurg districts (Maharashtra)	ICAR-NRRI, Cuttack	13th – 23rd Nov. 2022	5	31
Vegetable crops: okra and cucurbits (wild and cultivated) and M&AP	Sundargarh (Odisha)	ICAR-IIHR, Bengaluru ICAR-IIVR, Varanasi	7th to 16th Dec. 2022	45	125
Collaborative exploration					
Rose apple (*Syzyzium jombos* L.)	South and North 24 Parganas, WB	ICAR-IIHR, Bengaluru	17-21 April, 2022	2	10
			TOTAL	**78**	**227**

rufipogon without nodal tillering, semi-perennial type *Oryza nivara* germplasm.

11.1.3 Exploration and germplasm collection of vegetable crops viz. okra, cucurbits (cultivated and wild) and M&AP from Odisha

The third exploration mission was undertaken in collaboration with ICAR–Indian Institute of Horticultural Research, Bengaluru and ICAR-Indian Institute of Vegetable Research, Varanasi during 7th to 16th December, 2022. A total of 125 acc comprising and wild relatives of vegetable crops such as *Abelmoschus* (4), cucurbits (53), *Solanum* (8), *Amaranthus* (2), *Corchorus* (5) and 1 acc each of *Canavalia gladiata* and *Celosia argentea* and M&AP such as *Ocimum* spp. (20), *Abutilon indicum* (3), *Datura* spp.(7), *Costus* spp. (2), *Ipomoea* spp. (3), *Senna* (2), *Leonotis nepetifolia* (5), *Xanthium indicum* (2) and others (7) were collected from Sundargarh district of Odisha. Wide range of variability in morphological traits such as shape, size and colour of fruits in *Abelmoschus* spp., *Cucumis* spp., *Luffa, Solanum* was recorded.

11.1.4 Collaborative exploration

Under collaborative exploration programme, one exploration was conducted participated with ICAR-IIHR, Bengaluru for collection and *in situ* evaluation of rose apple (*Syzyzium jombos*) germplasm from South and North 24 Parganas, WB during 17-21 April 2022. A total of 10 accessions of *Syzyzium jombos* were collected from seven collection sites in two districts of West Bengal. All the accessions are being maintained at ICAR-IIHR, Bengaluru. The significant germplasm collections include accessions with intense rose flavor and oval shaped fruits.

11.1.5 New distributional record of plant genetic resources

During exploration mission for germplasm collection of *Ocimum* spp. in Eastern India, the occurrence of *Ocimum africanum* Lour. (syn. *O. citriodorum* Vis.), a wild relative and alien to the Indian flora, was explored from parts of Odisha, Tripura and Manipur. After critical assessment of published literature on distribution, its natural occurrence is found to be a new species record for the flora of Odisha extending to central India.

11.2 Germplasm characterization

A set of 385 accessions comprising cultivated rice (220), wild rice (56), *Ocimum* spp (48), *Hibiscus sabdariffa* (22), *Abelmoschus* spp (34), *Luffa aegyptiaca* (5) was characterized for different agro-morphological and economic traits to investigate the variability/ diversity among targeted crops.

11.2.1 Cultivated rice

A set of 220 rice germplasm acc collected during exploration missions are characterized for 2nd season to investigate the range of diversity based on agro-morphological traits. All the accessions were grown in augmented design with

Table 11.2: Variability among quantitative traits in cultivated rice germplasm

Traits	Range		Best check	Promising lines
	Minimum	Maximum		
Plant height (cm)	123.16 (IC568039)	190.2 (IC259929)	Naveen (124.3)	IC568039
EBT	4.8 (IC568918)	9.4 (IC568839)	CR Dhan-202 (8.2)	IC568839, 596896
Panicle length (cm)	21.0 (IC283301)	34.96 (IC203370)	Kalajeera (30.2)	IC203370, 568009
Panicle wt. (g)	1.82 (IC203500)	11.38 (IC596897)	Geetanjali (6.0)	IC596897
Spikelets/panicle	125.6 (IC257218)	445.6 (IC596897)	Geetanjali (286.0)	IC596897
Sterility %	4.6 (IC596897)	58.33 (IC596911)	Panidhan (3.8)	IC596897, 596896
Leaf length (cm)	41.3 (AC35770)	75.6 (IC568038)	I-lalat (63.2)	IC568038
Leaf width (cm)	0.74 (IC568008)	2.02 (IC145632)	Kalajeera (1.4)	IC145632
Ligule length (cm)	0.5 (IC280552)	3.1 (IC568038)	Geetanjali (2.2)	IC568038
100 seed wt. (g)	0.7 (IC203142)	3.3 (IC568038)	CR Dhan-202 (3.2)	IC568038,568009

Table 11.3: Range of variability among quantitative traits in *Oryza nivara*

Traits	Range		Mean	SEM (±)
	Min.	Max.		
Days to 50% flowering	95.3	122.7	121.5	0.56
Days to maturity	119.3	146.1	128.5	0.61
Plant height (cm)	62.8	143.7	102.0	1.98
Leaf length (cm)	24.0	56.4	40.8	1.8
Leaf width (cm)	0.7	1.0	0.8	0.36
Ligule length (cm)	0.6	1.5	0.9	0.04
EBT/Plant	5.4	10.7	8.6	0.85
Panicle length (cm)	15.4	26.3	21.4	0.81
Grains/panicle	55.0	182.2	106.6	3.8
Spikelet fertility (%)	31.8	89.1	66.1	1.12
100 grain weight (g)	1.7	2.8	2.2	0.30

seven blocks and six checks during *Kharif*, 2022. Each entry was transplanted in a spacing of 20 X 15 cm between rows and plants. Observation on 15 qualitative and 10 quantitative traits was recorded and promising acc was identified. The acc viz., IC-568038, 568009,568839, 596896 and 596897 found promising for multiple traits.

11.2.2 Wild rice

A set of 56 acc comprising *Oryza nivara* (27) and *Oryza rufipogon* (29) was characterized for different agro-morphological traits. Each acc was maintained in 3 rows in a plot size of 3.6m^2/entry following a spacing of 45 x 45cm between rows and plants. Observation on 11 quantitative and 15 qualitative traits was recorded and variability for quantitative traits was calculated (Table 11.3 & 11.4).

Table 11.4: Range of variability among quantitative traits in *Oryza rufipogon* germplasm

Traits	Range		Mean	SEM (±)
	Min.	Max.		
Days to 50% flowering	126.2	143.5	134.12	0.71
Days to maturity	142.0	166.0	145.4	0.63
Plant height (cm)	104.5	190.8	134.7	3.4
Leaf length (cm)	40.8	56.6	48.3	1.95
Leaf width (cm)	0.8	1.56	1.01	0.03
EBT/Plant	8.4	20.0	10.4	0.94
Panicle length (cm)	20.4	33.9	26.2	1.2
Grains/panicle	71.3	127.3	97.1	2.9
Spikelet fertility (%)	21.4	66.3	45.1	1.24
100 grain weight (g)	1.4	2.3	1.58	0.22

11.2.3 *Ocimum* spp.

Forty eight accessions of *Ocimum* spp. comprising *O. africanum* (6), *O. americanum* (3), *O. tenuiflorum* (9), *O. basilicum* (10), *O. gratissimum* (18) and O. *kilimandscharicum* (2) were characterized for 34 agro-morphological (qualitative and quantitative) and economic traits in RBD with two replications. The promising genotypes identified for highest herbage yield and essential oil yield/ plant in respect of corresponding species are mentioned below. The genotypes identified for highest herbage yield & essential oil yield/ plant are *O. africanum* (IC626384, 599354), *O. americanum* (IC641778, 599362), *O. basilicum* (IC641781, 599337,), *Ocimum tenuiflorum* (IC641702, 599304), *O. kilimandscharicum* (IC627244) and *O. gratissimum* (IC641738, 627242).

Table 11.5: Range of variability among quantitative traits in *Ocimum* germplasm

Sl.No.	Species	Highest estimation of herbage yield/plant (g)	Highest estimation of essential oil yield/ plant(ml)
1.	*O. africanum*	405.8 (IC626384)	1.9 (IC626384, 599354)
2.	*O. americanum*	403.2 (IC641778)	1.2 (IC641778, 599362)
3.	*O. basilicum*	441.9 (IC641781)	1.3 (IC599337, 641781)
4.	*O. tenuiflorum*	418.4 (IC641702)	1.8 (IC641702, 599304)
5.	*O. gratissimum*	467.3 (IC627242)	2.3 (IC641738, 627242)
6.	*O. kilimandscharicum*	396.7 (IC627244)	1.9 (IC627244)

11.2.4 *Abelmoschus* spp.

The plant taxonomic enumeration and agro-morphological characterization of *Abelmoschus* spp (34) was made in respect of habit stem, leaves, flowers, capsules and seeds and a total of ten species/ taxa were identified.

11.2.5 *Hibiscus sabdariffa*

Twenty-two acc of *Hibiscus sabdariffa* (roselle), used as leafy vegetable by rural/ tribes, were characterized for 34 agro-morphological and economic traits in RBD with two replications and promising genotypes such as IC610799, IC610800, IC614089, IC630724 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.

11.3 Germplasm evaluation

11.3.1 Validation of identity of wild okra

Studies on micro-morphology of seeds using scanning electron microscope (SEM) was made with respect to the surface pattern, trichome structure/density and spermoderm cells for identification of wild okra. Validated first time the recognition of three wild varieties viz. *Abelmoschus angulosus var. grandiflorus, Abelmoschus tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* analyzing the seed micro-morphology through scanning electron microscope. *Abelmoschus angulosus var. grandiflorus* exhibited non-spiral, thin bulbous based trichomes and pentagonal to hexagonal and uniform spermoderm cells. However, the two varieties of *A. tuberculatus* show thick, spiral or helical trichomes and polygonal and irregular spermoderm cells. Besides, *A. tuberculatus* var. *tuberculatus* varies from var. *deltoidefolius* in having seeds comparatively large ca 3.5 mm diam., villous hairy, longer hair length and narrower width. spermoderm cells are irregularly narrow, polygonal forming an asymmetric reticulum, thick walled and cell surface rugose with conspicuous striations.

11.3.2 Genetic variability in sweet basil

The germplasm of 26 acc of *Ocimum basilicum* (sweet basil) collected during previous explorations from Eastern India exhibited a good morphological variability in plant height, structure of leaves, stem, spike, flowers and nutlets. 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.

11.3.3 Biochemical evaluation of *Hedychium* spp.

The essential oil extracted from rhizomes *of three Hedychium spp. viz. H. coronarium, H. coccineum and H. flavescens, rare and underexploited medicinal species,* collected from forest habitats of Odisha and further grown in Field Gene Bank at Base centre, Cuttack was analyzed through GC-FID and GC-MS method at DGE, NBPGR, New Delhi. These species exhibited high inter-specific variation in volatile oil constituents such as i) 1,8-cineole (47.73%), beta-pinene (20.83%) in *H. coronarium* ii) linalool (25.76%), beta-pinene (19.29%) in *H. flavescens* and iii) E-nerolidol (40.20%) and caryophylline (24.76%) respectively, which identified characteristic major chemical markers in *Hedychium* species.

11.3.4 Wild rice

Fifty six acc of wild rice (*Oryza nivara*-27, *O.rufipogon*-29) and two checks (resistant: Swarna *Sub*-1 and susceptible: Swarna) were evaluated in collaboration with ICAR-NRRI for identification of submergence tolerance through artificial screening technique. Seedlings were grown in equal sized earthen pots in two replications and 40 days old seedlings were submerged in cemented tanks of 1.5 m. depth for 14 days. Observation on number of plants/ accession and height of plant both before and after submergence was recorded. Based on survival percentage and internode elongation as compared with submergence tolerant check values, the accessions viz. IC0638762, IC0638765, IC0638773, IC0638778 and IC0638768 were identified as submergence tolerant genotypes.

11.3.5 Medicinal & aromatic plants

Essential oil extracted from leaves/ aerial parts of 25 acc of *Ocimum* spp., *Hedychium* spp. (3) and rhizome shred samples of *Costus speciosus* (8), *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.

11.3.6 Leafy vegetables

Leaf and calyx powder of each twenty one acc of *Hibiscus sabdariffa* (roselle), used as leafy vegetable by rural/ tribal inhabitants of Odisha, harvested during 2020-21 and 2021-22 were supplied to ICAR-NBPGR, for nutritional analysis.

11.4 Germplasm multiplication

A set of 1884 accessions comprising cultivated rice (1075), wild rice (618), *Ocimum* spp. (49), *Abelmoschus* spp. (34), *Hibiscus sabdariffa* (22), *Cajanus scarabaeoides* (9), *Luffa* spp. (5), *Solanum* spp (3), *Thespesia lampas* (1), *Trichosanthes* spp. (3), *Dioscorea* spp. (18), *Costus speciosus* (9), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Canavalia gladiata* (2), *Argyreia nervosa* (1), *Coccinea grandis* (2), black gram (13), green gram (12), cowpea (4) were multiplied/ regenerated for seed enhancement, characterization, herbage and oil yield and further biochemical evaluation.

11.5 Germplasm exchange

Wild rice (29) collected from Maharashtra was supplied to ICAR-NRRI for seed multiplication, characterization and conservation. Essential oil of leaves/aerial parts of *Ocimum* spp. (25), *Hedychium* spp. (3) and rhizome samples of *Costus speciosus* (8), *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. In addition, leaf and calyx powder of each twenty one acc of *Hibiscus sabdariffa* (21 acc each), harvested during 2020-21 and 2021-22 were supplied to ICAR-NBPGR, for nutritional analysis. Cultivated rice (905) was received from ICAR-NBPGR for regeneration and conservation.

11.6 Germplasm conservation

A total of 766 accessions comprising of rice (697) multiplied during *Kharif*, 2021, 52 acc. comprising wild relatives of crop plants of *Cajanus*, cucurbits, and M&AP collected from Chandil-Dalma forest areas/ sanctuary (Jharkhand) and Ajodhya hills of Puruliya (West Bengal), wild rice (15), other CWR (2) were deposited for LTS in National Gene Bank, ICAR-NBPGR, New Delhi. In addition, *Cajanus scarabaeoides* (9), *Luffa aegyptiaca* (5), *Coccinea grandis* (2), *Cissus quadrangularis* (1), *Canavalia gladiata* (2), *Costus speciosus* (2), *Solanum sisymbrifolium* (2), *Amorphophallus paeoniifolius* (2), *Dioscorea alata* (2) and *D. oppositifolia* (1) were added to the FGB of the centre. Wild rice (29) collected from Maharashtra were conserved in MTS at NRRI.

11.7 Germplasm maintenance

A total of 595 acc comprising M&AP (205), *Ocimum* spp. (48), *H. sabdariffa* (22), *Dioscorea* spp. (18), horticultural crops (6), wild *Oryza* spp (219), wild *Abelmoschus* (34), *Costus speciosus* (9), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Luffa aegyptiaca* (5), *Canavalia gladiata* (2), *Scleichera oleosa* (1), *Thespesia lampas* (1), *Trichosanthes* spp. (3), *Costus speciosus* (9), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Canavalia gladiata* (2), *Argyreia nervosa* (1) and *Coccinea grandis* (2) were maintained in the FGB/ experimental plots of the centre.

11.8 Herbarium preservation

A total number of about 1480 herbarium voucher specimens of crop wild relatives, high valued M&AP and other economically useful plants are being maintained. These were collected from parts of Odisha, Bihar, Madhya Pradesh, West Bengal, Mizoram, Tripura and Manipur. The important specimens such as *Abelmoschus pungens, A.* spp., *A. tuberculatus, Atylosia scarabaeoides, A. crassus, Zingiber zerumbet, Luffa aegyptiaca, Ocimum kilimandscharicum, O. basilicum var. pilosum* etc were augmented to the herbarium.

Research Programme (Code, Title **and 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. R.C. Misra)**
Research Projects (PI, Co-PIs and *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)

12 REGIONAL STATION, HYDERABAD

सारांशः वर्ष 2022 के दौरान, संगरोध निकासी के लिए कुल 97,104 फसल जननद्रव्य नमूने (34,208 आयातय 62,896 निर्यात) संसाधित किए गए। 34 फाइटोसैनिटरी प्रमाणपत्र जारी किए गए। आयात फसल जननद्रव्य नमूने (11,691), कीटों/रोगजनकों से पर्याक्रांत/संक्रमित थे, को बचाया और जारी किया गया। संयुक्त राज्य अमेरिका से सूरजमुखी पर प्लास्मोपारा हल्स्टेडी, स्विट्जरलैंड से सोयाबीन पर पेरोनोस्पोरा मंशुरिका, नाइजीरिया से सोरघम पर कोलेटोट्रिकम ग्रामिनिकोला, नीदरलैंड से जौ में पॉलिगोनम एवीकुला खरपतवार के बीज संक्रमण कुछ महत्वपूर्ण अवरोधन हैं। डाउन मिल्ड्यू (प्लास्मोपारा हल्स्टेडी) से संक्रमित सूरजमुखी से युक्त एक प्रवेश को हिरासत में लिया गया। निजी उद्योग (5480), आईसीआरआईएसएटी (4769), विश्व सब्जी केंद्र (177), सार्वजनिक संगठनों (90), और एनबीपीजीआर आरएस हैदराबाद (404) में उगाई गई विभिन्न फसलों की 10,920 एक्सेशनों के लिए पोस्ट–एंट्री संगरोध निरीक्षण किया गया। कुल 150 एक्सेशन जिसमें ब्लैक ग्राम (9), ग्रीन ग्राम (8), काउपी (16), हॉर्स ग्राम (6), अरहर मटर (1), बॉटल गार्ड (25), ऐश गार्ड (9), कद्दू (4), ओरिएंटल पिकलिंग मेलोन (8), स्पंज गार्ड (4), अन्य कद्दू (22) और अन्य फसलें और प्रजातियां प्रजातियां (38) शामिल हैं। अन्वेषण के दौरान एकत्र किए गए। इसके अलावा, कंद फसलों के कुल 25 जीवित पौधों के नमूने और अन्य जिसमें डायोस्कोरिया, एन्सेट ग्लौकम, हल्दी, अदरक, चेलोकॉस्टस, कुरकुमा वाइल्ड आदि शामिल हैं, को एपीएस जैव विविधता परियोजना के तहत आंध्र प्रदेश के पापिकोंडलु वन्यजीव अभयारण्य से संवर्धित किया गया। विभिन्न कृषि–बागवानी फसलों के कुल 1,468 एक्सेशन का लक्षण वर्णन, मूल्यांकन और गुणन किया गया। लंबे समय तक संरक्षण के लिए धान, दालों और बाजरा की अड़तालीस एक्सेशन एनजीबी को भेजी गई। स्टेशन पर एमटीएस में संवर्धित, मूल्यांकन और गुणन किए गए स्वदेशी जननद्रव्य की कुल 240 एक्सेशनों को जोड़ा गया। 34 एसएयू/ आईसीएआर संस्थानों को 955 एक्सेशनों वाले कृषि–बागवानी फसल जननद्रव्य प्रदान किया गया। इसके अतिरिक्त, येलो मोजेक वायरस और मूंगबीन पीले मोजेक वायरस, चिली और रूट–नॉट नेमाटोड, मेलोइडोगीन इंकोग्निटा के खिलाफ कोला ग्राम और कोविया के एक्सेशनों की जांच की गई। रुपये के संसाधन आयातित खेपों के संगरोध प्रसंस्करण के माध्यम से रु 48,55,879/– उत्पन्न किए गए ।

Summary: During the year, 2022, a total of 97,104 crop germplasm samples (34,208 imports; 62,896 exports) was processed for quarantine clearance. 34 Phytosanitary certificates were issued. Import crop germplasm samples (11,691), infested/ infected with pests/pathogens, were salvaged and released. *Plasmopara halstedii* on sunflower from USA, *Peronospora manshurica* on soybean from Switzerland, *Colletotrichum graminicola* on sorghum from Nigeria, *Polygonum aviculare* weed seed infestation in barley from Netherlands are some of the significant interceptions. One accession consisting of sunflower infected with downy mildew (*Plasmopara halstedii*) was detained. Post-entry quarantine inspection was conducted for 10,920 accessions of different crops grown at private industry (5480), ICRISAT (4769), World Vegetable Center (177), public organizations (90) and NBPGR RS Hyderabad (404). A total of 150 acc. which include blackgram (9), greengram (8), cowpea (16), horse gram (6), pigeonpea (1), bottle gourd (25), ash gourd (9), pumpkin (4), oriental pickling melon (8), sponge gourd (4), other cucurbits (22) and other crops and wild species (38) were collected during an exploration. In addition, a total of 25 live plant samples of tuber crops and others including *Dioscorea, Ensete glaucum,* turmeric, ginger, *Cheilocostus*, *Curcuma* wild *etc.* were augumented from Papikondalu Wildlife Sanctuary, Andhra Pradesh under APS Biodiversity Project. A total of 1,468 acc. of different agri-horticultural crops were characterized, evaluated and multiplied. Forty eight accessions of paddy, pulses and millets sent to NGB for Long-Term Conservation. A total of 240 accessions of augmented, evaluated, multiplied and indigenous germplasm were added to the MTS at the station. Agri-horticultural crop germplasm consisting of 955 accessions was provided to 34 SAUs/ ICAR Institutes. In addition, blackgram and cowpea accessions were screened against *Yellow mosaic virus* and *Mungbean yellow mosaic virus,* chilli and cowpea against root-knot nematode, *Meloidogyne incognita*. Resources worth Rs. 48, 55, 879/- were generated through quarantine processing of imported consignments.

12.1 Germplasm quarantine

A total of 97,104 samples comprising 34,208 import samples and 62,896 export samples was received for quarantine processing as detailed below. In all, 4 international organizations, 8 public organizations (ICAR institutes, universities/state govt. organizations) and 27 private organizations received the quarantine service from this station. Resources worth Rs. 48, 55, 879/- were generated through quarantine processing of imported consignments.

12.2 Import quarantine

A total of 34,208 samples including paddy-21,906, barley-145, maize-5,164, sorghum-2,363, pearlmillet-1,291, pigeon pea-204, mung bean-44, groundnut-294, sunflower-324, sesame-50, linseed-223, soybean-117, mustard-240, bamabara groundnut-96, cotton-08, chilli-926, tomato-188, ridge gourd-43, bitter gourd-2, kale-14, cucumber-41, brinjal-06, okra-273, squash-1, musk melon-36, water melon-3, spinach-72, tobacco-06, rye grass-48, *Casuarina* sp. -15 and *Euclyptus* sp.- 25 were imported from different countries.

Imports released: Seed samples (34,536) consisting paddy-21,775, barley-145, maize-5,667, sorghum-2,542, finger millet-28, pearl millet-1,360, pigeonpea-200, mungbean-326, groundnut-320, sunflower-347, sesame-50, linseed-223, soybean-84, mustard-240, bamabara groundnut-90, cotton-08, chilli-200, tomato-228, brinjal-06, okra-273, onion-44, ridge gourd-43, bitter gourd-2, kale-14, cucumber-41, squash-1, pumpkin-29, musk melon-36, water melon-19, spinach-72, tobacco-06, rye grass-48, *Casuarina* sp. -15 and *Euclyptus* sp.- 25 were released after necessary mandatory treatments.

12.2.1 TSOP treatment

The mandatory trisodium orthophosphate treatment (10% sol) was given to the imported germplasm of tomato (228) and chilli (200) before release to the consignees.

12.2.2 Import germplasm salvaging details

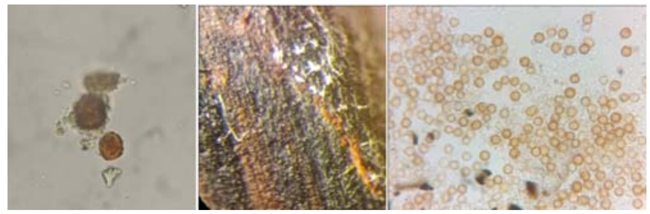
Total number of samples infected/infested: 11,691

Fungi: 11,663; (Pathogenic- 5,992; saprophytes-6,921); Bacteria: 68; Viruses: 15; Nematodes: 98; Insects: 42; Weeds: 01

Number of samples salvaged: 11,690

Number of samples detained: Nil

Alternaria sesami **conidia on Sesame from USA**

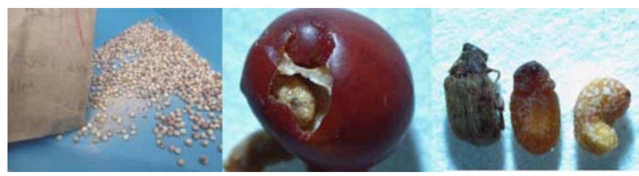


Peronospora manshuria **oospores on soybean from Switzerland**

Plasmopara halstedii **oospores on sunflower from USA**

Colletotrichum graminicola **on sorghum from Niger**

Drechslera sorghicola **on Sorghum from Niger**



Rhyzopertha dominica **infestation in sorghum from Kenya**

Pulse beetle (*Callosobruchus* sp.) infestation in bambara groundnut from Nigeria

Polygonum aviculare **seeds in barley sample from Netherlands**

Fig. 12.1. Important pathogen intercepted during quarantine processing

Number of samples rejected: 01

12.2.3 Interceptions

During quarantine processing, the following major pathogens were intercepted (Fig. 12.1).

Barley & Maize: *Pestalotiopsis* sp. Brazil and *Lasiodiplodia theobromae* from Philippines; **Sorghum:** *Drechslera sorghicola* from Kenya, Niger and Italy, *Colletotrichum graminicola, Phoma sorghina*, and *Drechslera rostrata* from Niger; **Pearl millet:** *D. rostrata* from Kenya; **Sunflower**: *Plasmopara halstedii* from USA, *Botrytis cinerea* from France; **Sesame:** *Alternaria sesami* and *Fusarium equiseti* from USA; **Linseed:** *Colletotrichum dematium, Colletotrichum gloeosporioides, Fusarium oxysporum* from USA; **Soybean**: *Peronospora manshuria* from Switzerland; **Okra:** *C. dematium* from Taiwan; **Chilli:** *Phoma* sp. from Taiwan.

Insects: **Sorghum:** Lesser grain borer (*Rhyzopertha dominica*) from Kenya; **Pigeonpea**: Bruchid infestation from Kenya; **Bambara groundnut:** pulse beetle (*Callosobruchus* sp.) infestation from Nigeria

Nematodes: *Aphelenchoides besseyi* on paddy from Philippines

Weeds: *Polygonum aviculare* in one accession of barley from Netherlands.

12.3 Export quarantine

Crop germplasm samples (62,896) consisting of maize (6,280) received from CIMMYT and chickpea-13,037, pigeonpea-10,507, sorghum-16,419, foxtail millet-1,353, finger millet-7,250, pearl millet-5,700, barnyard millet-610, kodomillet-614, little millet-435, and proso millet-691 received from ICRISAT were processed for export purpose. In all, 80 samples were detained or withdrawn, which include sorghum (04 samples), chickpea (70) and finger millet (06) due to Gram –ve bacteria infection and nil germination. In all, 34 Phytosanitary certificates were issued.

12.3.1 Post entry quarantine (PEQ) inspections

Post-entry quarantine inspection was conducted for 10,920 accessions of different crops grown at private industry (5,480), ICRISAT (4,769), World Vegetable Center (177), public organizations (90) and NBPGR RS Hyderabad (404).

12.3.1.1 PEQ growing and inspection at NBPGR RS Hyderabad

Crop germpalsm (404 accs) comprising of cucumber (10) and melons (16), received from USA, soybean (212) from USA (200) and Taiwan (12), groundnut (2) from Kenya, groundnut (6) from Nigeria and maize (158) from Thailand (157) and USA (1) were grown under post entry quarantine greenhouse. Regular inspections were carried out throughout the growing season. *Groundnut rosette virus* and *Groundnut rosette assistor virus* on groundnut from Kenya; *Soybean mosaic virus* (EC1118126 & EC1118134) on soybean from Taiwan; and *Cercospora* leaf spot and MYMV on bambara groundnut from Nigeria were observed.

12.3.1.2 PEQ inspection at ICRISAT

Post-entry quarantine inspection of 4,769 accessions comprising of finger millet (1,154) from Kenya; pearl millet (344) from Kenya (70) and Niger (274); sorghum (3,091) from Kenya (815), Niger (2,106) and Italy (170); Pigeonpea (57) from Kenya, meant for ICRISAT and maize (123) from Mexico meant for CIMMYT were inspected at regular interval. All accessions were found healthy. In few accession of finger millet imported from Kenya, blast (*Pyricularia grisea*) disease was observed.

12.3.1.3 PEQ inspection at World Vegetable Centre (WVC) and Public organizations

Post-entry quarantine inspection of tomato (14) and mungbean (163) imported from Taiwan and grown by WVC at ICRISAT field and bambara nut (90) from Nigeria grown at Bengaluru by University of Agricultural Sciences, Bengaluru was conducted. *Fusarium oxysporum* f sp. *lycopersici* was observed on tomato accession imported from Taiwan.

12.3.1.4 PEQ inspection at private industry

Post-entry quarantine inspection of different crop germplasm (5480 accessions) consisting of maize (3814) from Argentina (50), Brazil (1116), Indonesia (118), Kenya (225), Philippines (344), South Africa (650), Thailand (253) and USA (1033); barley (124) from Netherlands; tobacco (9) from Brazil (3) and Zimbabwe (6); mustard (364) from Canada; sunflower (48) from France, bitter gourd (187) from Taiwan (52) and Thailand (135); chilli (488) from Taiwan; okra (314) from Taiwan (202) and USA (112); onion (20) from

Israel; tomato (109) from Taiwan (57) and USA (52); Watermelon (3) from Thailand was conducted at indenter's site of private industry.

Important pests observed include **Maize:** Southern corn leaf blight from USA, Brazil and Philippines; **Barley:** *Bipolaris sorokiniana* (Spot blotch) from Netherland; **Tobacco:** *Leaf curl virus* and *Sclerotium* wilt from Brazil and Zimbabwe; **Bitter gourd:** *Leaf curl virus*, *Cercospora* leaf spot and powdery mildew from Taiwan; *Papaya ring spot virus* and *Yellow mosaic virus* from Thailand; **Chilli:** *Leaf curl virus* and *Cucumber mosaic virus* from Taiwan; **Okra:** *Okra enation leaf curl virus* from USA and Taiwan and *Yellow vein mosaic virus* from Taiwan; **Tomato:** Early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), and *Stemphylium lycopersicum* from USA. Plants suspected with viral and other pests of quarantine significance were uprooted and incinerated and released only the healthy harvest.

12.4 Germplasm exploration and collection

A multicrop exploration under the National Exploration Programme was undertaken for the collection of greengram, horse gram, cowpea, *Cucumis* and other cucurbits from parts of Warangal and Jayashankar Bhupalpally districts of Telangana state (Fig.12.2). The exploration was undertaken in collaboration with AICRP-Pigeonpea Centre (RARS, Warangal, PJTSAU) of ICAR-IIPR, Kanpur and KVK, Malyal. A total of 150 collections was made including blackgram (9), greengram (8), cowpea (16), horsegram (6), pigeonpea (1), bottle gourd (25), ash gourd (9), pumpkin (4), oriental pickling melon (8), sponge gourd (4), other cucurbits (22) and other crops and wild species (38). Good variability was observed in bottle gourd and oriental pickling melon.

Also, conducted a field trip in Papikondalu wildlife sanctuary and collected 25 live plant samples of tuber crops and others including *Dioscorea, Ensete glacucum,* turmeric, ginger, *Cheilocostus*, *Curcuma* wild etc. The augmented germplasm is currently being maintained in greenhouse complex.

12.5 Germplasm characterisation and evaluation

Agri-horticultural crop germplasm (1,468 acc.) consisting of chilli (50), cowpea (383) (Fig. 12.3), black gram (294) dolichos bean (34), and field bean (50) was grown for characterisation, evaluation, screening and multiplication along with appropriate check varieties during *rabi* / summer, 2021-22 & maize (157), bambara groundnut (06) sorghum (20), black gram (60), *Sesamum mulayanum* (24) green gram (77), foxtail millet (51),finger millet (10), pillipesara bean (75), brinjal (60) dolichos bean (17) and tomato (100) during *kharif,* 2022 seasons.

Fig. 12.2. Cucurbit diversity collected from Warangal District, Telangana

Fig. 12.3. Cowpea core promising accessions IC622586 (Pod length-left) and EC332352 (Early maturity-right)

12.5.1 Evaluation of germplasm for biotic stress

Blackgram germplasm (294 acc.) was screened against *Yellow mosaic virus* in association with Agri Biotech Foundation, Hyderabad in summer 2022. These consist of 202 accs. from the minicore set, 50 promising accs. based on earlier screening and 42 accs. being screened for the first time. PU31 and BG1531 were used as resistant checks and 11 accs./ varieties that showed 100% disease incidence in previous screening were used as susceptible checks. It was observed that 38 accessions from the core set and 43 accessions from the remaining lot were found disease free.

In summer 2022, a total of 383 acc. of Cowpea core collection was screened for *Mungbean yellow mosaic virus* disease using modified scale of All India Coordinated Research Project on MULLaRP 0-9 scale (Alice and Nadarajan, 2007). In this screening, NC-33379, EC4381, EC240648, EC240700, EC240982, EC724681, EC738118, IC202804, IC311918, IC338514, IC341244, IC372724, IC372726, IC383461, IC520835, and IC565707 show moderately resistant reaction to *Mungbean yellow mosaic virus* disease.

A total of 122 accessions comprising chilli (96) and cowpea (26) were screened for identification of source of resistance to root-knot nematode, *Meloidogyne incognita* under artificially inoculated pot condition. All the accessions recorded root galling in the range of 34-76 galls per root system and found susceptible.

12.5.2 Evaluation of pulses for resistance against pulse beetle, *Callosobruchus chinensis*

Genotypes belonging to cowpea, pigeonpea, blackgram and green gram were evaluated for resistance or susceptibility to pulse beetle, *C. chinensis* (Coleoptera: Bruchidae) using no-choice artificial conditions. Various insect biological parameters *viz*., oviposition, adult emergence/20 seeds (AE), percent adult emergence (PAE), mean developmental period (MDP), per cent seed weight loss (PSWL) and growth index (GI) were determined for each genotype.

Cowpea: Twenty seven cowpea genotypes were evaluated for resistance or susceptibility to pulse beetle, *C. chinensis.* It was found that there was significant difference among insect biological characters when fed on various accessions. On the basis of GI, out of 27 cowpea accessions, only one accession namely, IC 257844, which was collected from Komeru village, Vizianagaram District, Andhra Pradesh was found to be moderately resistant while, seven accessions were classified as moderately susceptible, 11 were susceptible, and eight were highly susceptible.

Blackgram: Of the twenty blackgram genotypes that were screened for resistance against pulse beetle, based on GI, ten genotypes were categorized as moderately resistant (MR), eight were moderately susceptible (MS) and two were susceptible (S). Genotypes *viz*., IC281981, IC343939, IC382811, IC634604, IC634606, IC634608, IC634611, IC634612, IC634613 and IC634617 were found with moderate resistance to the beetle.

Greengram: Twenty one genotypes were screened. Based on GI, it was found that none of the genotypes was completely resistant to *C. chinensis*. However, two genotypes *viz*., KEP 68 and IC634630 were categorized as moderately resistant (MR), eight were moderately susceptible (MS), eight were susceptible (S) and three were highly susceptible (HS).

Pigeonpea: Twenty one pigeonpea landraces were evaluated to identify sources of resistance against pulse beetle. On the basis of GI, four accessions were classified as moderately susceptible, 14 accessions were susceptible, while three accessions were highly susceptible. One landrace namely, IC637089 was found to be moderately resistant according to PSWL.

12.6 Germplasm conservation

12.6.1 Germplasm sent to NGB/GHU

A total of 48 acc. of paddy (24) sorghum (3), maize (2), finger millet (3), little millet (2), foxtail millet (1), greengram (3), blackgram (1), horsegram (2), rajma bean (2), lima bean (1), cowpea (2), linseed (1), dolichos bean (1) was sent to Germplasm Handling Unit, ICAR-NBPGR, New Delhi for facilitating national accessioning and long-term conservation in the NGB.

12.6.2 Medium term storage

Germplasm of different agri-horticultural crops (240), consisting of black gram (45), green gram (70), pillipesara (65) and others (60), which were augmented, evaluated and multiplied, were added to the MTS at the station.

12.7 Germplasm distribution

A total of 955 germplasm acc. of different agri-horticultural crops was distributed to 34 indentors from SAUs/NGO/ICAR and other institutes.

12.8 Supportive research

DIVA-GIS analysis on geographic divergence of cowpea germplasm: Twenty-four cowpea genotypes collected from different regions of Andhra Pradesh, Odisha, Tamil Nadu and Telangana States were evaluated for their reaction against pulse beetle, *Callosobruchus chinensis*. Seed traits *viz*., seed length, seed width, test seed weight and insect biological parameters *viz*., number of eggs laid/20 seeds, number of adults emerged/20 seeds, percent adult emergence, mean developmental period, insect growth index and percent seed weight loss were used to assess the spatial distribution and diversity in the reaction of cowpea germplasm against *Callosobruchus chinensis* using DIVA-GIS applications. Traits *viz*., percent adult emergence, growth index and number of eggs/ 20 seeds exhibited high variability as evidenced by high co-efficient of variation (CV) of 27.3%, 26.45% and 23.9% respectively. The study revealed that Adilabad district of Telangana and Srikakulam district of Andhra Pradesh were found highly diverse for all the traits including seed traits with high index values (1.433 – 2.000 for majority of the traits). The present findings would enable to identify the sources of resistance in cowpea germplasm geographically and spatially through grid maps.

Research Programme (Programme Code: Title, **Programme Leader)**

PGR/PQR-BUR-HYD-01.00: Quarantine processing of plant germplasm under exchange and supportive research (**K Anitha**)

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**)

Research Projects (**Code & 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 and L Saravanan)

PGR/PQR-BUR-HYD-01.02: Post-entry quarantine processing of imported germplasm (**Prasanna Holajjer,** K Anitha, Bhaskar Bajaru, B Parameswari and L Saravanan)

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. Nivedhitha** (w.e.f. 24.01.2022), S R Pandravada, N Sivaraj, P Pranusha, Bhaskar Bajaru and 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 (**P. Pranusha** (w.e.f. 01.04.2022), SR Pandravada, N Sivaraj, S. Nivedhitha (w.e.f. 24.01.2022), Prasanna Holajjer, B Parameswari and L Saravanan)

13 REGIONAL STATION, JODHPUR

सारांशः वर्ष के दौरान दो अन्वेषण यात्राएं आयोजित की गईं। पहली अन्वेषण यात्रा में, राजस्थान के बाड़मेर और जालोर तथा गुजरात के बनासकांठा और साबरकांठा जिलों से आईसीएआर–आईआईएचआर, बेंगलुरु के सहयोग से मोरिंगा कॉनेंसिस (54) और एम ओलिफेरा (38) की कुल 92 एक्सेशनों को एकत्र किया गयाय फल और बीज के आकार, आकार और रंग के संबंध में रूपात्मक भिन्नता की एक बड़ी मात्रा देखी गई। दूसरे अन्वेषण में, स्थानीय विविधता/भू–दौरों की कुल 82 प्राप्तियों में मुख्य रूप से अनाज, बाजरा, दलहन और कुकरबिट्स शामिल थे। राजस्थान के बांसवाड़ा, डुंगरपुर और चित्तौड़गढ़ जिलों से धान (23), बाजरा (12), कुकुरबिट्स (29), दलहन (7), तिलहन (3), सब्जियां (6), सोलानम एक्संथोक्रपम (01), और हिबिस्कस कैनाबिनस (01) एकत्र किए गए थे। जोधपुर स्टेशन पर रबी 2021–22 के दौरान 458 एक्सेशन और खरीफ 2022 के दौरान 2185 एक्सेशन वाले विभिन्न फसल समूहों के कुल 2643 जननद्रव्य एक्सेशनों का लक्षण वर्णन और मूल्यांकन किया गया। रबी 2021–22 के दौरान, मेथी की कुल 170 एक्सेशनों को कृषि–रूपात्मक और जैव रासायनिक लक्षणों के लिए लक्षण वर्णन और मूल्यांकन किया गया। विभिन्न बागवानी की कुल 288 एक्सेशनों को विभिन्न मात्रात्मक और गुणवत्ता मापदंडों के लिए विशेषता और मूल्यांकन किया गया। खरीफ 2022 के दौरान फसल वार अभिगम की विशेषता और मूल्यांकन में मोती बाजरा (1200), मोथ बीन (300), क्लस्टर बीन (400), और कृषि–मॉर्फोलॉजिकल लक्षणों के लिए लोबिया (285) शामिल हैं। ये प्रयोग संवर्धित ब्लॉक डिजाइन/रैंडमाइज्ड पूर्ण ब्लॉक डिजाइन में किए गए और आईसीएआर–एनबीपीजीआर द्वारा प्रकाशित न्यूनतम विवरण के अनुसार कृषि–रूपात्मक वर्णों को दर्ज किया गया। इन फसलों में लक्षण–विशिष्ट आशाजनक जननद्रव्य प्राप्तियों की पहचान की गई। भारत से विभिन्न कृषि बागवानी फसल प्रजातियों की कुल 530 जननद्रव्य एक्सेशनों की आपूर्ति एमटीएस और एफजीबी से भारत के विभिन्न मांगपत्रों को की गई। रिपोर्टिंग के तहत अवधि के दौरान विभिन्न बागवानी फसलों की 145 कटिंग को गुणा और पुनर्जीवित किया। फील्ड जीन बैंक में बारहमासी फसलों की कुल 453 जननद्रव्य पहुंच को जीवित पौध ों के रूप में बनाए रखा जा रहा है। क्षेत्रीय स्टेशन, जोधपुर की मध्यावधि भंडारण इकाई में नियंत्रित परिस्थितियों में विभिन्न फसलों/प्रजातियों के जननद्रव्य की कुल 43,264 एक्सेशनों को स्टेशन पर संरक्षित किया जा रहा है।

Summary: Two exploration trips were conducted during the year. In first exploration trip a total of 92 accessions of *Moringa concanensis* (54) and *M. oleifera* (38) were collected in collaboration with ICAR-IIHR, Bengaluru from Barmer and Jalore Districts of Rajasthan; Banaskantha and Sabarkantha Districts of Gujarat. A large amount of morphological variation with respect to fruit and seed shape, size and colour was observed. In second exploration, a total of 82 accessions of local diversity/landraces comprising mainly in cereals, millets, pulses and cucurbits viz. Paddy (23), Millets (12), Cucurbits (29), Pulses (7), Oilseed (3), Vegetables (6), *Solanum xanthocrpum* (01) and *Hibiscus cannabinus* (01) were collected from Banswara, Dungarpur and Chittaurgarh districts of Rajasthan. Total 2643 germplasm accessions of various crop groups comprising 458 accessions during *Rabi* 2021-22 and 2185 accessions during *Kharif* 2022 were characterized and evaluated at Jodhpur station. During *Rabi* 2021-22, total of 170 accessions of fenugreek have been characterized and evaluated for agro-morphological and biochemical traits. Total 288 accessions of various horticultural were characterized and evaluated for various quantitative and quality parameters. Crop wise accessions characterized and evaluated during *Kharif* 2022 includes pearl millet (1200), moth bean (300), clusterbean (400) and cowpea (285) for agro-morphological traits. The experiments were conducted in Augmented Block Design/ Randomized complete Block Design and the agro-morphological characters were recorded as per the Minimal Descriptors Published by ICAR-NBPGR. The trait specific promising germplasm accessions were identified in these crops. A total of 530 germplasm accessions of various agri-horticultural crop species were supplied from MTS and FGB to various indenters from India. Multiplied and regenerated 145 cuttings of various horticultural crops during the period under reporting. Total 453 germplasm accessions of perennial crops are being maintained as live plants in the field gene bank.A total of 43,264 accessions of various crops/ species germplasm are being conserved at the station under controlled conditions in the medium term storage unit of the Regional Station, Jodhpur.

13.1 Exploration and collection of germplasm

13.1.1 Exploration for collection of *Moringa concanensis* and *M. oleifera*

An exploration was conducted in collaboration with ICAR-IIHR, Bengaluru for collection of landraces of *Moringa concanensis* and *M. oleifera* from Barmer and Jalore Districts of Rajasthan; Banaskantha and Sabarkantha districts of Gujarat during 26.04.2022 to 09.05.2022. A total of ninety two germplasm accessions of local landraces of *Moringa concanensis* (54) and *M. oleifera* (38) were collected during exploration trip. A large amount of morphological variation with respect to fruit shape, size and colour of cucumis accessions was observed. A large amount of morphological variation with respect to fruit shape, fruit size, fruit length, seed size, seed shape and seed colour was observed. Diversity in the germplasm for seed colour varied from black to golden brown and whitish. Some of the accessions collected were having very thin pods and small seeded. One of the germplasm seeds does not have the typical wings and it was characterized as wingless. Generally, *M. concanensis* leaves and fruits are bitter in taste but we found some of the accessions which were sweeter in taste. Likewise we collected some germplasm accessions of *M. oleifera* giving bitter taste. The explored region represents unique genetic diversity for *Moringa* spp. landraces. Collected accessions would help in building the base material for future crop improvement programme as not much Moringa improvement work is carried out till now.

13.1.2 Exploration for collection of multi crops

Exploration for collections of multi crops *viz*. millets, rice, chilli, cultivated & wild moth bean, cowpea, cucurbits (melons) from Banswara, Dungarpur and Chittaurgarh districts of Rajasthan was undertaken from 28.09.2022 to 09.10.2022. A total eighty two germplasm accessions mainly in cereals, millets, pulses and cucurbits viz. Paddy (23), Millets (12), Cucurbits (29), Pulses (7), Oilseed (3), Vegetables (6), *Solanum xanthocrpum* (01) and *Hibiscus cannabinus* (01) crops were collected from the explored areas during exploration trip. A good variability in rice landraces (Zeera rice, Jal Zeera rice, KliKamod, Safed desi saal, Lal saal, Kali saal, Pahariyadhaan, Hingdadhaan, Barudhaan, Siti saal, Kali Badal, Chot zeera, Suthar/Wankli and Panwa) was collected which are on the merge of the extinction and also not collected earlier from these areas. Potential minor millet crops of local consumption and utilization such as proso millet, kodo millet, foxtail millet, barnyard millet, sanwa millet and little millet were collected. Local landrace of Kheera was collected that is locally known as Mandachara. As per farmers claim, it has self-life of 3-4 months. A large amount of morphological variation with respect to fruit shape, size and colour of cucumis accessions was

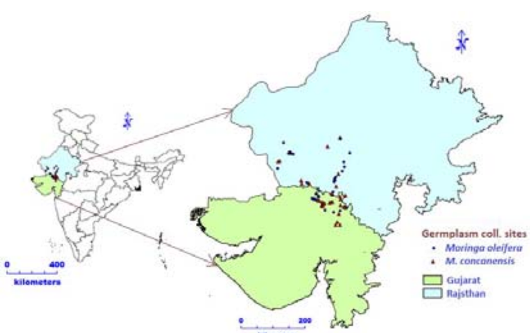


Fig. 13.1. Diversity map of collected germplasm from different locations

Fig. 13.2. Fruit collection from Moringa plants and morphological variation in fruit/seed shape, size and colour of collected germplasm

Fig. 13.3. Morphological variation in fruit/seed shape, size and colour of collected germplasm of cucurbits and rice landraces

observed. The explored region represents unique genetic diversity for different species of cucurbits.

13.2 Characterization and evaluation of germplasm

13.2.1 *Rabi* 2021-22

A total of 458 accessions were characterized and evaluated during *Rabi* 2021-22. Crop wise accessions characterized and evaluated were fenugreek (170), ber (26), karonda (18),aonla (41), phalsa (19), ker (15), bael (19), pomegranate (26), jamun (10), date palm (02) and jojoba (95). The experiments were conducted in ABD/RBD design.

13.2.1.1 Preliminary evaluation of fenugreek germplasm for agronomic and biochemical trait

170 accessions of fenugreek were evaluated for agro-biochemical traits in Rabi 2021-22. Accession EC510664 identified promising for higher number of pods per plant and early days to 50 % flowering, EC510658 identified for dense foliage dense foliage, EC 510685 for green- copper colour leaf with high antioxidants value, EC510559 for high protein content in seed (30.59 %) and EC 510705 for High oil content in seed (5.10 %) respectively. The fully mature leaves of fenugreek germplasm were also subjected for bio-chemical analysis and it has revealed that EC510717 found rich for protein (5.5 %) and Zn content (1.12 mg/100 gm) respectively while EC510559 reported to have higher Ca content (330mg/100 gm).

13.3 Characterization and evaluation of horticultural germplasm

During the reported period total of 288 accessions of horticultural germplasm were characterized and evaluated for morphological as well as for biochemical traits during 2021-2022. Among ber germplasm (26), it was found that there was wide variation in mineral content composition (fresh weight basis) *viz*. Cu (0.05 to 0.16), Fe (0.17 to1.21), Zn (0.05 to 0.18), Ca (5.8 to58.2) and mg (7.25 to 22.74) mg/100 gm respectively. Significant difference was observed in term of mineral content. Maximum Cu recorded from IC625863 (0.16) and Fe (1.21) mg/100gm from IC625856. Both of these accessions belong to *Z. mauritiana* species. While highest Ca (58.24) and Mg (22.74) mg/100gm content observed in IC625848 belonging to *Z. rotoundifolia*. Wild species of Ber *Z. nummularia* reported to have the highest amount of Ca (0.18) mg/100gm.

13.3.1 *Kharif* 2022

A total of 985 accessions were characterized and evaluated during *Kharif* 2022. Crop wise accessions sown for characterization and evaluation moth bean (300), cluster bean (400) and cowpea (285) for agro-morphological traits. The experiments were conducted in Augmented Block Design using appropriate checks and the agro-morphological characters were recorded as per the Minimal Descriptors Published by ICAR-NBPGR.

13.3.1.1 Preliminary evaluation of moth bean germplasm

Total 300 accessions of moth bean along with four checks were multiplied and evaluated in ABD during *Kharif* 2022 for various traits of agronomical importance.Wide range of variability among the germplasm accessions for agro-morphological traits was recorded and promising accessions have been identified (Table 13.1). The genotype IC28155 identified early in flowering in just 28 days after sowing which mature in just 66 days.

13.3.2 Preliminary evaluation of cluster bean germplasm

Total 400 accessions of guar (*Cyamopsis tetragonoloba)* were evaluated in ABD for agronomic traits viz. plant height, no of cluster / plant, no pod/plant, yield per plant, days to 50 % flowering and days to maturity and 1000 seed weight. No. of seed/Pod reported from IC113305 (11) and IC10520 (11), respectively.

13.3.3 Preliminary evaluation of cowpea germplasm

Total 285 accessions of cowpea were evaluated in ABD for agronomic traits like plant

Table 13.1: Characterization and evaluation of agri-horticultural crops germplasm during 2022

S. No.	Crops	Characters	Promising accessions
1	Fenugreek	Green purple Leaf Color	EC510685
		Early flowering (50%)	IC0624520 (39 days), EC510678 (40 days), EC510664 (43 days)
		Higher branches/ plant (>6)	IC510559 (10), EC510633 (8)
		High pod length (>12 cm)	IC333214 (13.9), EC510571 (14.1)
		No of pods / plant	EC510664 (88)
		Protein (%)	EC510559 (30.59), EC510722 (29.80)
		Oil content (%)	EC510705 (5.10) EC510608 (4.63)
2	Cow pea	No. of Branches	EC390239 (11.2)
		No. of Pods/Plant	IC349857 (29), EC101292 (28.8)
		Pod length (cm)	EC714298 (24.56), EC724300 (24.46), EC724296 (21.4)
		No. of seeds/pod	EC724298 (17.2), EC724300 (17)
		Long Peduncle	EC724380, EC724306
3	Moth bean	Early flowering (Days)	IC28155 (28 Days), IC28146 (29 days)
		Early maturity (Days)	IC28155 (66), IC28146 (69)
		Branches per plant	IC10145 (15), IC10144 (14)
		Clusters per plant	IC28156 (54), IC415132 (47)
		Pods per plant	IC28156 (176), IC28792 (165)
		Pod length (cm)	IC11304 (4.60 cm) , IC16213 (5.61)
		Number of seeds per pod	IC28792 (8)
4.	Mustard	Flower color	IC426381P5 (White)
		Extra dwarf & Early in maturity (< 65 cm &<85 days)	IC392314 ,IC363656
5.	Sesame	Early flowering (Day)	IC500816 (26 days) IC208657 (75 days)
		Capsule per plant (Ã150)	IC023271 (194.00)
6	Cluster bean	Plant height (cm)	IC421833 (186.48), IC-102800 (186.4)
		Higher no of Pods / plant	IC40056
		No. of seeds/Pod	IC113305 (11), IC10520 (11)
7.	Ber	TSS(°B) (Ã22)	IC625863
		Total Phenol (Ã200)	IC625864
8.	Ker	Flower colour	IC103395 (Saffron)
		Fruit weight (Ã10gm)	IC103393
9.	Bael	Shell thickness (< 0.70mm)	IC644661
10	Karonda	Fruit /cluster(Ã6)	IC644655

height, days to 50 % flowering, branches per plant, Pods per plant , no. of seed/Pod, days to maturity and test weight. Detail of superior identified accession given in Table 13.1.

13.4 Regeneration and multiplication of germplasm and New Initiative

- During the period under report, 2385 accessions consisting of pearl millet (1200), moth bean (300), cluster bean (400) and cowpea (285) and 200 accessions of mustard were multiplied and regenerated.
- Multiplied unique stone less Ber Genetic stock (INGR No. 19100) and fruit fly resistant genetic stock (INGR No. 19099) for supplying to horticultural institutes and SAU.
- Prepared about 55 accessions of Horticultural germplasm through asexual propagation

Fig. 13.4. IC28155 Early days to 50 % flowering (28 days) and early maturity (66 days) in compare to best check RMB-25

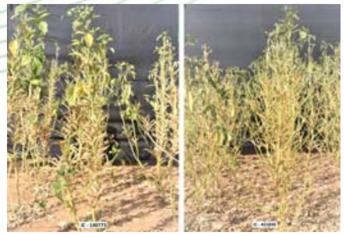


Fig. 13.5. Identified promising accessions of clusterbean; IC140773 (Early & Higher Pod bearer) and IC 421839 (Early & Branched)

IC 333208 (Purple color pod) EC-724248 (Longer pod 24.56cm)

Fig. 13.6. Identified promising accessions of cowpea

belonging to ber (26), pomegranate (10), phalsa (02), guggal (10), lemon (02) karonda (03) and date palm (02) being maintained at FGB Jodhpur.

- Developed wild species/Famine food garden of economic important plants belonging to Rare and endangered and threatened spp of Rajasthan. Presently 10 species are being conserved.

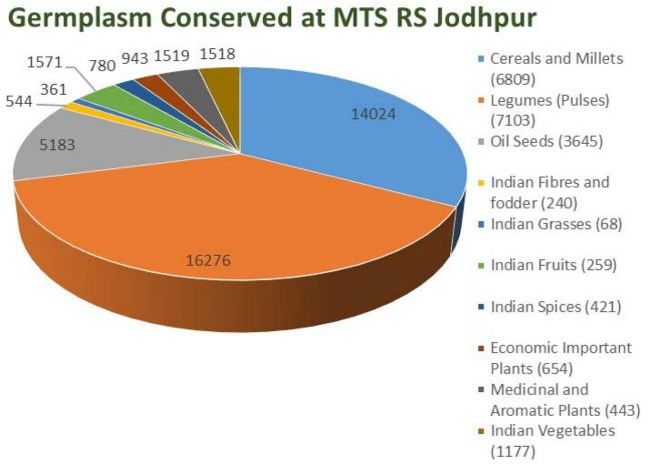


Fig. 13.7. Status of germplasm conserved at station MTS

13.5 Germplasm conservation

13.5.1 Germplasm conservation in MTS unit

13.5.2 Germplasm conservation in FGB

Total 453 germplasm accessions of horticultural crops are being maintained as live plants in the field gene bank of the station.

13.6 Germplasm supplied (530 Accessions)

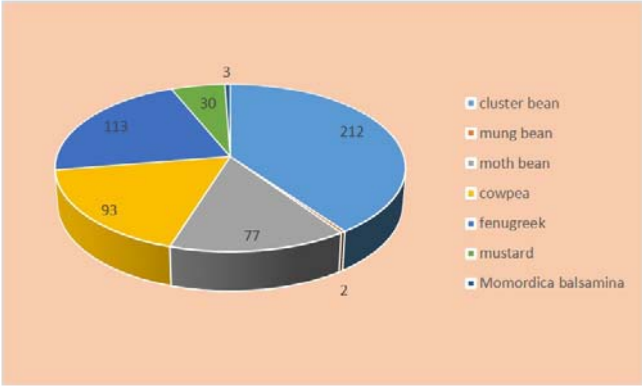


Fig. 13.8. Status of germplasm supplied during the year 2022

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

14 BASE CENTRE, RANCHI

सारांश: शिमला और आसपास के क्षेत्र से सजावटी पौधों के आनुवंशिक संसाधनों को एकत्र करने के लिए एक खोज की गई। हॉर्सग्राम के एक कोर सेट का मूल्यांकन किया गया। लीफ स्पॉट (पेस्टालोटिओप्सिस क्लोस्टिका), और राइजोपस फ्रूट रॉट (राइजोपस आर्टोकार्पी) के खिलाफ बीमारी की प्रतिक्रिया के लिए फील्ड जीन बैंक में संरक्षित कटहल अभिगम का मूल्यांकन किया गया। कृषि और जैव रासायनिक लक्षणों के लिए इमली की कुल 38 एक्सेशनों का मूल्यांकन किया गया। फील्ड जीन बैंक में कुल 609 बागवानी पौधों एक्सेशन और 300 औषधीय पौधों के एक्सेशन को संरक्षित किया जा रहा है। तिसरी ब्लॉक, गिरिडीह, झारखंड में 23.03.2022 से 25.03.2022 तक तीन दिवसीय प्रशिक्षण कार्यक्रम का आयोजन किया गया। झारखंड के गुमला जिले में 24.06.2022 को एक दिवसीय पादप आनुवंशिक संसाधन संरक्षण जागरूकता कार्यशाला सह जैव विविधता मेला का आयोजन किया गया।

Summary: One exploration was undertaken to collect ornamental plant genetic resources from Shimla and the surrounding area. A core set of Horsegram was evaluated. Jackfruit accessions conserved in Field Gene Bank were evaluated for disease response against Leaf spot (*Pestalotiopsis clostica*), Rhizopus fruit rot (*Rhizopus artocarpi*). A total of 38 accessions of tamarind were evaluated for agronomic and biochemical traits. A total of 609 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank. A three days training programme was organized from 23.03.2022 to 25.03.2022 in Tisri block, Giridih, Jharkhand. A one day Plant Genetic Resources Conservation Awareness Workshop cum Biodiversity Fair was organized in Gumla district of Jharkhand.

14.1 Exploration and germplasm collection

14.1.1 Germplasm exploration

Shimla district and parts of Solan were surveyed from 20/05/2022 to 27/05/2022 for the ornamental plants. Details of collected germplasm are mentioned in Table 14.1.

14.2 Gemplasm evaluation, characterization and multiplication

We evaluated the newly developed core set of Horsegram (*Macrotyloma uniflorum*) consisting of a total of 345 accessions. Trait-specific superior accessions identified during the last three years' consecutive evaluation (from 2018-2021) were

Table 14.1: Collected ornamental plant genetic resources

S.No.	Crops	Species
1.	Rose	*Rosa banksiae, R. centifolia, R. viridiflora, R. webbiana, R. canina, R. multiflora*
2.	Jasmin	*Jasminum arborescence, J. grandiflorum, J. humile*
3.	Aprajita	*Clitorea ternatea, C. annua*

Table 14.2: Trait-specific superior accessions of Horsegram

Sl. No.	Trait	Accession
1	Number of pod/plant	IC120837 (350), IC261287 (315), IC262143 (312), IC145292(311), IC261284 (310), IC145286 (310), IC47185(300), IC139357 (300)
2	Determinate habit	IC33072
3	Bold seed	IC121635, IC145264
4.	Waxy leaf	IC121535
5.	The highest number of seeds/pod	IC139357
6.	Fodder purpose plant type	IC261286

validated. These accessions are mentioned in Table 14.2.

Jackfruit (*Artocarpus heterophyllus*) accessions evaluated for stress response against Leaf spot (*Pestalotiopsis clostica*), Rhizopus fruit rot (*Rhizopus artocarpi*) (Fig. 14.1). A total of eight accessions were found moderately resistant to leaf spot pathogens. While 178 accessions recorded moderately to highly susceptible against the pathogen. Similarly, for the Rhizopus fruit rot pathogen, 165 accessions were found immune, 17 accessions were recorded resistant but 35 accessions were susceptible.

A total of 38 accessions of tamarind were evaluated for agronomic and biochemical traits and their performance mentioned in Table 14.3.

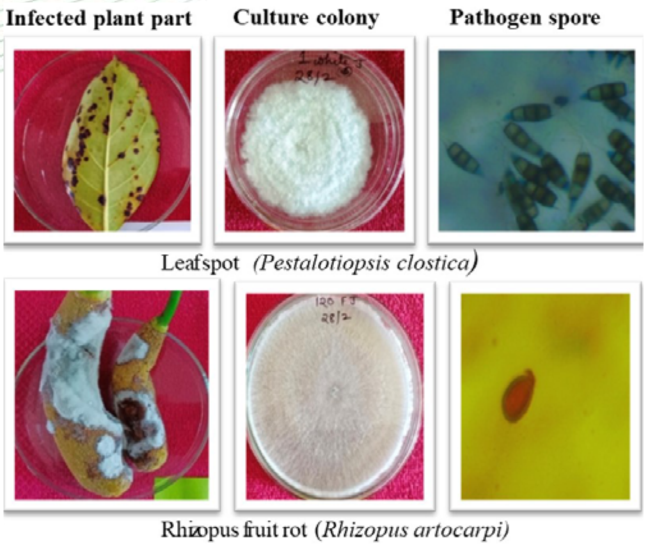


Fig. 14.1. Infected Jackfruit part, cultured colony and spore of leaf spot and Rhizopus fruit rot pathogen

Table 14.3: Performance of Tamarind accessions conserved in Field Gene Bank

S.No	Traits	Average	Range		SD
			Max	Min	
1	Inflorescence length	6.76	9.88	5.12	1.39
2	Mature pod weight	13.01	19.38	1.93	4.05
3	Mature pod length	11.87	15.00	7.00	2.29
4	Seed weight/pod	3.88	7.02	2.06	1.23
5	Ripening period	289.42	306.00	265.00	9.26
6	No. of seeds per pod	5	8	1	1.72
7	Percentage acidity	15	21	9	0.03
8	Reducing sugar	10.99	15.15	6.48	2.50
9	Total sugar	22.39	40.00	15.38	5.74
10	Total soluble Sugar	24.73	29.37	19.33	3.40
11	pH	2.68	2.90	2.50	0.11

14.3 Germplasm multiplication and maintenance

A total of 617 accessions of fruit/ vegetable/ natural dye yielding plants are being conserved in field gene bank of the station (Table 14.4).

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 Gene Bank block. Besides, a total of 254 accessions of *Macrotyloma uniflorum* L. multiplied at the station for LTS.

Table 14.4: Details of accessions conserved in field gene bank

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* spp.	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 **and 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. **(SB Choudhary)**
Research Projects (PI, Co-PIs 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 (**SB Choudhary;** Shephalika Amrapali)

15 REGIONAL STATION, SHILLONG

एनबीपीजीआर, क्षेत्रीय केंद्र ने मेघालय के चार जिलों पूर्वी खासी, हिल्स, पूर्वी पश्चिमी खासी हिल्स, नोंगपोह और पश्चिमी जयंतिया हिल्स क्षेत्रों को शामिल करते हुए साइट्रस पर एक खोज की है। स्टेशन ने साइट्रस टैक्सा के 33 एक्सेशनों को एकत्र किया है, जिसमें मक्का में 400 एक्सेशनों के मूल्यांकन को शामिल किया गया है, जिससे एक्सेशन नंबर आईसी–557463 (41 ग्रा.) में 100 बीज वजन (ग्रा.) के अधिकतम वजन के साथ जननद्रव्य की खोज हुई। 125 चावल बीन प्राप्तियों और 132 कोइक्स एक्सेस्शनों का लक्षण वर्णन किया गया और विभिन्न लक्षणों के लिए बेहतर जीनोटाइप की पहचान की गई। विभिन्न कृषि–बागवानी फसल जननद्रव्य की 2235 एक्सेस्शनों को बनाए रखा और पुनर्जीवित किया। साइट्रस और जंगली जिंजर कैम्पफेरिया गलांगा का स्थापित संग्रह। इस स्टेशन ने जनजातीय उप–योजना (01) और एनईएच (04) के तहत एक दिवसीय पादप अनुवांशिक संसाधन जागरूकता कार्यक्रम आयोजित किया जिससे 438 किसान लाभान्वित हुए। एनईएच के तहत 3 (तीन) दिनों का प्रशिक्षण आयोजित किया गया जिससे एनईएच क्षेत्र के 35 किसानों और 2 (एक) दिवसीय कार्यशालाओं को लाभ हुआ।

Summary: NBPGR, Regional Station has conducted a exploration on citrus covering four districts of Meghalaya namely: East Khasi, Hills, Eastern West Khasi Hills, Nongpoh and West Jaintia Hills. The station has collected 33 accession of citrus taxa covering eight species Evaluation of 400 accession in maize (*Zea mays*) led to finding of germplasm with maximum weight of 100 seed weight (g) in accession number IC 557463 (41g). Characterization of 125 rice bean accessions and 132 Coix accessions were done and superior genotypes were identified for various traits. Maintained and regenerated 2,235 accessions of various agri-horticultural crop germplasm. Established collection of citrus and wild ginger *Kaempferia galanga*. Station had conducted one day plant genetic resources awareness programme under Tribal Sub-Plan (01) and NEH (04) benefitting 438 famers. Conducted 3 (three) days training under NEH benefiting 35 farmers and 2 (One) day workshop on Citrus diversity of NEH region.

15.1 Germplasm exploration

An exploration and collection was conducted in citrus taxa covering four district of Meghalaya: East Khasi Hills, Eastern West Khasi Hills, Ri-Bhoi and West Jaintia Hills. During this exploration 33 collections were made from eight species Rough lemon (*Citrus jambhiri*-09), Khasi Mandarin (*Citrus reticulata*-05), Hill lemon (*Citrus pseudolimon*-05), Satkara (*Citrus macroptera*-02), acid lime (*Citrus aurantifolia*-06), Lemon (*Citrus limon*-02), Khai papeda (*Citrus latipes*-02), Sour orange (*Citrus aurantium*-02). Seeds are beings sent to national gene bank for cryopreservation.

15.2 Germplasm evaluation

Maize : Evaluation of 400 germplasm with four checks in maize led to finding of germplasm which showed maximum width for 100 seed weight in accession IC 557463(41g). Kernel length (IC 278815-2 cm) and kernel width (IC 411757-3.3 g).

1a: DJ22-01 1b: DJ22-03 1c: DJ22-06

Fig. 15.1. Variability in fruit characteristics of Rough lemon(*Citrus Jambhiri*) collections

2a: DJ 22-20

2b: DJ 22-22

Fig. 15.2. Variability in Sour orange (*Citrus aurantium*) from Mairang areas of Eastern west khasi hills

Fig. 15.3a. Khasi Mandarin (*Citrus reticulata* (DJ22-07) with high TSS

Fig. 15.3b. Hill lemon *Citrus pseudolimon* (DJ22-08)- Skin aroma resembling to Mint (*Menta arvensis*)

Citrus: Biochemical test for total soluble solids among the five collections of Khasi mandarin (*Citrus reticulata*) made from three districts of East Khai Hills, Esatern West Hills and Ri-Bhoi district revealed highest TSS (10.2Brix) from Mawphu village of East Khasi Hills. Unique aroma of neglected rare hill lemon(*Citrus pseudolimon*) resembling to that of Mint (*Mentha arvensis*).

Rice bean: Eleven agro-morphological traits were studied in 125 accessions and 04 checks of rice bean. Superior genotypes were identified for various traits such as plant height (IC524083, 36.3cm; IC524094, 36.0cm; PRR1, 37.3cm), no. of branches/plant (SH/HGD/JU-2021, 3.3), leaf length (IC524071/ IC-24512, 10.3cm; KP/SC-1502, 9.05cm), leaf breadth (KP/SC-1502, 7.06cm), stem thickness (IC421876, IC-524076, IC524085, KP/SC-1502, SH/HGD/JU-2021, 0.6cm), pod length (IC009634, 10.92cm), no. of seeds/pod (IC524082, IC-526560, 8.7; PRR1, PRR2, 9.0), seed length (IC-009634, 1.13cmc), seed width (IC009634, 0.7cm), 100 seed weight (IC-009634, 23.5g) and seed yield/ plot (IC524082, 87.4g; IC009634, 72.0g).

Job's tear (*Coix lacryma-jobi*): Twenty agro-morphological traits were studied in 132 accessions and 02 checks of *Coix lacryma-jobi*. Superior genotypes were identified for various traits *viz*. number of tillers per plant (IC 634126,

Table 15.1: Descriptive statistics of agro-morphological traits of rice bean accessions

Sl. No.	Traits	Mean	Max	Min	SD	CV%	Superior genotypes
1	Plant height (cm)	26.20	37.33	17.33	4.34	16.57	IC524083 (36.3); IC524094 (36.0); PRR1 (37.3)
2	No. of branches/plant	1.19	3.33	0.00	0.71	60.00	SH/HGD/JU-2021 (3.3)
3	Leaf length (cm)	8.07	10.37	6.19	0.97	11.99	IC524071, IC524512 (10.3); KP/SC-1502 (9.05)
4	Leaf breadth (cm)	5.01	7.07	3.29	0.77	15.26	KP/SC-1502 (7.06)
5	Stem thickness (cm)	0.46	0.63	0.33	0.06	13.97	IC421876, IC524076, IC524085, KP/SC-1502, SH/HGD/JU-2021 (0.6)
6	Pod length (cm)	8.86	10.92	6.67	0.72	8.17	IC009634 (10.92)
7	No. of seeds/pod	7.07	9.00	4.11	0.92	13.05	IC524082, IC526560 (8.7); PRR-1, PRR-2 (9.0)
8	Seed length (cm)	0.73	1.13	0.50	0.08	10.56	IC009634 (1.13)
9	Seed width (cm)	0.41	0.70	0.30	0.05	12.02	IC009634 (0.7)
10	100 Seed weight (g)	7.22	23.50	4.40	1.76	24.33	IC009634 (23.5)
11	Seed yield/plot (g)	34.55	87.40	7.20	15.49	44.83	IC524082 (87.4); IC009634 (72.0)

Fig. 15.4. Field evaluation of rice bean germplasm

Fig. 15.5. Variability in rice bean seed colour and size

Fig. 15.6. Field evaluation of Coix germplasm

Fig. 15.7. Variability in Coix seed colour and size

Table 15.2: Descriptive statistics of agro-morphological traits of *Coix lacryma-jobi* accessions

Sl. No.	Traits	Mean	Max	Min	SD	CV%	Superior genotypes
1	No of days to germination	8.03	7.00	11.00	0.44	5.52	IC540181, IC540244 (7)
2	First leaf unfolding	10.06	10.00	13.00	0.41	4.08	0.00
3	No. of tillers/plant	3.05	1.33	6.67	1.05	34.35	IC634126 (6.6)
4	Plant height (cm)	295.00	153.33	426.67	62.17	21.07	SH/TM/2020-28 (153.3)
5	No. nodes/stem	13.08	8.00	17.33	2.10	16.03	IC486143 (17.3)
6	Culm diameter (cm)	1.80	1.03	2.20	0.22	12.16	SH-2020-6 (2.2)
7	Angle between leaf & stem (cm)	5.47	1.70	20.17	2.34	42.73	SH-2020-20 (20.1)
8	Leaf sheath length (cm)	17.81	6.50	21.67	2.14	11.99	IC591729 (21.6)
9	Leaf blade length (cm)	72.71	45.67	88.67	8.16	11.22	IC330440 (88.6)
10	Leaf blade width (cm)	5.11	3.67	6.43	0.54	10.56	IC330440 (6.4)
11	Days to 50 % flowering	109.48	98.00	126.00	6.90	6.30	IC591727, IC634126, SH/TM-2021-12 (98)
12	No. of seeds/ plant	370.27	70.33	1267.67	230.56	62.27	SH/TM-2021-10 (1267.6)
13	Total seed wt./plant (g)	46.15	5.00	213.33	37.15	80.49	SH/TM-2021-10 (213.3)
14	Total seed wt/plot (g)	345.44	25.00	1550.00	276.68	80.10	SH/TM-2021-12 (1550)
15	Seed length (cm)	0.90	0.50	1.27	0.12	12.82	IC591727 (1.2)
16	Seed width (cm)	0.70	0.40	2.43	0.17	24.83	IC540222 (2.4)
17	Seed length/width ratio	1.33	0.42	2.15	0.23	17.45	IC623381 (2.1)
18	Kernel length (cm)	0.49	0.30	0.67	0.06	11.74	IC591727 (0.66)
19	Kernel width (cm)	0.49	0.30	0.73	0.06	12.89	SH-2022-67 (0.73)
20	Kernel length/width ratio	1.00	0.63	1.42	0.12	11.63	IC12639 X (1.41)

6.6), plant height (SH/TM/2020-28, 153.3cm), number of nodes/plant (IC 486143, 17.3), culm diameter (SH-2020-6, 2.2cm), angle between leaf and stem (SH-2020-20, 20.1 cm), leaf sheath length (IC591729, 21.6 cm), leaf blade length (IC330440, 88.6 cm), leaf blade width (IC330440, 6.4 cm), IC591727, IC634126, SH/TM-2021-12 for days to 50% flowering (98 days), no. of seeds/plant and seed weight/plant (SH/TM-2021-10, 1267.6 g and 213.3 g), seed weight/plot (SH/TM-2021-12, 1550 g), seed length (IC591727, 1.2cm), seed width (IC540222, 2.4cm), kernel length (IC 591727, 0.66 cm) and kernel width (SH-2022-67, 0.73 cm).

15.3 Germplasm regeneration/maintenance and conservation

A total of 2235 accessions comprising of annual agricultural–Horticultural crops: Buckwheat (640), Taro (60), Yam (30), cow pea (66), Maize (400), Sohplang (25), Ginger (94), Turmeric (240), Chilli (13), Cucumber (29), Ash gourd (04), Seasame (02), Sponge gourd (03), Ridge gourd (06), spine gourd (10) Sesame (08), Okra (03), Ricebean (125), Mustard (50), Bottle gourd (02) Perilla (10), Brinjal (07), Mustard (50), Horsegram (01), Pumpkin (01), Muskmelon (02), Rice (Upland-72, lowland-112), coix (170) were regenerated and maintained. Additionally, five species of Citrus namely *C. aurantium, C. sinensis, C. medica, C. indica* and *Citrus jambhiri* and 132 collections from CSIR-North East institute of Science and technology, Jorhat, Assam of *Kaempferia galanga* established in Field Gene Bank.

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. (**Harish GD** (Upto 30.08.2021), Julius Uchoi (*w.e.f.*, 13.01.2020) and 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. (**S Hajong** ; Julius Uchoi -*w.e.f.*, 13.01.2020 and Harish GD- upto 30.08.2021)

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. (**Harish GD** (Upto 30.08.2021), Julius Uchoi (*w.e.f.*, 13.01.2020) and S Hajong)

16 REGIONAL STATION, SHIMLA

सारांशः एक एक्सप्लोरेशन मिशन के परिणामस्वरूप अरुणाचल प्रदेश के कुरुंग कुमेई, जिला से 34 एक्सेशनों का संग्रह हुआ। इसी तरह, एक्टिनीडिया एसपी के पांच एक्सेशन और द्विपक्षीय क्षमता निर्माण कार्यक्रम के तहत कैलिफोर्निया विश्वविद्यालय, यूएसडीए–एआरएस और उज्बेकिस्तान से शीतोष्ण फल फसलों की 56 एक्सेशनों का आयात किया गया। कृषि फसलों के जननद्रव्य लक्षणवर्णन में, कुल 989 एक्सेशनों की विशेषता थी और प्रदर्शन की तुलना क्षेत्रीय और राष्ट्रीय जांचों के साथ की गई थी। अनाज अमरांथ में, अर्लिनेस (IC583640, IC583625), फ्लोरोसेंस लंबाई (IC582913, IC582925, IC568197) और बीज उपज/पादप (IC583635, IC583609, JCR1985) के खिलाफ आशाजनक एक्सेशनों की पहचान की गई। एक एक्सेशन EC583640 को अगेती के समक्ष आशाजनक पाया गया। इसी तरह, बकगेहूं में भी पर्याप्त परिवर्तनशीलता की सूचना दी गई, जिसके परिणामस्वरूप बीज उपज/ पादप (EC125940, IC599205, JCR1958), 1000–बीज वजन (EC125940, IC412762), पुष्पक्रम की संख्या/पादप (EC125940, IC599205), और पौधे की ऊंचाई (IC599207, IC582977, 583592) के खिलाफ बेहतर एक्सेशनों की पहचान हुई। चिनोपॉड में, बीज उपज/पादप और इसके महत्वपूर्ण घटक लक्षणों के समक्ष उल्लेखनीय परिवर्तनशीलता का आकलन किया गया। IC341708 एक्सेशन बीज उपज/पादप में उत्कृष्ट पाया गया। अदजुकी बीन में, एक्सेशन IC360533 में उच्च संख्या के क्लस्टर/पादप के लिए आशाजनक पाया गया। हालांकि, मटर में, कुछ आशाजनक एक्सेशन को बीज उपज/पादप (IC629594, IC629624, P3757), 100–बीज वजन (EC598646, IC629624) और पॉड नंबर (IC278813, IC629597) के लिए चुना गया। फ्रेंच बीन में, बीज उपज/पौधे और इसके महत्वपूर्ण घटक लक्षणों से परिवर्तनशीलता की विस्तृत श्रृंखला का पता चला, जिसके परिणामस्वरूप बीज उपज (IC328655, EC400406, EC500945), 100–बीज वजन (EC500945, EC421105, IC258378) और पॉड लंबाई (IC341864, IC341856) के खिलाफ बेहतर एक्सेशन का चयन हुआ। इसके अलावा, फ्रेंच बीन के कुल 8 क्रॉस संयोजनों को एफ1 से एफ2 तक उन्नत किया गया और प्रमुख गुणात्मक और मात्रात्मक पात्रों का उपयोग करके टिप्पणियों को भी दर्ज किया गया। जहां तक जननद्रव्य पंजीकरण का संबंध है, राष्ट्रीय जीन बैंक में सफेद मोल्ड (IC278744–INGR20091; EC2715–INGR20090) और सामान्य बीन के BCMV (IC340947–INGR21103) के खिलाफ कुल तीन आनुवंशिक स्टॉक पंजीकृत किए गए हैं। में बागवानी फसल प्रजातियां, कीवी के दो एक्सेशन (IC977548, IC977549) पीले गुद्दे वाली पाई गई। विभिन्न कृषि फसल प्रजातियों के कुल 5279 बीज नमूनों की आपूर्ति देश भर के विभिन्न मांगकर्ताओं को उनके बुनियादी के साथ–साथ सामरिक अनुसंधान के लिए सामग्री हस्तांतरण समझौतों के माध्यम से की गई। कृषि में आनुवंशिक संसाधनों की भूमिका के बारे में कृषक समुदाय को शिक्षित करने के लिए दो पादप आनुवंशिक संसाधन जागरूकता कार्यक्रम भी आयोजित किए गए।

Summary: A germplasm exploration was undertaken, which resulted into collection of 34 accessions from Kurung Kumey, Distt of Arunachal Pradesh. Likewise, five accessions of *Actinidia* sp. and 56 accessions of temperate fruit crops were imported from the University of California, USDA-ARS and Uzbekistan under bilateral capacity building programme. In germplasm characterization of agricultural crops, total 989 accessions were characterized and performance was compared with regional and national checks. In grain amaranth, promising accessions were identified against earliness (IC583640, IC583625), inflorescence length (IC582913, IC582925, IC568197) and seed yield/plant (IC583635, IC583609, JCR1985). An accession EC583640 was reported promising against earliness. Likewise, substantial variability has also been reported in buckwheat, which resulted into identification of superior accessions against seed yield/plant (EC125940, IC599205, JCR1958), 1000-seed weight (EC125940, IC412762), number of inflorescence/plant (EC125940, IC599205), and plant height (IC599207, IC582977, 583592). In chenopod, remarkable variability has been assessed against seed yield/plant and its important component traits. An accession IC341708 was recorded promising for seed yield/plant. In adzuki bean, accession IC360533 found promising for high number of clusters/plant. However, in field pea, some promising accessions were selected for seed yield/plant (IC629594, IC629624, P3757), 100-seed weight (EC598646, IC629624) and pod number (IC278813, IC629597). In french bean, seed yield/plant and its important component traits of interest revealed wide range of variability, which resulted into selection of superior accessions against seed yield (IC328655, EC400406, EC500945), 100-seed weight (EC500945, EC421105, IC258378) and pod length (IC341864, IC341856). Further, total 8 cross combinations of french bean were advanced from F_1 to F_2 and observations were also recorded using major qualitative and quantitative characters. Three genetic stocks have been registered in National Gene Bank against white mold (IC278744-INGR20091; EC271515-INGR20090) and BCMV (IC340947-INGR21103) of common bean. In horticultural crop species, two accessions (EC977548, EC977549) of Kiwi were found yellow fleshed. A total of 5279 seed samples of various agricultural 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 conducted to educate farming community about role of genetic resources in agriculture.

16.1 Germplasm augmentation

One germplasm exploration was undertaken in collaboration with Central Seri cultural Germplasm Resource Centre, Central Silk Board, Hosur in Tamil Nadu for the collection of fruits and mulberry species from Kurung Kumey district of Arunachal Pradesh. Total 34 collections of different fruit crop species, including Morus and minor fruits were made. The important collections include *Actinidia callosa* and *Rubus sumatranus*. Likewise, total five accessions of *Actinidia arguta* (EC1124951, EC1124952, EC1124953) and *Actinidia macrosperma* (EC1124954, EC1124955) were imported from the University of California, USDA-ARS. One more set of 56 accessions of temperate fruit crops viz., apple (14), apricot (6), peach (1), plum (4), cherry plum (3), cherry (3), almond (4), walnut (4), ribes (4), ber (1), hazelnut (2) and grapes (10) were also introduced from Uzbekistan under bilateral capacity building programme.

16.2 Germplasm characterization and evaluation of field crops

During the reporting period, total 989 germplasm accessions of grain amaranth (88), buckwheat (82), chenopod (211), french bean (336), adzuki bean (27) were characterized against agro-morphological characters during kharif season of 2022 and 245 accessions of field pea in the rabi season of 2021-22 in the experimental field of station under Augmented Block Designs (ABD) along with standard checks. The recommended observations were taken as per minimal descriptor of ICAR-NBPGR, which resulted an impressive variability among the germplasm accessions. The promising accessions were also selected against important traits using range, mean and coefficient of variation. In grain amaranth, the mean seed yield/plant was recorded 43.11 g. and it ranged from 15.04-142.85 g, which resulted into identification of promising accessions IC583635, IC583609, JCR1985 against the trait. Likewise, inflorescence length ranged from 22.10-99.74 cm and it averaged 65.89 cm. The promising accessions against the character were IC582913, IC582925 and IC568197. The others characters viz; days to flowering, maturity and plant height also revealed substantial variability in the germplasm and accession EC583640 was reported promising for earliness (117 days). In buckwheat, seed yield/plant showed range of variation from 0.16-6.61 g. and the average yield was recorded 1.02 g. The accession IC125940 was selected promising against seed yield (6.61 g) and 1000-seed weight (33.50 g). The average number of inflorescence/plant was 15.88 and it ranged from 6.00-29.66, which resulted into identification of promising accessions EC125940, IC599205, JCR1962. However in chenopod, a wide range of variability was captured for different agro-morphological traits, where seed yield/plant was recorded 18.73 g. and it ranged from 4.10-55.36. The accession IC341708 was selected promising for seed yield/plant (55.36 g). Further, the crop adzuki bean also manifested good variation for important agro-morphological characters and more number of clusters/plant exhibited in accession IC360533. The other characters like number of pods/plant, seeds/pod and 100-seed weights

Table 16.1: Characterization of germplasm accessions of mandate crops

Crop	Accessions	Checks
Grain Amaranth	88	Durga, PRA-2, Annapurna, PRA-3
Buckwheat	82	PRB-1, Himpriya, VL-7, Shimla B-1, Him Phaphra
Chenopod	211	NIC 22503, Him Shakti, Himbathua, PRC9801
French bean	336	Triloki, Kailash, Baspa, Jawala
Adzuki bean	27	HPU51, Totru local
Pea	245	Arkal, Azad Pea, DMR-11, DMR-7, HFP-4, IC279125, Super lincon, Rachna
Total accessions	**989**	

Table 16.2: Promising accessions identified for important agro-morphological traits

Character	Range	Mean ±SE	CV%	Promising accessions
Grain Amaranth				
Days to flowering	36.00-96.00	72.13±0.33	0.20	IC583625, IC583640-1, IC583626
Days to maturity	117.00-199.00	172.39±0.41	10.58	IC583640, IC583625, IC583640-1
Plant height (cm)	120.70-325.50	246.95±1.08	19.72	IC568197, IC582922, IC582913
Infl. length (cm)	22.10-99.74	65.89±0.35	23.66	IC582913, IC582925, IC568197
Seed yield/plant(g)	15.04-142.85	43.11±0.41	63.00	IC583635, IC583609, JCR1985
1000-seed wt. (g)	0.40-0.90	0.61±0.00	15.76	JCR1971, SKY38, JCR1990
Buckwheat				
Days to flowering	28.00-52.00	36.51±0.63	15.73	IC79184, IC79185, IC274444
Days to maturity	66.00-136.00	113.94±1.44	11.41	IC79184, IC79185, IC274444
Plant height (cm)	55.13-179.90	110.53±3.36	27.55	IC599207, IC582977, IC583592
No. of infl./plant	6.00-29.66	15.88±0.58	32.92	EC125940, IC599205, JCR1962
Seed yield/plant(g)	0.16-6.61	1.02±0.09	82.76	EC125940, IC599205, JCR1958
1000- seed wt. (g)	11.30-33.50	19.54±0.41	19.13	EC125940, JCR1957, IC412762
Chenopod				
Days to flowering	45.00-113.00	65.91±1.12	25.78	EC896110, EC896102, IC341697
Days to maturity	108.00-237.00	147.11±2.04	19.30	IC540842, IC258254, IC341697
Plant height (cm)	84.40-349.50	203.49±4.43	39.67	IC341708, IC341707, IC341698
Infl. length (cm)	19.80-60.40	37.97±0.56	24.15	IC107585, IC341708, EC896194
Seed yield/plant(g)	4.10-55.36	18.73±0.64	62.57	IC341708, IC274533, EC896212
1000-seed wt. (g)	0.10-2.60	0.80±0.05	59.17	EC896208, EC896071, EC896277
Adzuki bean				
No. of clusters/plant	5.33-19.33	9.74±0.76	40.69	IC360533, EC59489, IC360534
No. of pods/plant	7.66-32.33	14.86±1.35	47.18	IC141939, IC360533, IC59489
No. of seeds/pod	4.33-9.66	6.35±0.21	17.34	IC141939, IC360538, EC340244
Days to flowering	58.00-98.00	65.52±1.53	12.12	IC360532, EC340261, EC340246
Days to maturity	107.00-148.00	121.33±1.38	5.92	EC340261, EC340246, EC120466
100-seed weight (g)	7.07-15.19	10.66±0.38	18.70	IC360534, EC340271, EC340240
Pea				
Days to flowering	77.00-132.00	112.18±0.71	9.97	IC629621, P3173, IC629620
Days to maturity	143.00-164.00	156.58±0.33	3.31	P3173, JCR-JV-35, IC629637
Plant height (cm)	27.30-163.40	99.69±1.65	25.98	EC598674, IC629580, EC838233
No. of pods/plant	5.00-38.00	13.60±0.35	40.46	P2387, IC278813, IC629597
Seed yield/plant(g)	2.38-35.73	12.02±0.39	50.81	IC629594, IC629624, P3757
100- seed wt. (g)	5.13-27.06	16.04±0.29	28.76	P3332, EC598646, IC629624
French bean				
Days to flowering	30.00-64.00	42.11±0.37	15.98	EC271517, EC397825, EC398512
Days to maturity	73.00-117.00	89.85±0.53	10.77	EC271517, IC311698, EC397826
Pod length (cm)	6.75-18.40	12.81±0.12	16.57	IC341864, EC537967, IC341856
No. of pods /plant	3.50-19.00	9.83±0.16	29.57	IC341850, IC329154, EC500547
No. of seeds / pod	2.50-6.50	4.58±0.05	19.39	EC500547, IC329154, IC372697
Seed yield/plant(g)	3.82-40.07	13.70±0.29	38.24	IC328655, EC400406, EC500945
100-seed wt.(g)	12.10-56.31	31.52±0.52	30.29	EC500945, EC421105, IC258378

Table 16.3: Development of genetic stocks

Sr. No.	Crop/accession name	INGR Number	Trait of interest
1	French bean (EC271515)	INGR20090	White mold
2	French bean (IC278744)	INGR20091	White mold
3	French bean (EC340947)	INGR21103	Bean Common Mosaic Virus

also revealed variability in germplasm accessions. In Himalayan grain legumes, field pea and french bean are very important pulses, it showed substantial variability against seed yield and its important component traits of interest. In field pea, seed yield/plant showed wide range of variability ranging from 2.38-35.73 g and averaged 12.02 g. The genotype P2387 exhibited high number of pods/plant. The other promising accessions for seed yield /plant found IC629594, IC629624. In french bean substantial variability against seed yield/plant and its component traits including phenological characters was reported. The trait seed yield manifested variability ranged from 3.82-40.07 g. and it averaged 13.70 g. However, other characters like seed weight, and pod number also exhibited significant average performance as 31.52 g and 9.83 g respectively. An accession EC500945 was reported maximum seed weight (56.31 g). The germplasm characterization performance concluded that selected promising accessions against target traits (seed yield, seed weight, pod number, earliness, inflorescence length and number of clusters) could be a useful resource for their maximum utilization in crop improvement programmes.

16.3 Generation advancement of french bean crosses

The F_1 populations consisting of 24 hybrid seeds obtained from eight intra-specific crosses (PLB-10-1 × IC340947, Kailash × Arun, Baspa × IC340947, Jawala x Kanchan, Baspa × IC340947, Kailash x IC340947, PLB-14-1 x Arun and PLB-14-1 × IC340947) have been advanced to F_2 generation. The F_1 generation plants of these crosses were assessed for various qualitative (plant growth habit, stem pigmentation, flower wing colour, leaflet shape, pod colour, pod pubescence, pod shape, pod beak shape, seed mottling and seed colour) and quantitative traits (Days to flowering, Days to 80% maturity, leaf length (cm), leaf width (cm), pod length (cm), pod width (cm), number of pods per plant, number of seeds per pod, seed length (mm), seed width (mm), yield per plant (g). Subsequently, F_2 populations of these crosses will also be screened against BCMV and anthracnose resistance in real field and controlled conditions.

16.4 Morpho-chemical evaluation and conservation of ground apple [*Smallanthus sonchifolius* (Poepp.) H.Rob.]

Tubers of ground apple were collected from the farmer field and sown in the field in the month of March, 2021 and the plants attained the average height of 5.8 feet and weight 3.5 kg along with 10-12 numbers of rhizomes. The TSS of edible tuber after harvest was found 15 °B and when it stored for 2 months at room temperature, the TSS increased upto 24 °B without deterioration the quality of tubers. The biochemical study revealed that the roots had higher accumulation of fructose (0.086 mg/g) as compared to glucose (0.041 mg/g). The roots also manifested low phenol (0.061 mg/g), flavonoid (0.0093 mg/g), tannin (0.004 mg/g), alkaloid (1.193 mg/g) and saponin (0.25%) content. The germplasm was conserved in the field gene bank and TCCU of ICAR-NBPGR New Delhi and National identity number IC644477 has also been assigned.

16.5 Preliminary evaluation of newly introduced kiwifruit germplasm

Out of 23 accessions successfully established in field gene bank, five accessions (EC977560, EC977563, EC977564, EC977572 and EC977574) were reported male genotypes. After its successful establishment in real field condition, fruits were harvested from the accession EC977548, EC977549, EC977556, EC977565, EC977566 and EC977569. Out of which, two germplasm accessions EC977548 and EC977549 were reported yellow fleshed.

16.6 Germplasm supply

Germplasm comprising 5279 seed samples of agricultural crops were supplied to researchers/ indenters across the country.

- **Seed crops:** Amaranth (1,773), Buckwheat (946), Chenopod (1,034), Adzuki bean (179), French bean (654), Pea (298), Rice bean (223), Millets (121), Chickpea (5), Soybean (1) and Wild *Cicer* (45)

16.7 Germplasm conservation

16.7.1 Medium term storage

A total of 12,565 accessions of various seed propagating crops are conserved in MTS (Table 16.4).

16.7.2 Field Gene Bank

A total of 1,023 germplasm accessions of various perennial crops such as fruits, medicinal and aromatic plants including other economic plants are maintained in the field gene bank at ICAR-NBPGR Regional Station Shimla (Table 16.5).

Table 16.4: Status of MTS at RS Shimla

Crop	Accession	Crop	Accession	Crop	Accession
French bean	4353	Foxtail millet	278	Soybean	144
Amaranth	3270	Chickpea	258	Paddy	108
Buckwheat	1000	Cowpea	228	Barnyard millet	71
Pea	705	Chenopod	199	Meetha karela	42
Wheat	642	Adzuki bean	169	Urd	30
Finger millet	410	Proso millet	160	Cuphea	16
Rice bean	332	Horse gram	150	**Total**	**12565**

Table 16.5: Status of FGB at RS Shimla

Crop	Accession	Crops	Accession
Apple	241	Pine-apple guava	2
Peach	52	Fig	7
Pear	87	Olive	6
Plum	49	Crataeagus	3
Apricot	38	Chest nut	2
Cherry	4	Viburnum	3
Walnut	115	Rubus spp.	20
Hazelnut	20	Quince	10
Pecan nut	50	Grape	41
Almond	11	Mespilus spp.	2
Kiwi	8	Mulberry	4
Persimmon	9	Rose	35
Pistacia	1	Pomegranate	90
Chinese ber	7	M&AP	27
Hops	2	Ornamentals	51
Citrus	4	Other economic plants	22
Total			**1023**

Research Programme (Code, Title and **programme Leader)**
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**, Mohar Singh, and Rahul Chandora)

17 REGIONAL STATION, SRINAGAR

वर्ष 2022 में केंद्र द्वारा दो अन्वेषण और जननद्रव्य संग्रह कार्यक्रम किए गए थे; एक जम्मू के पुंछ जिले से और दूसरा कश्मीर के गंदरबल और बांदीपुर जिलों से और कुल 183 सब्जी फसलों और जंगली खाद्य पदार्थों के एक्सेशन एकत्र किए गए। इन अन्वेषणों के दौरान कुछ दूरस्थ और दूर–दराज के क्षेत्रों को कवर किया गया और एकत्र किए गए जननद्रव्य में कई अद्वितीय एक्सेशन शामिल हैं, कुछ पहली बार एकत्र किए गए हैं। रबी 2021–22 के दौरान न्यूनतम वर्णनकर्ताओं के अनुसार फैबियन (39), जौ (47) और गेहूं (38) सहित कुल 124 जननद्रव्य एक्सेशनों को उनके कृषि–रूपात्मक लक्षणों के लिए लक्षण वर्णन किया गया। खरीफ 2022 के दौरान बीसीएमवी रोग सहित उपज और अन्य कृषि–रूपात्मक लक्षणों के लिए आम बीन के तेईस (23) जीनोटाइप के एक सेट की जांच की गई। इसके अतिरिक्त, 2021 की शुरुआत में टीसीसीयू यूनिट, आईसीएआर–एनबीपीजीआर नई दिल्ली से प्राप्त इन विट्रो संरक्षित रुबस पादपों के ग्यारह (11) एक्सेशनों और एफजीबी में स्थापित कुछ प्रारंभिक फल लक्षणों के लिए मूल्यांकन किया गया। अनुसंधान उद्देश्य के लिए मांगकर्ताओं को विभिन्न फसलों की बयालीस (42) जननद्रव्य एक्सेशनों की आपूर्ति की गई।

Summary: Two exploration and germplasm collection programmes were undertaken by the station in the year 2022; one from Poonch district of Jammu and another from Ganderbal and Bandipore districts of Kashmir and a total of 183 accessions of vegetable crops and wild edibles were collected. Some remote and farflung areas were covered during these explorations and the germplasm collected include several unique accessions, some collected for the first time. A total of 124 germplasm accessions comprising of fababeans (39), barley (47) and wheat (38) were characterized for their agro-morphological traits as per the minimal descriptors during *Rabi* 2021-22. A set of twenty-three (23) genotypes of common bean were screened for yield and other agro-morphological traits including BCMV disease during *Kharif* 2022. Besides, eleven (11) accessions of *in vitro* conserved *Rubus* plants received from TCCU, ICAR-NBPGR New Delhi during early 2021 and established in the FGB were evaluated for some preliminary fruit traits. Forty-two (42) germplasm accessions of different crops were supplied to indenters for research purpose.

17.1 Germplasm exploration and collection

Following two germplasm exploration and collection programmes were assigned to the station under National Exploration Plan (NEP) for 2022-23:

1. Vegetables: chilli, cucurbits, brinjal, radish, carrot and wild edibles from Poonch district of Jammu province
2. Vegetables: chilli, cucurbits, brinjal, radish, carrot and wild edibles from Ganderbal and Bandipore districts of Kashmir province

Fig. 17.1. Representative variability collected in different vegetable crops

These explorations were carried out successfully and a total of 183 diverse and valuable germplasm accessions of these crops have been collected including several first time collections.

17.1.1 Exploration and germplasm collection of vegetables: chilli, cucurbits, brinjal, radish, carrot and wild edibles from Poonch district of Jammu province

This programme was carried out during the month of september in collaboration with SKUAST (J) different areas of Poonch district including Jhullas, Mangnar, Dingla, Khanetar, Chaktroo, Kheit Chhambar Mandi, Sib Loran, Sakhi Maidan Meinder, Kote Fazalabad Surankote were explored. A total of 68 germplasm samples of these crops besides *Allium sativum*, *Lepidium sativum*, *Momordica charantia* and *Lablab purpureus* were collected.

17.1.2 Exploration and germplasm collection of vegetables and wild edibles from Kashmir

Under this programme, remote and some underexplored areas falling in the districts of Ganderbal and Bandipore including Telail Gurez, Narannag, Sarbal and Baltal areas have been explored. This exploration has yielded a total of 115 germplasm accessions belonging to 32 (18 cultivated and 13 wild) genera and 40 (25 cultivated and 15 wild) species. The maximum numbers of species *i.e*. four have been collected in *Rubus*. Maximum number of 25 accessions have been collected in *Cucurbita pepo* followed by 15 accessions in *Brassica napus* cv. Gurez Local and 11 in *Capsicum annuum. Brassica napus* cv. Gurez Local, locally called as "Bagtore Saag" is a unique and popular dual purpose vegetable cultivated and consumed across Gurez and Telail areas of Bandipore district was collected for the first time. Its leaves are cooked as kale while its radish like roots are used for making pickle especially during winter. Little millet, *Panicum sumatrense* (BAB/MAGRAY/WAD/SHEIKH-1158) has also been collected first time from the region. Rose hip (*Rosa multiflora*) collection (SHEIKH-1191) with bigger attractive hips has also been collected first time from Ganderbal area. Locally it is known as "Phalwadi" and is eaten by the children. *Daphne oleoides* (SHEIKH-1218) or "Kashmir Daphne" has also been collected for the first time from Ganderbal area. This medicinal shrub has a very narrow distributional range and bears small attractive orange colored berries believed to be poisonous. Other notable collections, include *Rubus pedunculosus* (SHEIKH-1127 and SHEIKH-1128), not so prickly *Rubus saxatilis*, bearing soft shining red tasty fruits (SHEIKH-1129), *Corylus jscquemontii* (SHEIKH-1130) and thorn less hawthorn, *Crataegus songarica* (SHEIKH-1219).

Most of the collected material were sent for LTS at NGB at ICAR-NBPGR New Delhi while few accessions including those of *Allium sativum*, *A. cepa* var. *proliferum* and *Dioscorea deltoidea* were sown in the field for multiplication/maintenance.

Fig. 17.2. Significant collections: SHEIKH-1129 (IC 0647240) of *Rubus saxatilis*, SHEIKH/BAB-1132 of unique dual purpose vegetable *Brassica napus* cv. Gurez Local, SHEIKH-1161 (IC 0647246) of *Hippophae rhamnoides*, SHEIKH/NHM-1182 of *Solanum nigrum*, SHEIKH-1191 (IC 0647249) of hip rose (*Rosa multiflora*) and SHEIKH-1218 (IC 0647253) of *Daphne oleoides*

17.2 Germplasm supply

During the period under report, twenty seven (27) accessions of pea was supplied to the Department of Vegetable Sciences, SKUAST (K). Three accessions, one each of finger millet, proso millet and foxtail millet was supplied to Division of Biotechnology, SKUAST (K). Five accessions of local wheat genotypes were supplied to the Department of Plant Breeding & Genetics, SKUAST (K) Wadura Sopore Campus. Four accessions of *Fagopyrum tataricum* and two accessions of *F. esculentum* were supplied to the Department of Botany, University of Kashmir, Srinagar for physiological studies. One accession of wild safflower (*Carthamus lanatus*) has been supplied to ICAR-IIOR Hyderabad.

17.3 Germplasm characterization

One hundred and twenty four (124) germplasm accessions of fababean, barley and wheat were characterized for their agro-morphological traits as per the minimal descriptors during *rabi* 2021-22 under rainfed conditions and promising accessions for these traits were identified in each of these crops. Besides, a set of twenty three (23) genotypes of common beans were screened for yield and other agro-morphological traits including BCMV disease during *Kharif* 2022.

17.3.1 Characterization of fababean (*Vicia faba*) germplasm

39 local germplasm accessions of fababean (*Vicia faba*) were characterized along with two checks (HFB-1 and Vikrant) using randomized block design (Table 17.1).

17.3.2 Characterization of barley germplasm

Forty-seven (47) germplasm accessions of barley along with two checks Jyoti and DL-36 were characterized for their agro-morphological traits as per the minimal descriptors during *Rabi* 2021-22 under rainfed conditions using randomized block design (Table 17.2).

17.3.3 Characterization of wheat germplasm

Thirty eight (38) germplasm accessions of wheat along with four checks Raj-3765, WR-544, HD-2967

Fig. 17.3. Interesting germplasm identified: wheat genotype SHEIKH-1114 collected from Garkon village of remote Aryan valley of Ladakh has been identified as late maturing with longer spike and flag leaf length with waxy coating and compact spikes, common bean *Phaseolus vulgaris* genotype EC 400454 has been identified as a promising candidate genotype for higher yield, resistance to BCMV infection and early flowering, buckwheat *Fagopyrum esculentum* genotype SHEIKH-1112 identified for early flowering trait (30 days), scarlet runner bean *Phaseolus coccineus* genotype SHEIKH/SR-1117 identified for white flowers/seeds, foxtail millet *Setaria italica* genotype IC 0631512 identified for having primitive traits and *Allium cepa* var. *proliferum* identified for bigger aerial bulbils

Table 17.1: Promising accessions identified for some important agro-morphological traits in fababean (*Vicia faba*)

Trait	Range	Mean	CV%	Best check value	Promising accessions
Plant height (cm)	55.8 - 91.3	70.8	10.7	55.4 (HFB-1)	IC0637971 (91.3), IC0637973 (84.7), IC0637972 (83.1)
Pod length (cm)	5.2 - 9.7	7.2	15.4	5.1 (HFB-1)	IC0637972 (9.7), IC0637971 (9.2),SHEIKH/SR/SA/SS-918A (8.9)
Pod width (cm)	1.1 - 1.8	1.4	14.9	1.2 (Vikrant)	IC0637962 (1.8), IC0637972 (1.8), IC0637976 (1.8)
Days to 80% maturity	193 - 200	196	0.9	196.5 (HFB-1)	IC0637968 (193), SHEIKH/SR-903A (193), SHEIKH/SR-903B (193)
No. of seeds/pod	2.2 - 3.4	2.9	9.2	3.0 (HFB-1)	SHEIKH/SR-906A (3.4), SHEIKH/SR/SA/SS-923A (3.4), SHEIKH/SR-926A(3.4)
Seed yield/plant (g)	18.748 - 42.050	31.397	19.8	20.018 (Vikrant)	IC0637974 (42.050), IC0637978 (41.725), SHEIKH/SR-925 (41.724)
100-seed weight (g)	41.118 - 89.966	62.302	23.0	26.713 (Vikrant)	IC0637978 (89.966), IC0637962 (88.684), SHEIKH/SR-924 (86.146)

Table 17.2: Promising accessions identified for some important agro-morphological traits in barley and wheat

Trait	Range	Mean	CV%	Best check value	Promising accessions
Barley					
Plant height (cm)	70.9 - 102.8	89.8	8.8	86.0 (Jyoti)	IC138143 (70.9), EC492362 (71.2), IC445542 (75.2)
Days to 75% spike emergence	138 - 170	153.6	4.4	150 (DL-36)	IC138119 (138), IC138120 (138), IC138115 (138)
Spike length (cm)	6.0 - 11.5	8.6	14.1	7.6(DL-36)	IC 138156 (11.5), IC 138161 (11.1), EC 0667478 (11.1)
Days to 80% maturity	171 - 190.5	182.2	2.5	182(DL-36)	EC492362 (171), IC138115 (171), IC247752 (171)
Seed yield/ plant (g)	6.175 - 28.865	16.639	28.4	26.550 (Jyoti)	IC138278 (28.865), EC578671 (28.020)
100-seed weight (g)	2.750 - 6.750	4.375	22.7	4.950 (Jyoti)	EC492317 (6.750), IC138119 (6.100), IC 138120 (6.100)
Wheat					
Plant height (cm)	55.6 - 120.6	83.8	14.9	69.7 (HD-2967)	EC0520997 (55.6), IC539315 (56.3), EC 0521007 (58.3)
Days to 75% spike emergence	154.5 - 176	162.6	3.0	155 (WR-544)	IC617422 (154.5)
Flag leaf length (cm)	11.1 - 20.2	15.9	11.6	18.3 (WR-544)	KV 3 (20.2), IC0078741A (19.7), IC28932 (19.1)
Flag leaf width (cm)	0.8 - 2.0	1.4	18.4	1.5 (WR-544)	SHEIKH-1114 (2.0), IC539531 (1.8), IC542494 (1.8)
Spike length (cm)	10.4 - 17.3	13.2	9.9	14.2 (Raj-3765)	SHEIKH-1114 (17.3), IC529450 (15.7), IC 28932 (15.1)
Days to 80% maturity	181.5 - 202.5	187.1	2.6	182 (H-240)	IC0591073 (181.5), IC574476 (182), IC 0078741A (182)
Seed yield/ plant (g)	7.250 - 48.365	22.729	45.5	26.260 (H-240)	IC542494 (48.365), EC540810 (43.855), IC 0624751 (38.745)
100-seed weight (g)	2.800 - 5.950	4.316	19.9	5.250 (Raj-3765)	1C542494 (5.950), KV 6 (5.700), EC540810 (5.650)

and H-240 were characterized for their agro-morphological traits as per the minimal descriptors during *Rabi* 2021-22 under rainfed conditions using randomized block design (Table 17.2).

17.3.4 Characterization of common bean (*Phaseolus vulgaris*) germplasm

Twenty three (23) genotypes of common beans were screened for yield and other agro-morphological traits including BCMV disease during *Kharif* 2022. Shalimar Rajma-1 was used as local check while genotype SD-44 which was previously identified as highly susceptible to BCMV infection and in which virus load was detected using ELISA procedure, was used as a susceptible check for BCMV screening. On the basis of field evaluation, genotypes EC400454, EC400441, SD44, IC362077 and EC400436 were identified as high yielding compared to the local check. For days to flowering for EC400451, EC400441, EC400440, EC400454, EC400444, EC400453 and IC199205 were identified as early flowering. Based on visual scoring of BCMV symptoms like yellowing/puckering of the leaves, genotypes EC400454, EC400436, EC400433, EC500515 and EC400440 were identified as resistant. Overall, EC400454 was identified as a promising candidate genotype for higher yield, resistance to BCMV infection and early flowering.

17.3.5 Preliminary characterization of *Rubus* germplasm

Eleven (11) accessions of *in vitro* conserved *Rubus* plants received from Tissue Culture & Cryo-preservation Unit (TCCU), ICAR-NBPGR New Delhi during early 2021 and established in the FGB were evaluated and preliminary observations on some fruit traits were recorded (Table 17.3). Most of these accessions have started flowering and fruiting in the month of May unlike local wild growing *Rubus* species which commonly come to flowering and fruiting in the months of July and August. *Rubus* accession EC560271 has been identified to be promising in terms of overall robust growth, fruit size, weight and also taste. Besides, this accession has produced two fruiting cycles one in the months of May-June and another in August-September.

17.4 Germplasm conservation

One hundred and six (106) germplasm accessions of agri-horticultural crops collected from different parts of Jammu and Kashmir and Ladakh including 86 diverse gemrplasm accessions of wild Triticeae were conserved under LTS at the National Gene Bank.

Table 17.3: Some fruit traits of *in vitro* cultured *Rubus* plants established in the FGB

S No.	TCCU ID/Accession Number	Fruit length (cm) ± SD	Fruit width (cm) ± SD	Fruit weight (g) ± SD	Brix (%) ± SD
1	TC-RUB 20 (EC560275)	1.7 ± 0.2	1.3 ± 0.2	1.2 ± 0.4	11.7 ± 2.4
2	TC-RUB 22 (EC560277)	1.8 ± 0.1	1.6 ± 0.1	1.2 ± 0.1	10.6 ± 1.6
3	TC-RUB 59 (EC570281)	1.9 ± 0.1	1.4 ± 0.1	2.0 ± 0.5	9.9 ± 1.7
4	TC-RUB 3 (EC381257)	1.2 ± 0.2	0.8 ± 0.5	0.8 ± 0.2	11.7 ± 2.5
5	TC-RUB 14 (EC560269)	2.1 ± 0.3	1.5 ± 0.2	2.9 ± 0.6	11.5 ± 3.1
6	TC-RUB 10 (EC560265)	2.0 ± 0.3	1.3 ± 0.2	2.3 ± 0.3	9.8 ± 1.5
7	TC-RUB 66	1.8 ± 0.5	1.4 ± 0.1	1.9 ± 0.9	10.2 ± 1.1
8	TC-RUB 4 (EC381258)var. Black Satin	1.8 ± 0.2	1.2 ± 0.0	1.9 ± 0.5	12.2 ± 0.5
9	TC-RUB 16 (EC560271)	2.7 ± 0.2	1.9 ± 0.2	4.7 ± 0.7	13.3 ± 1.2
10	TC-RUB 43 (EC560300)	1.7 ± 0.1	1.2 ± 0.06	2.1 ± 0.2	11.3 ± 1.8
11	TC-RUB 61 (EC570283)	1.3 ± 0.1	1.5 ± 0.2	1.6 ± 0.1	9.0 ± 2.7
12	*Rubus fruticosus* (local collection)	1.9 ± 0.2	1.7 ± 0.3	2.9 ± 0.7	12.4 ± 0.8

Fig. 17.4. *In vitro* cultured *Rubus* plants established in the field: from left to right EC570281, EC3812589 and EC560271

Research programme (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)

18 REGIONAL STATION, THRISSUR

सारांशः वर्ष के दौरान, रिपोर्ट के तहत, लक्षद्वीप, मध्य प्रदेश, मणिपुर और मिजोरम जिलों को शामिल करते हुए, तीन अन्वेषण मिशनों में जननद्रव्य के 227 नमूने एकत्र किए गए थे। कुल 743 संग्रह जिनमें 400 ग्रीनग्राम, 300 हॉर्सग्राम और 43 कटहल शामिल थे, का लक्षण वर्णन किया गया। मूसा, सोलानम और सीसम की जंगली और खेती की प्रजातियों की स्क्रीनिंग पर, प्राकृतिक एपिफाइटोटिक स्थितियों के तहत क्रमशः केला स्यूडोस्टेम वीविल, बैंगन बैक्टीरियल विल्ट और सीसेम फाइलोडी के लिए प्रतिरोध के स्रोतों की पहचान की गई। एंथोसाइनिन सामग्री के लिए पिगमेंटेड टारो जननद्रव्य का विश्लेषण किया गया। कद्दू (केरल के इडुक्की जिले में यूराली जनजाति द्वारा संरक्षित एक जातीय लैंडरेस), व्लाथनकराचीरा (तिरुवनंतपुरम से गहरे लाल रंग का अमरांथस तिरंगा लैंडरेस), दोप्पासौद दोहरे उद्देश्य – दक्षिण कन्नड़, कर्नाटक से सलाद और करी प्रकार के ककड़ी लैंडरेस नामक सब्जियों की अनूठी लैंडरेस एकत्र करने, गुणन करने और संरक्षित करने के प्रयास किए गए। विग्ना और वन्य चावल में टैक्सोनोमिक अध्ययन किया गया। एनजीबी में एलटीएस के लिए अन्वेषण यात्राओं और विभिन्न फसलों और उनके फसल वन्य प्रजातियां/औषधीय पौधों से 289 नमूनों के जननद्रव्य को भेजा गया। त्रिशूर में विभिन्न फसलों/बारहमासी बागवानी पौधों और उनकी वन्य प्रजातियों की 12711 एक्सेशन का एक जननद्रव्य है, जिनमें से 10392 एमटीएस में हैं और 2319 एफजीबी में हैं। एमटीए के तहत 28 उपयोगकर्ता एजेंसियों को विभिन्न प्रजातियों/टैक्सा में कुल 820 एक्सेशनों की आपूर्ति की गई। "प्लांट टैक्सोनोमी फॉर प्लांट जेनेटिक रिसोर्स मैनेजमेंट" पर वर्चुअल ट्रेनिंग प्रोग्राम का आयोजन किया गया।

Summary: During the year under report, 227 samples of germplasm were collected in three exploration missions, covering Lakshadweep, districts of Madhya Pradesh, Manipur and Mizoram. A total of 743 collections comprising 400 of greengram, 300 of horsegram and 43 of jackfruit were characterized. On screening of wild and cultivated species of *Musa*, *Solanum* and *Sesamum*, sources of resistance were identified for banana pseudostem weevil, brinjal bacterial wilt and sesame phyllody, respectively under natural epiphytotic conditions. Pigmented taro germplasm were analysed for anthocyanin content. Efforts were made to collect, multiply and conserve unique landraces of vegetables namely *Uralimathan* of pumpkin (an ethnic landrace conserved by Urali tribe in Idukki Dist., Kerala), *Vlathankaracheera* (deep red coloured *Amaranthus tricolor* landrace from Thiruvananthapuram), *Doppasouthe* dual purpose - salad and curry type cucumber landrace from Dakshina Kannada, Karnataka. Taxonomic studies in *Vigna* and wild rice were undertaken. Germplasm of 289 samples from exploration trips and multiplied accessions comprising various crops and their crop wild relatives/ medicinal plants were sent for LTS in NGB. Thrissur has a germplasm holding of 12711 accessions of various crops/ perennial horticultural plants and their wild relatives of which 10392 are in the MTS and 2319 in the FGB. A total of 820 accessions in various species/taxa were supplied to 28 user agencies under MTA. Virtual Training Programme on "Plant Taxonomy for Plant Genetic Resources Management" was organized.

18.1 Germplasm exploration and collection

A total of three explorations were conducted and 227 samples were collected as detailed below:

Lakshadweep Islands: Three islands in Lakshadweep namely Kavaratti, Agatti and Bangaram were explored and 33 collections were made. This includes representative samples of economically important species occurring in the coastal ecosystem such as *Aerva lanata*, *Bacopa monnierii*, *Boerhavia diffusa*, *Calophyllum inophyllum*, *Catharanthus roseus*, *Colubrina asiatica*, *Cordia subcordata*, *Eclipta prostrata*, *Hibiscus tiliaceus*, *Indigofera tinctoria*, *Ipomoea violacea*, *Lawsonia inermis*, *Ocimum americanum*, *Pemphis acidula*, *Physalis lagascae*, *Scaveola taccada*, *Sida cordifolia* and *Tephrosia strigosa*. Germplasm of *Cucumis melo* subsp. *agrestis* (JLPS/22-2, 15) and *Gossypium hirsutum* (JLPS/22-33), collected from the coastal area, would offer scope for the saline tolerance trait. Also collections from profusely bearing elite plant of tree-borne oilseed *Calophyllum inophyllum* (JLPS/22-30) was made.

Satpura Range in Madhya Pradesh: An exploration in the Khandwa, Betul, and Chhindwara districts of Madhya Pradesh for crop wild relatives resulted in the collection of 100 accessions involving 55 taxa. Regarding wild rice, both the pigmented and non-pigmented types in *Oryza nivara* were common and co-inhabiting the stagnated water bodies such as pools, and roadside marshy areas. The population of wild sesame, *Sesamum mulayanum*, was found in Khandwa and Betul districts which were too sparse in the exposed areas. *Linum mysorense* was spotted under the flowering condition in the Patalkot area and seeds would mature from late November to December. Rich species diversity in *Ocimum* and *Vigna* was noticed and collected in areas between Khandwa and Asirgarh, and Betul and Chhindwara, respectively. Other important germplasm collections include endemic CWR taxa namely *Cucumis setosus* and *Trichosanthes cucumerina* subsp. *sublobata*.

Areas bordering Myanmar in southern Manipur and northern Mizoram: Exploration in remote and gap areas in Churachandpur and Pherzawl districts of Manipur and Saitual district of Mizoram for the collection of local crops, *Trichosanthes* and wild useful species resulted in the collection of 139 accessions involving 86 taxa. Germplasm of taxa such as *Musa ochracea*, *M. thomsonii*, *M. sikkimensis* var. *simmondsii*, *Aristolochia acuminata*, *Dioscorea arachidna*, *Diospyros glandulosa*, *Dunbaria podocarpa*, *Elsholtzia communis*, *Lycianthes laevis*, *Paspalum conjugatum* and *Plukenetia volubilis* are collected probably for the first time. Some trait-specific germplasm collected are apically-branching foxtail millet (KP/SC/22-24), highly-branched sesame (c. 25 primary branches) (KP/SC/22-60, 77), carotenoid-rich/red-fleshed cucumber (on ripening) (KP/SC/22-10, 30, 42, 90, 106, 125), and cluster-bearing *Citrus medica* (8-10 fruits/ cluster, each weigh 1 kg) (KP/SC/22-122). Crops like sorghum and foxtail millet, very common some 20-30 years before, are now confined to 1 or 2 areas/ farmers. Job's tears (*Coix lacyrma-jobi* var. *ma-yuen*) was found only in three localities as a field border crop. Information on the cultivation of exotic species such as *Plukenetia volubilis* (star fruit), *Smallanthus sonchifolius* (ground apple) was gathered, besides details on semi-domesticates, genetic erosion and ethnobotanical information from *Paite* tribes inhabiting this surveyed area.

Apart from the above, two short trips were made in Tamil Nadu (Kotagiri in Nilgiris & East Coast area from Pondicherry to Chennai) and collected 18 germplasm acc. (15 taxa). Some important collections include *Sesamum prostratum* from East Coast, *Solanum pubescens*, *Cardiospermum canescens, Macrotyloma ciliatum* and *Phoenix pusilla*.

18.2 Germplasm characterisation and evaluation

18.2.1 Greengram coreset

A total of 400 accessions of green gram core set were evaluated in Augmented RCBD in six blocks along with five checks for 40 traits as per NBPGR minimum descriptor (NBPGR, 2001). The results of the experiments depicted in table 18.1 showed that, the coreset was representing accessions superior for multiple traits. EC520039 was promising for earliness, which initiated flowering at 15 days and reached maturity at 50 days after sowing. In addition, EC396156 and EC396402 were also early types manifested by reaching 50% flowering at 15 days after sowing respectively. Four accessions namely IC11365, IC76585, IC119001, IC76479 were superior in terms of pods per cluster (9 pods per cluster), which was on par with the check PLM90. Number of seeds per pod ranged from 2 to 32 with a mean of 12. Seed yield per plant was maximum (39 g) in IC548369, IC121262 and IC394431 on par with the checks; PLM645 and PLM473.

18.2.2 Horsegram coreset

A total of 300 accessions of horsegram coreset were evaluated for 19 traits in an Augmented RCBD in 10 blocks with 6 check varieties *viz.*, HGGP, Paiyur-1, PHG9, AK21, Birsa Kulthi and DPI2278. IC400120 was identified as a promising early type which attained 50 per cent flowering and 80 percent maturity at 28 and 88 days after sowing. Five accessions (IC425088, IC330562, IC347180, IC139347, IC470275) outperformed the superior check PHG9 (18.60g) with respect to single plant yield. Pods with more than 6 cm length was exhibited by eight accessions (IC139352, IC213929, IC71815, IC23444,

Table 18.1: Variability parameters of quantitative characters in greengram

Characters	Range	Mean	Superior	Superior accessions	CV	
					(%)	SE
Days to first flowering	15-54	29.7	C4-PDM139 (16.00)	EC396402, EC520039, EC396156	15.2	1.8
Days to 50% flowering	22-53	33.8	C4-PDM139 (24.00)	EC396156, EC396402	12.03	1.5
Days to 80% maturity	54-70	60.76	C4-PDM139 (55.00)	EC520039, IC102954, IC10502, IC76479, IC9127-1, PLM141	4.58	0.6
Pods per cluster	1.80-8.60	4.95	C2-IPM2-14 (7.40)	IC11365 IC76585 IC119001 PLM90 IC76479	20.53	0.3
Pod length	2.50-14.68	8.7	C5-SML668 (12.24)	EC396113 EC396143 EC396402 IC273267	19.20	0.9
No of seeds per pod	8.6-18.0	12.06	C4-PDM139 (13.40)	EC313926 IC336750 IC338852 IC338882 IC282121	10.33	0.4
Average single pod weight (g)	2.00-19.70	8.23	C5-SML668 (13.00)	IC259531 EC396133 EC396104 EC396530 EC398882	28.87	0.6
Grain yield/plant (g)	3.44-38.53	15.51	C3-MH421 (23.57)	IC548369 IC121262 PLM473 IC394431 PLM645	33.99	1.8
100 seed wt (g)	1.78-7.94	4.59	C5-SML668 (7.00)	IC39549 EC396133 IC39459 IC39464	30.79	0.3
No. of pods/plant	20.00-252.00	94.88	C2-IPM2-14 (156.00)	EC16556 IC76464 IC8592 IC488657 PLM1014	39.78	1.1

IC283868, IC145246, IC71763, IC39374). The superior accessions identified for economically important traits are listed in Table 18.2.

18.2.3 Jackfruit

Forty-three seedling-origin accessions of jackfruit germplasm conserved in the FGB have been characterized for 35 fruit and seed descriptors (18 qualitative & 17 quantitative characters) developed by NBPGR. Out of 43 acc., 31 belonged to 'varikka' (firm-fleshed types), 11 to 'koozha' type (soft-fleshed fibrous types) and one (IC91836-2A) had intermediate flesh type. Good variability was exhibited in the qualitative

Table 18.2: Superior accessions identified in horse gram coreset

Characters	Range	Mean	Superior check	Superior accessions
Days to 50 per cent flowering	28.00-77.00	46.39	Birsa Kulthi (37 days)	IC570763, IC262880, IC276110, IC280032, IC32834, IC337229, IC400120, IC436596, IC561016
Days to 80 per cent maturity	88.65-134.00	105.48	Birsa Kulthi (93.5 days)	IC361648, IC361650, IC361648, IC361650, IC385916, IC398281, IC400120, IC424463, IC424465, IC427526, IC436596, IC520825, IC520826, IC520828, IC521467, IC548801, IC561015, IC561016
Pod length (cm)	3.52-6.48	5.11	HGGP (5.37)	IC139352, IC213929, IC71815, IC23444, IC283868, IC145246, IC71763, IC39374
No of seeds per pod	3.80-7.40	5.90	DPI2278 (6.56)	IC71815, IC27604, IC71781, IC425085
Seed yield per plant (g)	1.48-48.64	11.74	PHG9 (18.60g)	IC425088, IC330562, IC347180, IC139347, IC470275
100 seed weight (g)	1.50-4.19	3.07	PHG9 (3.48g)	IC330562, IC71798, IC425073, IC398703, IC71735, IC343849

Fig. 18.1. Field view of green gram (a) and horse gram (b) coreset raised for evaluation

Fig. 18.2. Jackfruit landrace '*Thamarachakka*' (IC91665-2A) bearing very small round fruits in bunches

characters, as all the character states were represented in 13 out of 18 studied characters (Table 18.3). The landrace *Thamarachakka* accessions (IC91665-2A and IC91768-3A) had flat-shaped spines, yielding nearly smooth-surfaced fruits. Except for the 'reddish yellow' fruit-rind colour and 'reniform' seed shape, all other character states were represented in these two traits. Out of six-character states in the key trait 'pulp colour', barring 'coppery red' and 'white', all the states were represented in the collection. While 'ellipsoid' and 'oblong' shaped fruits and 'twisted' and 'rectangular' shaped flakes were predominant in the collection, 35 accessions had a 'sweet' pulp taste, 25 had 'very juicy' pulp and 17 had 'strong' pulp flavour. The characters 'fruit shape', 'fruit rind colour' and 'pulp colour' exhibited additional character states, while 'flake texture' had unrelated states, all needing updating in the descriptor.

A high coefficient of variation (>40%) was exhibited by some economically important characters such as fruit weight and flake weight (with or without seed), indicating a good level of variation in the collection. Higher TSS of 30° Brix was exhibited by IC645404 (31.70), IC91768-3A (30.9) and IC97628-1A (30), while 18 other accessions had TSS of >25° Brix. The firm-fleshed type, IC645894 with medium plant stature shall be promoted, as it yielded profusely (>80 fruits/plant), bore regularly, with medium-sized fruits

Table 18.3: Descriptive statistics of quantitative characters in jackfruit

#	Character	Min	Max	Mean	SD	CV(%)	SE	CD
1.	Fruit length (cm)	10.50 (IC91665-2A)	48.75 (IC645402)	35.38	7.61	21.52	1.16	1.96
2.	Fruit width (cm)	10.90 (IC91665-2A)	30.75 (IC96152-2A)	22.51	3.96	17.61	0.60	1.02
3.	Fruit weight (kg)	0.37 (IC91665-2A)	17.30 (IC96152-2A)	7.64	3.26	42.70	0.50	0.84
4.	Spine density (5 x 5 cm^2)	21.00 (IC91768-3A)	127.50 (IC645405)	58.20	19.28	33.14	2.94	4.95
5.	Weight of flakes with seed (g)	12.30 (IC645405)	67.70 (IC645395)	27.67	11.67	42.16	1.78	3.00
6.	Weight of flakes without seed (g)	6.20 (IC92254-2B)	57.60 (IC645395)	19.38	10.21	52.70	1.56	2.62
7.	Flake length (cm)	3.04 (IC91665-2A)	8.59 (IC97630-2A)	5.73	0.97	16.92	0.15	0.25
8.	Flake width (cm)	1.81 (IC92259-2A)	4.49 (IC645395)	2.87	0.61	21.38	0.09	0.16
9.	TSS (° Brix)	17.50 (IC91736-3A)	31.70 (IC645404)	25.19	3.02	11.98	0.46	0.77
10.	Seed length (cm)	2.50 (IC91665-2A)	4.23 (IC91761-2A)	3.44	0.37	10.62	0.06	0.09
11.	Seed width (cm)	1.33 (IC645404)	2.48 (IC91736-3A)	1.92	0.26	13.73	0.04	0.07

(6.49 kg) having a very less proportion of rags, and sweet pulp taste and no viviparity. Other elite accessions identified are IC91808-1A (small-sized seeds), IC91806-3A, IC645404, IC97628-1A (early maturing) and IC91761-2A among 'varikka', and IC470605-5B and IC97626-1A among 'koozha'.

18.3 Evaluation for biotic stress tolerance

18.3.1 Evaluation of *Musa* spp. for resistance/tolerance to Pseudostem weevil, *Odoiporus longicollis*

Field evaluation of four wild relatives of banana collected from Andaman and Nicobar Islands along with nine landraces of Kerala against pesudostem weevil has shown that two accessions (IC630992 and IC623499) of *Musa balbisiana* var. *andamanica* (wild species) were found free from the visible infestation of banana pseudostem weevil. Feeding marks and development stages of the weevil were not present in pseudostem of *M. balbisiana* var. *andamanica* accessions. Species namely, *M. kattuvazhana* (IC631126) and *Musa balbisiana* (*Beejakela* – IC645347) exhibited resistant reaction and landrace, *Njalipoovan* has shown moderately resistance reaction to weevil infestation (Table 18.4). Wild species namely, *M. acuminata* (IC631154), *M. inandamanensis* (IC631162) and landraces such as, *Karpuravalli, Nendran* and *Monthan* were susceptible to infestation of pseudostem weevil. *In-vivo* screening of pseudostem pieces of wild and landraces germplasm against weevil has confirmed the above results. Biochemical analysis revealed that crude fibre content of 20-21% and water content of 89% in pseudostem of *M. balbisiana* var. *andamanica* compared to 11-15% crude fibre content and 93-96% water content in other wild genotype and landraces may have possible roll for the resistance.

18.3.2 Screening of *Solanum* species against bacterial wilt (*Ralstonia solanacearum*)

Total of 140 accessions belong to brinjal and its wild relatives including landraces were screened under artificial inoculation technique (root injury method) in field for resistance to bacterial wilt caused by *Ralstonia solanacearum*. Lateral roots of 30 days old plants were trimmed and drenched with 10 ml of *R. solanacearum* culture containing 7 x 10^8 cfu/ml. Symptoms of

Table 18.4: Reaction of wild species of banana to Psuedostem weevil

S. No.	Musa species and its local name	Accession number	Genome	Number of bore holes*	Number of adults + grubs + pupa*	Length of feeding patches on pseudo-stem** (cm)	Host reaction type
1	*M. acuminata*	IC631154	-	14	11	34-177	S
2	*M. balbisiana* var. *andamanica*	IC623499	-	0	0	0	HR
3	*M. balbisiana* var. *andamanica*	IC630992	-	0	0	0	HR
4	*M. kattuvazhana*	IC631126	-	3	3	41-93	R
5	*M. inandamanensis*	IC631162		4	4	Sep-54	S
6	Karpuravalli	-	ABB	11	8	13-102	S
7	Nendran	-	AAB	9	9	24-96	S
8	Njalipoovan	-	AB	6	4	27-84	MR
9	Palayankodan	-	AAB	6	5	19-71	S
10	Cavendish	-	AAA	7	9	13-39	MS
11	Chundillakunnan	-	AB	10	8	22-86	MS
12	*M. balbisiana* (*Beejakela*)	IC645347	BB	2	2	23-63	R
13	Mondan	-	ABB	9	8	24-114	S

either partial or whole plant wilting were recorded as susceptible and confirmed by ooze test. Accessions namely IC256708, IC624237, IC626119, IC333527, IC 624213, IC611551 (Arunachal local), IC641518 (*vengeri* brinjal), Surya (*S. melongena*), and IC599705 (*S.insanum*) were found resistant to bacterial wilt.

18.3.3 Phytoplasma associated with phyllody of *Sesamum* spp. in India

Wild species of sesame present in India were studied for association of phytoplasma at group and sub-group level. Phyllody and associated symptoms were recorded in all the species of *Sesamum* existing in India with varying degree of susceptibility. The lowest incidence of phyllody was found in *S. alatum* (0-6%) followed by *S. laciniatum* (11-17%) and *S. prostratum* (16-27%). In other species namely *S. indicum, S. indicum* subsp. *malabaricum*, *S. mulayanum* and *S. radiatum* incidence of phyllody was recorded in the range of 44-68%. In the present investigation, phytoplasma strain associated with phyllody of *S. indicum* was found as 16SrI-B ('*Candidatus* Phytoplasma asteries') whereas a strain of 16SrII-D ('*Candidatus* Phytoplasma australasiae') was found associated with phyllody in wild species namely, *S. indicum* subsp. *malabaricum*, *S. mulayanum*, *S. prostratum*, *S. laciniatum*, *S. alatum* and *S. radiatum.* This is the first observation made in phyllody of *Sesamum* species existing in India, and strains classified up to subgroup level.

18.4 Biochemical characterization

18.4.1 Anthocyanin rich taro germplasm

Anthocyanins are water-soluble pigments possessing higher antioxidant property compared to other flavonoids. Generally, taro tubers exhibit white to cream coloured flesh. However, five taro accessions collected from south-west Khasi hills, Meghalaya were exhibiting purple pigmentation in the flesh, which was attributed to the presence of anthocyanins. Hence total anthocyanins in the freshly harvested tubers were estimated and the values are depicted in the table 18.5. Anthocyanin content of IC636544 (22.77 mg/100g), IC636540 (16.45 mg/100g), IC636542 (14.19 mg/100g) and IC636543 (11.88 mg/100g) were significantly higher than the control varieties; Muktakeshi (3.48 mg/100g) and CGarvi-2 (3.38 mg/100g).

Table 18.5: Anthocyanin content in taro germplasm

S. No.	Samples	Anthocyanin (mg/100g)
1	IC636544	22.77
2	IC636540	16.45
3	IC636542	14.19
4	IC636543	11.88
5	Muktakeshi	3.48
6	CGArvi-2	3.38
7	IC636541	2.72

18.5 Pre-breeding activities

18.5.1 *Sesamum* species

For the first time, secured F_1 hybrid between *S. indicum* (2n-26) x *S. radiatum* (2n=64) which is characterized by dark green lanceolate leaves, shorter internodes, almost horizontal flower arrangement in axils, smaller ill-filled capsules with black seeds. Advanced 14 F_2 generations of wide hybrids (involving *S. mulayanum* and *S. malabaricum*), 42 F_1 hybrids of wide hybrids (involving *S. laciniatum*, *S. prostratum* and *S. radiatum* as male parents), and trial on extra-long capsuled sesame germplasm identified at Vriddhachalam Centre (as a part of the multi-location trial). Besides seed multiplication (108 acc.) and back-crossing was undertaken in crosses between *S. indicum* x *S. laciniatum* (direct and reciprocal) and *S. indicum* x *S. prostratum*.

18.5.2 *Abelmoschus* species

Pre-breeding was undertaken to incorporate genes for resistance to YVMVD and OELCV from *Abelmoschus moschatus* (EC360830, EC360794, EC360586) and *A.enbeepeegearensis* to okra (cv. Pusa sawani). Further five amphidiploids *viz.*, Ruchi x *A.tetraphyllus* (Brahmavara), Ruchi x AM-24 ($C_2$50 Mizo 34), Ruchi x AM-6 ($C_3$50 Mizo 24), $C_3$50 Mizo 24 x IC22232, Arka Anamika x 4 ($C_2$50 Mizo 34 x Parbhani Kranthi) were advanced through back crossing /open pollination.

18.5.3 Taxonomic studies

Wild rice: Andaman endemic *Oryza meyeriana* var. *indandamanica* was often considered as an ecotype/variant or subspecies of *O. granulata*, or variously treated/synonymized under *O. meyeriana* var. *granulata* or often all the infraspecific taxa names were subsumed/kept under *O. meyeriana* only. A critical study of protologues, the type specimen(s) of var. *granulata*, var. *meyeriana* and var. *indandamanica* coupled with the study of the latter taxon at the natural field and FGB conditions revealed that var. *indandamanica* (IC641181) collected from Saddle Peak National Park of Andaman falls well under the circumscription of var. *meyeriana*, instead of var. *granulata*. The observed key characters, *viz*., fruiting spikelets oblong, 3.7-5.1 times as long as wide, and caryopsis 4.60-5.94 mm long, readily differentiate from var. *granulata* (having an elliptic fruiting spikelet which is only 2.1-2.7 times as long as wide, and caryopsis 3.4-4.1 mm long).

***Vigna*:** Studies in *Vigna* wild species (50 acc. involving >12 taxa) were made based on protologues, type specimens, online herbaria and field-grown germplasm at the station. The characteristics which are helpful in distinguishing a poorly studied endemic taxon *Vigna radiata* var. *setulosa* from var. *radiata* (green gram) and var. *sublobata* have been identified. This is very close to var. *radiata* but a wild taxon exhibiting twining habit with early maturity (40 days) and seeds dull, greenish with black blotches over it; showing characters intermediate between green gram and var. *sublobata*. While *V. stipulacea* has been recently reported from A&N Islands, preliminary studies indicated that the possible occurrence of *V. trinervia*, *V. hirtella* and *V. reflexopilosa* in these islands may not be ruled out. Literature analysis indicated *Vigna umbellata* var. *gracilis*, a taxon originally described from Malaysia, was invariably kept under either Himalayan *V. prainiana* Babu & Sharma (which is now kept under *V. gracilicaulis*), East Asian *V. minima* or *V. gracilicaulis* or *V. umbellata* (without recognizing infraspecific status), and all the above taxa names appear in Indian literature which has resulted in great confusion, needing critical studies. While truly wild populations of *V. umbellata* do exist in India, genebank material from the Western Ghats labelled as *V. minima* or *V. umbellata* var. *gracilis*, are in fact *V. dalzelliana*, owing to their creeping glabrous or minutely hairy plants which are rooting at nodes, flat style-beak, erecto-patent pods, long hilum and slightly sickle-shaped pods. The taxonomic identity of some wild *Vigna* germplasm accessions was corrected after sufficient authentication.

Herbarium study in Blatter Herbarium, Mumbai (25 specimens) provided information on new collection localities for the endemic species, *Sesamum laciniatum*.

As a part of work under the National Herbarium of Cultivated Plants project, updated/corrected the details on botanical names, author citations, family names, synonymy (for homotypic names), spelling mistakes, and possible wrong identification for about 25,000 herbarium specimens deposited at NHCP.

18.6 Germplasm conservation and regeneration

A total of 10392 accessions comprising cereals (3123), millets (85), oilseed (48), pulses (3040), vegetables (3221) and crop wild relatives (874) were conserved in the MTS facility of the station.

In the field gene bank, currently 2410 accessions are maintained including 642 of tropical fruits, 713 of spice crops, 179 of tuber crops, 270 of medicinal plants, 560 of crop wild relatives and 270 of other economic plants and major crop/wild relatives maintained are detailed Table 18.6.

18.6.1 Additional repository for tropical fruit crops

A new block on *Musa* wild species (5 acc.) and banana landraces from Kerala (10 acc.) was developed. About 20 species (mostly exotic species), not yet represented in FGB, have been added during the period under the report. This includes interesting species like *Eugenia neonitida*, *Musa hirta*, *Phalaeria macrocarpa*, *Synsepalum dulcificum*, *Saba comorensis*, *Diospyros nigra*, *Pachira aquatica*, and *Byrsonima crassifolia.*

Seed multiplication was taken up in 387 samples comprising 84 of bitter gourd, 150 of

Table 18.6: Field Genebank holding at Thrissur station

Crops	Acc.	Crops	Acc.
Mango	143	Curry leaf	47
Jackfruit	189	*Zingiber* spp.	21
Indian gooseberry	36	*Curcuma* spp.	88
Musa spp.	19	*Piper* spp.	95
Citrus spp.	46	*Garcinia* spp.	80
Artocarpus spp.	29	Elephant foot yam	22
Turmeric	161	Taro	140
Black pepper	111	Greater yam	28
Malabar tamarind	273	Drum stick	48
Kokum	95	Other wild relatives/Economically important species	739

okra, 41 of yard long bean and 112 of other agri-horticultural crops collected in various exploration trips for deposition in NGB. A total of 190 accessions representing 10 species under the genera *Abelmoschus* were raised for multiplication/ regeneration which include *A. caillei, A. angulosus* (var. *angulosus* and var. *grandiflorus*), *A. tetraphyllus* var. *tetraphyllus, A. moschatus* subsp. *moschatus, A. manihot subsp. manihot, A. enbeepeegearensis, A. tuberculatus, A. crinitus* and *A. ficulneus*. Indigenous accessions include collections from 21 states and three Union Territories. Efforts were made to collect, multiply and conserve unique land races of vegetables namely *Uralimathan* of pumkin (an ethnic landrace conserved by Urali tribe in Idukki Dist., Kerala), *Vlathankaracheera* (deep red coloured Amaranthus tricolor landrace from Thiruvananthapuram), *Doppasouthe* (IC644588, dual purpose - salad and curry type cucumber landrace from South Kannada, Karnataka).

For long term storage, 289 samples consisting of collected (246 collected samples) and multiplied (43 samples) germplasm were deposited at NGB, which comprises *Oryza nivara* (10 samples), *Sesamum indicum* subsp. *malabaricum* (7), *S. mulayanum* (3), *Trichosanthes anaimalaiensis* (3), *Cucumis hystrix* (3), Sesame (10), *Abelmoschus tuberculatus* (4)

One accession each of *Momordica subangulata* subsp. *subangulata, M. subangulata* subsp. *renigera, Sterculia balanghas* and 10 accessions of *Bacopa monnieri* were sent for cryo-conservation.

18.7 Germplasm exchange

Supply to user agencies: Under Material Transfer Agreement (MTA), 820 accessions of germplasm of various crops/ species were supplied to 28 user agencies, comprising 3 ICAR institutes (150.), 20 State Agricultural Universities (602 accs.) and 5 Other Agencies (68 accs.). A total of 1126 accessions comprising teasel gourd (44 accessions), greengram (469), horsegram (268) were supplied within NBPGR.

Germplasm receipt: A total of 459 germplasm in 18 *Abelmoschus* taxa were received from NBPGR, New Delhi for multiplication.

Research Programme (Code, Title **and programme Leader)**
PGR/ DGE-BUR-THR-01.01: Plant Genetic Resources Management of field crops and their wild relatives. **M Latha,** Joseph John K., (upto 31.03.2022), K. Pradheep, PP Thirumalaisamy, K Venkatesan (from 09.09.2022) **S**uma A, S Mani and A Indiradevi
PGR/ DGE-BUR-THR-01.02: Plant Genetic Resources Management of vegetables, tropical tubers and their wild relatives. **Suma A.,** Joseph John K, (upto 31.03.2022), M Latha, K. Pradheep, PP Thirumalaisamy, K Venkatesan (from 09.09.2022), S Mani, and A Indiradevi
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**, Joseph John K., (upto 31.03.2022), PP Thirumalaisamy, K Venkatesan (from 09.09.2022), Suma A., S. Mani, and A Indiradevi

19 TRAININGS AND CAPACITY BUILDING

Summary: In 2022, the institute was involved in organizing 11 trainings / workshops / awareness programs in the headquarters and regional stations. Various scientific staff attended 17 training programs. The technical and Skilled Supporting staff attended 6 and 4 trainings, respectively.

19.1 Trainings/workshops/visits/fairs organized in 2022

S. No.	Title of programme	Duration in 2021	Venue
1.	TSP programme on "Promotion of homestead organic vegetable cultivation for nutritional security" jointly with KVK of ICAR -CMFRI, Kavaratti	January 9-10, 2022	Kavaratti and Agatti Islands of UT of Lakshadweep Islands
2.	Awareness Programme cum study tour for medicinal plants for Unani medical students as part of Science Week celebrations was organized in association with Association for promotion of ethno-medicine and traditional crops diversity	Feb 26, 2022	ICAR-NBPGR, RS, Hyderabad
3.	Awareness Programme cum study tour for Unani medical students on medicinal plants was organized in association with Association for promotion of ethno-medicine and traditional crops diversity	March 5, 2022	ICAR-NBPGR, RS, Hyderabad
4.	A programme on "Conservation of plant genetic resources for health and nutritional security" under Schedule Caste Sub-Plan	March 22, 2022	Vill: Mazod, Tal: Akola, Dist: Akola (Maharashtra)
5.	A Workshop cum awareness programme under Tribal Sub-Plan on "Conservation of Plant Genetic Resources for Health and Nutritional Security".	March 27, 2022	Vill: Alegaon, Tal: Patur, Dist: Akola, (Maharashtra)
6.	Awareness cum-agro biodiversity conservation fair under SCSP Plan.	March 25, 2022	Pipaltad, Muwani, Pithoragarh
7.	Awareness cum agro biodiversity fair under Tribal Sub Plan.	May 13, 2022	Sitarganj, U. S. Nagar (UK)
8.	In-house orientation training programme for technical and skilled support staff of NBPGR, RS, Hyderabad	June, 20-28, 2022	ICAR-NBPGR, RS, Hyderabad
9.	DBT sponsored Training Programme on "Genetically engineered plants: Biosafety considerations, policies, challenges and detection strategies"	July. 19-25	ICAR- NBPGR, New Delhi
10.	Training on '*Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*' under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material	August 2-11, 2022	ICAR- NBPGR, New Delhi
11.	Training on "Post- entry quarantine for imported planting material of horticultural crops"	September 17, 2022	ICAR- NBPGR, New Delhi

19.1.1 I[st] National Conference on Plant Genetic Resources Management at NASC, New Delhi from 22-24 November, 2022

In order to devise future strategies and to find possible solutions for agricultural diversity and genetic resources that support crops in the context of climate change, declining natural resources and increasing population, the "1[st] National Conference on Plant Genetic Resources Management" was organized jointly by the Indian Society of Plant Genetic Resources, Indian Council of Agricultural Research, National Bureau of Plant Genetic Resources, Alliance of Bioversity International and CIAT, Protection of Plant Varieties and Farmers' Rights Authority from 22-24 November, 2022 at NASC Complex, New Delhi (Fig. 19.1). Other Co-organisers are: the Trust for Advancement of Agricultural Sciences, International Centre for Agricultural Research in the Dry Areas, International Centre for Research in Agro-Forestry, International Crop Research Institute for Semi Arid Tropics, CIMMYT and National Academy of Agricultural Sciences. Dr Himanshu Pathak, Secretary, DARE & Director General, ICAR inaugurated the conference and Padma Bhushan Dr R S Paroda delivered Plenary Lecture on 'Managing our Biodiversity". Dr K V Prabhu, Chairperson, PPV&FRA, Dr Jai C Rana, Country Director, Alliance for Bioversity International and CIAT, Director, ICAR-NBPGR beside many eminent scientists delivered special lectures. The Conference was attended by more than 300 scientists, professors, faculty, postgraduate students and research scholars, including many by experts from abroad. During the three day conference, there were plenary session, five technical sessions as covering all relevant themes such as (i) Augmentation of Germplasm for Enhanced Utilization, (ii) Trait Discovery, Gene Mining and Genome Editing, (iii) Conservation through Utilization, (iv) On-Farm PGR Management and Local Food Systems, and a panel discussion. In total, there were 7 Keynote lectures, 21 Invited Lectures, 10 short lectures and 33 rapid oral presentations and hundreds of poster presentations covering all the themes. The keynote speakers, invited speakers and delegates from across the world deliberated on various management perspectives of plant genetic resources. On the last day, there was a session on enabling policy on PGR management, a panel discussion on Public-Private Partnership followed by Valedictory Session co-chaired by Dr RS Paroda and Dr RC Agrawal. The deliberations and interactions during the NCPGRM provided an overview on current developments in the area of PGR management and developed an action-oriented roadmap for future to meet the Sustainable Development Goals.

Fig. 19.1 Glimpses of NCPGRM-2022

19.1.2 DBT sponsored Training Programme on "Genetically Engineered Plants: Biosafety Considerations, Policies, Challenges and Detention Strategies" in hybrid mode (19-25 July 2022) at ICAR-NBPGR, New Delhi

A total of 46 participants (9 in person and 37 in virtual mode) from ICAR institutions, State Agricultural Universities, other universities, National Referral GM detection laboratories, private GM testing laboratories benefited from the training. The training was organized by Dr Gurinderjit Randhawa (Course Director) and Dr Monika Singh and Dr VandanaTyagi (Course

Fig. 19.2. DBT sponsored Training Programme on "Genetically Engineered Plants: Biosafety Considerations, Policies, Challenges and Detention Strategies"

Conveners) under DBT funded National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material (Component – 2) (Fig. 19.2). The course comprised of 17 invited lectures under six themes: Introductory Concepts of GE Plants, National Regulatory Framework for GE Plants, Genetically Engineered Crops: Technologies, Applications and Biosafety, Understanding the IPR landscape of GE Plants, Plant Genetic Resources, Molecular Detection of GE Plants: Current and Emerging Technologies along with four sessions on hands-on-training on GE Detection using PCR, real-time PCR, lateral flow strip assay, loop-mediated isothermal amplification and two virtual Practical sessions in parallel.

19.1.3 Training programme on "Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues"

A 10-days training programme was organised under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Materialduring August 2-11, 2022 in which, 80 participants representing DPPQS, ICAR Institutes, CSIR institute, SAUs and private organisations were trained in various aspects of biosecurity and biosafety (Fig. 19.3).

19.1.4 Training on "Post- entry Quarantine for Imported Planting Material of Horticultural Crops"

Training was organized on 17th September, 2022 at ICAR-NBPGR, New Delhi in virtual mode for the researchers from ICAR institutes *viz.*, ICAR-Central Institute of Temperate Horticulture (CITH), Srinagar, Central Institute of Arid Horticulture (CIAH), Bikaner, ICAR-Indian Institute of Oil Palm Research (IIOPR), Pedavegi (Fig. 19.4). Main objective of the training was to provide guidance on post-entry quarantine requirements for imported planting material of horticultural crops by these three ICAR organizations and sensitize the participants about importance of quarantine for these crops. The

Fig. 19.3. Training programme on "Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues"

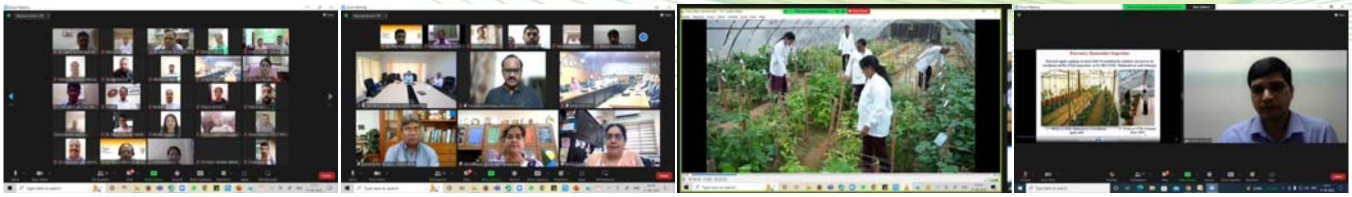


Fig. 19.4. Training on "Post- entry Quarantine for Imported Planting Material of Horticultural Crops"

training was attended by 41 participants from various organizations such as ICAR-CITH, ICAR-CIAH, ICAR-IIOPR and Sher-e-Kashmir University of Agricultural Sciences &Technology of Kashmir. The plant quarantine officials of Regional Plant Quarantine Stations located across the country also attended the training programme.

19.1.5 Workshop cum awareness programme organized under Scheduled Caste Sub-Plan & TSP

i) A Workshop cum Awareness programme under Tribal Sub-Plan on "Conservation of Plant Genetic Resources for Health and Nutritional Security" was organized at Vil:- Alegaon, Tal: Patur, Dist: Akola, Maharashtra State on 27th March 2022. It was organized with the local support from Smt. Padmabai Jain English Primary School, Alegaon. A total of 130 participants comprising tribal farmers and organizers were part of the programme.

ii) A programme on "Conservation of Plant Genetic Resources for Health and Nutritional Security" under Schedule Caste Sub-Plan was organized at village Mazod, Tal: Akola, Dist: Akola of Maharashtra State on 22nd March 2022. It was organized with the local support from Gram Panchayat, Mazod and Srushti Organic Farms, Mazod. A total of 130 participants comprising farmers and organizers were the part of the programme. Women farmers also participated proactively in the event.

19.1.6 Training organized for Skilled Supporting Staff

A one week training programme entitled "Skill upgradation in good office practices cum general awareness for Skilled Supporting Staff" was organized for the SSS staff of the station during 27th June to 02nd July 2022. Supporting staff were trained on the field layout preparation and intercultural operation, nursery management for horticultural crops, processing of seed sample in MTS, office register record maintenance, and office letter receiving and dispatch and maintenance of Farm Machinery and farm implements. Certificates were awarded on successful completion of the training.

Fig. 19.5. TSP programme organised by RS, Akola

Fig. 19.6. SC-SP programme organised by RS, Akola

19.2 Trainings undertaken during 2022

Name of employee	Title of training programme	Period	Place
Scientific staff			
Vikender Kaur using R (Online)	Advanced Statistical Techniques for Data Analysis	Jan. 3-15	ICAR-IIRR, Hyderabad
Archana P Raina	Exploitation of Genetic Resources of Underutilized Tuber Crops (Online)	Feb. 2-11	ICAR- CTRI, Thiruvanan-thapuram
Gayacharan	QTL Analysis and Genome-wide Association Studies	Feb. 15-24	ICAR-IASRI, New Delhi
SR Pandravada	Geospatial Analysis using QGIS and R	Feb. 27-Mar. 3	ICAR-NAARM, Hyderabad
SK Yadav	Sensitization of Government Functionaries on issues relating to Minorities	Mar. 7-9	JNU
N Sivaraj, Prasanna Holajjer	Data visualization using R	Mar. 9-11	ICAR-NAARM, Hyderabad
Narender Negi	Horticultural Biodiversity Conservation for Livelihood and Nutritional Security in the Era of Anthropocene and Climate Change	Mar. 11-31	ICAR-IIHR, Bangalore
Chithra Devi Pandey, Vikender Kaur, Subarna Hajong, S Nivedhitha, Gowthami R, Subhash Chander	Plant Taxonomy for Plant Genetic Resources Management (Online)	Mar. 21-26	ICAR-NBPGR, Regional Station Thrissur
K. Anitha	Training programme for Phytosanitary issuing authorities of Telangana state	Apr. 18-21	NIPHM, Hyderabad
Monika Singh	5-days Assessor's Training Course on ISO/IEC17025:2017 organized by the National Accreditation Board for Testing and Calibration Laboratories (NABL)	Oct. 8-12	Institute for Studies in Industrial Development (ISID), New Delhi
Anjali Kak Koul	Generic Online Training in Cyber Security(Online)	Apr. 27	Ministry of Electronics and Information Technology
VandanaTyagi	Training Programme for Technical Committee Members (BSS 2.0)	May 30-31	National Institute of Training for Standardization, BIS
Harish GD	Cellular and Molecular Cytogenetics	Jun. 1-14	NEHU, Shillong
VandanaTyagi, K Pradheep	Advances in Web and Mobile Application Development	Aug. 2-6	ICAR-NAARM, Hyderabad
Vikender Kaur, Sunil Shriram Gomashe	Analysis of Multi-Environment Trials (Online)	Nov. 3-8	ICAR-NAARM, Hyderabad
Puran Chandra	Winter School in Geospatial Science and Technology	Nov. 1-21	ICAR-CAZRI, Jodhpur
Archana P Raina	MDP on leadership Development (a pre-RMP programme)	Dec. 12-23	ICAR-NAARM, Hyderabad

Name of employee	Title of training programme	Period	Place
Technical staff:			
Safna K	Integrated Pest Management (IPM) for Sustainable Agriculture	May 9-13	ICAR-NCIPM, New Delhi & MANAGE, Hyderabad
MV Reddy, MBCHK Raju	In-house Training programme for all the Technical and Skilled Supporting Staff	Jun. 20-28	ICAR-NBPGR RS, Hyderabad
MV Reddy	Automobile maintenance, Road Safety and Behavioural Skills for Regular Drivers in Technical Grade	Aug. 22-27	ICAR-CIAE, Bhopal
Smita Lenka	Application of Bioinformatics in Agricultural Research and Education	Nov. 15-24	ICAR-NAARM, Hyderabad
Gopal Singh	Automobile Maintenance, Road Safety and Behavioural Skills for Regular drivers in Technical Grade	Nov. 21-26, 2022	ICAR-CIAE, Bhopal
AnkurTomar, Shivangi Mathur	Computer Application for Technical Personnel of ICAR (Online)	Dec. 15-21	ICAR-IASRI, New Delhi
SSS:			
Rohit, Shanker Das, Mangat Ram, Leela Dhar, Paras Ram	Skill Development Training Related to Farm and Office Work	May 23-28	ICAR-NBPGR, RS, Shimla
Md. Mazhar Pasha, M Srinivas, GN Chary, P Gandhi, G Narsimha, G Rajamani, D Kalamma, N Srinivas, M Kalamma, K Babu, J Sahadev, M Yellaiah	In-house Training programme for all the Technical and Skilled Supporting Staff	Jun. 20-28	ICAR-NBPGR RS, Hyderabad
Rajkumar P Barse, Arun D Gadlinge, Mukund B Nikose	Skill Upgradation in Good Office Practices-cum-General Awareness for Skilled Supporting Staff	Jun. 27-Jul. 02	ICAR-NBPGR, RS, Akola

19.3.1 Deputation/ Visits Abroad

- Dr Sunil Archak participated in the "Informal consultation on possible steps forward in enhancing the functioning of the multilateral system" organized at the United Nations, Geneva, Switzerland during 14-15 July 2022.
- Dr Sunil Archak participated in in the meeting held for "Developing Standardized Methods for Sharing Digital Sequence Information" organized at Rockefeller Foundation, Bellagio, Italy during 3-5 May 2022.
- Dr KuldeepTripathi attended Fourth Jack R Harlan International Symposium at Brisbane, Australia and presented a paper on "The INGB Lentil Core: a resource for accelerating lentil improvement" on November 2, 2022.
- Dr Sunil Archak participated (virtual mode) in the Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 15) organized at Montreal, Canada during 7-19 December 2022.

19.3.2 Participation in Seminars/ Conferences/ Symposia/Workshops/meetings

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
N Sivaraj	Promotion of the Farmer Producer Organizations (FPOs) in Floriculture Sector: Opportunities and challenges	Virtual	Jan. 07, 2022
Gurinderjit Randhawa (Co-convener), V. Celia Chalam, Monika Singh	Stakeholders Consultation on Draft regulation for Genetically Modified (GM) food and feed imports and detection of unauthorized GM food events (Organized by NAAS)	Virtual	Jan. 10, 2022
V Celia Chalam	ICAR NBAIR- Webinar on Application of genome editing in insect pest management	ICAR - NBAIR, Bengaluru	Jan. 20, 2022
V Celia Chalam, Kavita Gupta	Virtual peer group meeting on biological diversity (Amendment Bill) 2021	ISPGR, New Delhi	Jan. 22, 2022
V Celia Chalam, Kavita Gupta	National network of plant health experts second Biannual sub committee meeting	NIPHM, Hyderabad, Telangana	Jan. 25, 2022
S R Pandravada	Webinar on Indian Agriculture: Transformation from subsistence to commercial farming	ICAR-CTRI, Rajahmundry (Virtual)	Jan. 27, 2022
N Sivaraj	Inaugural function of Telangana International Seed Testing Authority (TISTA)	TISTA, Hyderabad	Feb. 2, 2022
S R Pandravada	Webinar on Appemidi: An endangered treasure of Western Ghats of Karnataka	ICAR-DCR, Puttur (Virtual)	Feb. 04, 2022
AnithaKodaru	Launching ceremony of Golden Jubilee celebrations of ICRSAT, marking 50 years of scientific innovation and impact since its establishment	ICRISAT, Patancheru	Feb. 05, 2022
V Celia Chalam	National Webinar on phytosanitary regulations, diagnostics and capacity development for biosecurity against transboundary plant pests	Lovely Professional University, Jalandhar, Punjab	Feb. 12, 2022
Jameel Akhtar	National symposium on 'Recent trends in Phyto-pathology to address emerging challenges for achieving food security' organized by Indian Phytopathological Society (Mid-East Zone) at ICAR-VPKAS, Almora	Online	Feb. 20-21, 2022
Anitha Kodaru	42nd Research Advisory Committee meeting	CSGRC, Hosur (Virtual)	Feb. 24, 2022
N Sivaraj, Anitha Kodaru	Chickpea germplasm Field day	ICRISAT, Patancheru	Feb. 28, 2022
Vijay Singh Meena	57 Annual Group Meeting of ICAR-All India Coordinated Research Project on Pearl Millet	Virtual	Mar. 02-03, 2022
K Anitha, N Sivaraj, L Saravanan, B Parameswari, P Pranusha, B Bhaskar	Sorghum germplasm field day	ICAR-IIMR, Hyderabad	Mar. 03, 2022
Vijay Singh Meena, Neelam Shekhawat, Kartar Singh	International Conference on "Advances in smart agriculture and biodiversity conservation for sustainable development (SABCD-2022)	Jaipur National University, Jaipur, Rajasthan	Mar. 04-06, 2022
V Celia Chalam	Biosafety and biosecurity training workshop	BCIL & ICAR-IARI, New Delhi	Mar. 15, 2022

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
S Nivedhitha	Grass root level Awareness Programme on Agri-Biodiversity conservation cum Farmer Benefit delivery	Horticultural Research Station, SKLTSHU, Konda Mallepally	Mar. 16, 2022
Jameel Akhtar	8th International conference on 'Plant Pathology: Retrospect and prospects' organized by the Indian Phytopathological Society, New Delhi at SKN Agricultural University, Jobner	Online	Mar. 16-18, 2022
S R Pandravada	National conference on 'IP issues in the post Covid World'	DPIIT, Hyderabad (Virtual)	Mar. 19-20, 2022
V Celia Chalam Kartar Singh	8th International conference of Plant Pathology: Retrospect and prospects	SKN Agriculture University, Jobner-Jaipur, Rajasthan	Mar. 23-26, 2022
L Saravanan, P Pranusha, S Nivedhitha, Bhaskar Bajaru	Maize germplasm field day	ICAR-IIMR, Winter Nursery Centre, Hyderabad	Mar. 28, 2022
N Sivaraj	Webinar- Lecture on Atmanirbhar Bharat – Harnessing potential of pulses for import substitution organized by ICAR-CRIDA, Hyderabad	Virtual	Apr. 01, 2022
Sheikh M Sultan, SK Raina	27th meeting of ICAR-Regional Committee-1 meeting	ICAR-CPRI, Shimla (Virtual)	Apr.22, 2022
Archana Raina	Participated and delivered lecture on Aromatic profile of rhizomatous plants of *Zingiberaceae* family used for food and health benefits	JSS, Mysuru	Apr. 22-24, 2022
Anitha Kodaru	Board meeting of AP state biodiversity	APSBB, Vijayawada	Apr. 28, 2022
M Latha, PP Thirumalaisamy, A Suma	Mango Festival	Kannapuram Mango Heritage Village	May 02, 2022
Pratibha Brahmi, Vandana Tyagi	Regional Webinar on the 'International Treaty Implementation'	ITPGRFA Secretariat (online)	May 05, 2022
B Parameswari, S Niveditha	One day workshop on 'Genome Editing for Crop Improvement: Potential and Policy'	PJTSAU, Hyderabad	May 06, 2022
Safna K	'Integrated Pest Management (IPM) for Sustainable Agriculture'	ICAR-NCIPM, New Delhi & MANAGE, Hyderabad	May 09-13, 2022
A Suma	"*Vazhuthana Vaividhya Udyanam*" (Brinjal Diversity Garden) programme	Koodalma-nikyam Devaswom Board Authorities, Irinjalakkuda, Thrissur	May 11, 2022

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
Susheel Kumar Raina	National Symposium on Self-Reliant Coastal Agriculture	Association for Coastal Agricultural Research (ACAR) and ICAR-CCARI, Goa (Virtual)	May 11-13, 2022
V Celia Chalam, Kavita Gupta, Z Khan, Jameel Akhtar, BH Gawade, Pardeep Kumar, Bharat Raj Meena	National e-Conference 'Biotic stress management strategies for achieving sustainable crop production and climate resilience'	ICAR-NCIPM, Online	May 19-21, 2022
Archana Raina	Webinar on 'Building a shared future for all life through utilizing biodiversity sustainably and conserving the threatened elements'	CSIR-NBRI, Lucknow (Virtual)	May 21, 2022
Archana Raina	Attended lecture on Global Genebanks and Biodiversity Management for Sustainable Agriculture	NAAS, New Delhi (Virtual)	May 22, 2022
Jyoti Kumari	Guest speaker on International day for biological diversity	YBN University, Ranchi (Virtual)	May 22, 2022
Vandana Tyagi	Webinar on 'Collection subsets and trait data Genesys'	Crop Trust (online)	May 24, 2022
M Latha, Safna K.	65th half yearly TOLIC meeting	Hotel Garuda, Thrissur	May 31, 2022
A Suma, K Pradheep	'Under-utilized Horticultural Genetic Resources: Conservation and Utilization (NCUHGR-2022)'	Andaman Science Association, Port Blair, Andaman & Nicobar Islands	June 03-04, 2022
S R Pandravada, P Pranusha, S Nivedhitha	National Conference on 'Underutilized Horticultural Genetic Resources: Conservation and Utilization (NCUHGR-2022)'	ICAR-CIARI, Port Blair (Virtual)	June 03-04, 2022
Anitha Kodaru, L Saravanan, B Parameswari, Prasanna Holajjer, B Bhaskar	Seminar on Global issues in 'plant bio security'	ICRISAT, Hyderabad	June 10, 2022
Archana Raina	Lecture on 'Accelaarated breeding by *de novo* domestication of crop plants'	(Virtual)	June 13, 2022
Archana Raina	Attended webinar on 'Biodiversity Governance: Global and national perspectives'	(Virtual)	June 15, 2022
V. Celia Chalam	Virtual Webinar on 'Key considerations for risk assessments of gene drive technologies'	ISAAA Inc.	June 16, 2022
DP Wankhede	North Zonal Seminar-2022 on Inter-Disciplinary Research Strategies for Climate Resilient Agriculture	ICAR-SBI, Regional Centre, Karnal	June 25, 2022
Sunil Gomashe, Smita Karale	Town Official Language Implementation Committee (TOLIC), Akola half yearly meeting	NARAKAS, Akola	June 28, 2022

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
Archana Raina	Attended and presented oral lecture on Bio-molecular Variability of Different Ocimum species in India	Jadavpur University, Kolkata (Virtual)	June 28-30, 2022
V Celia Chalam	Clean Plant Nursery Certification Workshop	New Delhi	July 6, 2022
M Latha, K Pradheep	Stakeholder's meet for Jack fruit, Kokum	ICAR-CCARS, Goa (on-line)	July 7, 2022
Jyoti Kumari	Mendel symposium on 'Tending Mendel's Garden for a perpetual and bountiful harvest'	IARI, New Delhi (Virtual)	July 19-21, 2022
Jyoti Kumari	NICRA review meeting	NASC, New Delhi (Virtual)	23 July, 2022
Archana Raina	Attended and presented oral paper on Chemical Characterization of Important Aromatic Plants from Uttarakhand	Patanjali Research Institute, Haridwar	Aug. 01-04, 2022
Archana Raina	Conference chair on 'Agriculture Revolution in India'	Patanjali Research Institute, Haridwar	Aug. 01-04, 2022
B Parameswari	External member of Institute Biosafety Committee (IBSC) of ICAR-IIRR, Hyderabad attended 20th IBSC meeting	ICAR-IIRR, Hyderabad	Aug. 5, 2022
Archana Raina	Attended webinar on 'Science for the Society: Agricultural Imperatives'	Virtual	Aug. 12, 2022
P P Thirumalaisamy	International Conference on 'Advances in Agriculture and Food System Towards Sustainable Development Goals'	Bengaluru	Aug. 22-24, 2022
Pratibha Brahmi, Vandana Tyagi	Asia Region Consultation for 9th GB of ITPGRFA	ICAR-NBPGR & ITPGRFA Secretariat (online)	Aug. 25-26, 2022
Pratibha Brahmi, Vandana Tyagi , RK Gautam, Jyoti Kumari, Kuldeep Tripathi	National Symposium on 'Food, Nutrition and Environmental Security: Towards Achieving SDGs'	New Delhi	Aug. 29-30, 2022
BH Gawade	Meeting for 'Revitalising Plant Nematology Research and Education in the country'	Nematological Society of India, New Delhi (Online)	Aug. 30, 2022
N Sivaraj, L Saravanan	Capacity building and training programme: Sharing of outcomes of the Scientific projects with BMC members, NGOs & Stakeholders of Andhra Pradesh	APSBB, Pandirimamidi	Sept. 02, 2022
Yasin JK	Participated in an International workshop 'When predictions meet experiments: the future of structure determination' held at Palermo, Italy	Virtual	Sept. 05-08, 2022
Archana Raina	Attended lecture on 'The International Governance of Plant Genetic Resources for Food and Agriculture: The Role and Place of the International Plant Treaty'	NASC Complex, Pusa Campus, New Delhi (Virtual)	Sept. 15, 2022

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
Sunil Archak, Pratibha Brahmi, Vandana Tyagi, RK Gautam, Kuldeep Tripathi, Vartika Srivasatava, Pragya, Sherry R Jacob	9th Session of Governing Body of the ITPGRFA	New Delhi	Sept. 19-24, 2022
V. Celia Chalam	NAHEP – IDP Work shop on "Capacity Building of Teachers in the Advancement of Science and Technology"	Acharya NG Ranga Agricultural University, Tirupati, A.P.	Sept. 24, 2022
N. Sivaraj	National Seminar on "Harnessing the potential of Panchabhutas (tatvas) for sustainable climate resilient rainfed agriculture"	ICAR-CRIDA, Hyderabad	Sept. 28, 2022
Susheel Kumar Raina	National conference on 'Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022)'	Gandhi Bhawan, University of Kashmir, India	Sept. 28-30, 2022
A Suma	Brinjal Diversity Garden Harvest Festival organized by the Dept. of Agriculture, Govt. of Kerala	Irinjalakuda, Thrissur	Oct. 04, 2022
Monika Singh	5-days Assessor's Training Course on ISO/IEC17025: 2017 organized by the National Accreditation Board for Testing and Calibration Laboratories (NABL)	Institute for Studies in Industrial Development (ISID), New Delhi	Oct. 8-12, 2022
B Parameswari	Workshop on Global Food and Nutritional Security, and Sustainable Development through Major and Minor Pulses	NAAS, New Delhi (Virtual)	Oct. 14, 2022
M Latha	Research Advisory Committee meeting of Institute of Forest Genetics and Tree Breeding	Coimbatore	Oct. 14, 2022
Sunil Gomashe	ICRISAT Genebank Field Day -Sesame	ICRISAT, Patancheru, Hyderabad	Oct. 28, 2022
Kuldeep Tripathi	Fourth Jack R. Harlan International Symposium in TropAg conference	Brisbane, Australia	Oct. 31-Nov. 02, 2022
S R Pandrawada	Global conference on 'Sustainable plant production (GPC) - Innovation, efficiency and resilience'	FAO of UN, Rome, Italy (Virtual)	Nov. 02-04, 2022
Sunil Gomashe	Training workshop on 'Analysis of Multi-Environment Trials'	Online mode by ICAR-NAARM, Hyderabad	Nov. 03-08, 2022
A Suma, M Latha	Inclusive Agricultural Development Programme "*Pachakkuda*"	Irinjalakuda constituency of Thrissur	Nov. 04, 2022
V. Celia Chalam	National Symposium on 'Multidisciplinary Approached for Plant Health Management.	GBPUA&T Pantnagar, Uttarakhand	Nov. 4-5, 2022

Name	Title of Seminars/ Conferences/ Symposia/ Workshops/meetings	Venue	Period
V. Celia Chalam	Webinar on 'Revitalizing ICAR: Aspirations and Action Plan'	ICAR, New Delhi	Nov. 11, 2022
B Parameswari	International Workshop on 'Complementing Current Techniques with Next Generation Technologies for Crop Health Improvement'	AMU, Aligarh Virtual	Nov. 14-19, 2022
M Latha	TOLIC meeting	Virtual	Nov. 17, 2022
Anitha Kodaru, S. Nivedhitha	Inception workshop on " State Biodiversity Strategy and action plan (SBSAP) 2022-2032	Begumpet, Hyderabad	Nov. 22, 2022
Veena Gupta, Sherry R Jakob, Padmavati Gore, Sushil Pandey, Chithra Devi Pandey, Anjali Kak Koul, Harish GD, Badal Singh, Vikender Kaur, RK Gautam, Jyoti Kumari, Kuldeep Tripathi, SK Kaushik, Pratibha Brahmi, Vandana Tyagi, SK Yadav,Pragya, Surender Singh, Manjusha Verma, Rakesh Singh, Rajkumar, Amit Singh, Monika Singh, S, Lait Arya, Mukesh Rana, Yasin Jeshima K, DP Wankhede, Sanjeev Kumar Singh, Kushaldeep Kaur, Vijay Singh Meena, Kartar Singh, KM Rai	1st National Conference on 'Plant Genetic Resource Management (NCPGRM 2022)'	National Agricultural Science Center (NASC), Pusa Campus, New Delhi	Nov. 22-24, 2022
V Celia Chalam, Kavita Gupta, Mool Chand Singh, Jameel Akhtar, BH Gawade, Pardeep Kumar	1st National Conference on Plant Genetic Resources Management organized by ICAR-NBPGR and ISPGR, New Delhi	NASC Complex, New Delhi	Nov. 22-24, 2022
Susheel Kumar Raina	International Conference on Natural Science and Green Technologies for Sustainable Development (NTSD-2022) organized by National Environmental Science Academy, New Delhi and Goa University, Goa, India	(Virtual)	Nov. 30 - Dec. 02, 2022
Sunil Gomashe	13th Institutional Bio-safety Committee (IBSC) Meeting	Centre of Excellence in Plant Biotechnology, Dr. PDKV, Akola	Dec. 06, 2022
V Celia Chalam	Workshop on "Export and Import of Tissue Culture Plants and Planting Material"	NIPHM Hyderabad, Telangana	Dec. 14, 2022

20 GENERAL INFORMATION

20.1 Institute management committee (IMC)

The Director, ICAR-NBPGR, Pusa Campus, New Delhi	Chairman
The Director (Agri.) Delhi Government 5/9 under Hill Road, Delhi	Member
The Director (Agri.) Govt. of Punjab, Near Dara Studio, Plot No. 204 , Phase 6, Sector 56, Kheti Bhawan, Third Floor, S.A.S. Nagar (Mohali), Punjab	Member
Head, Plant Breeding, Punjab Agricultural University, Ferozepur Rd, Ludhiana, Punjab	Member
Shri Mukesh MannVillage Alipore, Narela, Delhi	Member
Shri Sanjay Maruti Patil, BAIF Office, Amrai Campus, Jauhar, District-Palghar, Maharashtra	Member
Dr. Poonam Jasrotia, Principal Scientist & PI (Co-odination), ICAR-IIWBR, Gahoon Vihar, Karnal, Haryana	Member
Dr. (Mrs.) Neelu Jain, Principal Scientist, Division of Genetics, ICAR-IARI, New Delhi	Member
Dr. Nagendra Rai, Principal Scientist, ICAR-IIVR, Post Bag No. 01, P.O. Jakhini (Shahanshapur) Varanasi, Uttar Pradesh	Member
Dr. Vijay Veer Singh, Principal Scientist, ICAR-DRMR, Bharatpur, Jyoti Nagar, Jail Area, Sewar Bharatpur, Rajasthan	Member
ADG (Seeds), ICAR, Krishi Bhawan, New Delhi	Member
Comptroller, ICAR-IARI, Pusa Campus, New Delhi	Member
Chief. Admn. Officer (SG) ICAR-NBPGR, New Delhi	Member Secretary

20.2 Research advisory committee (RAC)

24th meeting of RAC of ICAR-NBPGR, New Delhi was held through hybrid mode on 13th September, 2022 under the chairmanship of Dr PL Gautam. Other members of the RAC; Dr. M.R. Dinesh, Dr. Paramjit Singh, Dr. Ramesh Venkata Sonti, Dr

Name and Address	
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 EvaluationICAR-NBPGR, New Delhi	Member Secretary

SK Barik, Dr JS Chauhan, Sh. Sanjay Maruti Patil and Dr Ashok Kumar, Director cum Member Secretary participated in the meeting. Brief presentations on salient achievements were made by the Heads of divisions/Unit Incharges/ Officer Incharges of different Regional Stations. The members of RAC provided general and division specific recommendations

20.3 Institute research council (IRC)

The 33rd Institute Research Council (IRC) meeting was held under the Chairmanship of Dr GP Singh, Director, ICAR- NBPGR with Dr. Sushil Pandey as Member secretary on 7, 12 and 19 December, 2022. The Principal Investigators / OICs / scientists of the respective regional stations presented the progress report of the institute projects operational at headquarters and various regional stations / base centres. HoDs and OICs of units / RS / BC made the presentations followed by the PIs of the respective projects.

20.4 Institute Joint Staff Council (IJSC)

Elected members of IJSC for different categories: Technical Staff: Sh Satya Prakash (Secretary, Staff Side) and Sh Braham Prakash (TO); Administrative staff: Mr Yogesh Kumar (Assistant); Skilled Supporting Staff: ShYatish Chandra and Sh Braham Dev Paswan. Office side members were: Dr Rakesh Bhardwaj, Dr SP Ahlawat, Dr Anuradha Aggarwal, Dr Amit Kumar Singh and Sr AO.

20.5 Prioritization monitoring and evaluation (PME) cell

PME cell coordinated all scientific activities such as project proposals (20), manuscripts (83)/ abstracts (180); training/ fellowship proposals (28) etc. as per the ICAR guidelines. It also coordinated professional attachment training for ARS scientists, conducts 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 six MoUs with various universities for collaborative research, teaching and training.

PME Cell

Dr Kavita Gupta OIC
Dr S Rajkumar Co-nodal officer
Dr MK Rana, Member
Dr Sandeep Kumar, Member
Dr Jyoti Kumari, Member
Dr Padmavati G Gore, Member
Mr Rajeev Gambhir, Member
Dr KS Hooda HRD Nodal Officer
Dr Sushil Pandey IRC Member Secretary
Dr Rakesh Bhardwaj Nodal officer Krishi Portal
Ms. Shivangi Mathur, Technical Assistant

FMS-MIS at ICAR-NBPGR

Five management modules viz., financial, project (project and scheme code generation for RPP-I, submission of RPP II and RPP III), procurement & stores (indent raising), human resource (training information, applying leaves) and payroll (information related to transfer and joining of employees) were supported through FMS-MIS.

HRD Activities

Annual Training Plan (ATP) of all the staff members of the Bureau for the year 2022 was prepared based on the training needs assessment and submitted to the Council. During the reporting period, 21 scientists, 8 technical, one admin and 19 SS 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).

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.

20.6 Personnel

The list of staff at NBPGRis provided herewith. It is not a documentary proof of seniority.

(i) Scientific Staff in position as on 31st December 2022

S. No.	Name	Designation	Discipline
1	Dr Ashok Kumar (Act.) Dr GyanendraPratap Singh (since 28th Oct, 2022)	Director	Genetics & Plant Breeding
DIVISION OF PLANT EXPLORATION & GERMPLASM COLLECTION			
1.	Dr Sudhir Pal Ahlawat	Head	Plant Breeding
2.	Dr Anjula Pandey	Principal Scientist	Economic Botany
3.	Dr KC Bhatt	Principal Scientist	Economic Botany
4.	Dr Dinesh Prasad Semwal	Principal Scientist	Economic Botany
5.	Dr Ranbir Singh Rathi	Principal Scientist	Economic Botany
6.	Sh Soyimchiten	Scientist	Horticulture (Fruit science)
7.	Ms Nivedhitha	Scientist	Economic Botany & PGR
8.	Dr Pavan Kumar Malav	Scientist	Economic Botany & PGR
9.	Sh Ravi KishorPamarthi	Scientist	Economic Botany & PGR
10.	Dr Puran Chand	Scientist	Agroforestry
11.	Dr Pankaj Kumar Kannaujia	Scientist	Vegetable Science
AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT			
12.	Dr Sunil Archak	National Fellow & Incharge, Principal Scientist	Biotechnology
13.	Madhu Bala Priyadrashi	Senior Scientist (SS)	Computer Application
UU & UEP			
14.	Dr Hanuman Lal Raigar	Principal Scientist	Agril. Statistics
GERMPLASM EXCHANGE AND POLICY UNIT			
15.	Dr Pratibha Brahmi	Principal Scientist & Incharge	Economic Botany
16.	Dr Vandana Tyagi	Principal Scientist	Economic Botany
17.	Dr SK Yadav	Principal Scientist	Horticulture
18.	Dr Pragya	Principal Scientist	Horticulture
DIVISION OF GERMPLASM EVALUATION			
19.	Dr RK Gautam	Principal Scientist & Head (Act.)	Plant Breeding
20.	Dr. KK Gangopadhyay	Principal Scientist	Horticulture
21.	Dr Archana P. Raina	Principal Scientist	Biochemistry (Plant Science)
22.	Dr Rakesh Bhardwaj	Principal Scientist	Biochemistry
23.	Dr Sandeep Kumar	Principal Scientist	Biochemistry
24.	Dr Jyoti Kumari	Principal Scientist	Plant Breeding
25.	Dr KP Mohapatra	Principal Scientist	Agroforestry
26.	Dr Rashmi Yadav	Principal Scientist	Agronomy
27.	Dr Ishwar Singh	Principal Scientist	Agronomy
28.	Dr Vinod Kumar Sharma	Principal Scientist	Plant Breeding
29.	Dr KS Hooda	Principal Scientist	Plant Pathology
30.	Dr Vikender Kaur	Senior Scientist	Economic Botany

S. No.	Name	Designation	Discipline
31.	Dr Gayacharan	Scientist	Agril. Biotechnology
32.	Dr Ruchi Bansal	Scientist	Plant Physiology
33.	Dr Kuldeep Tripathi	Scientist	Economic Botany & PGR
34.	Dr Mamta Singh	Scientist	Genetics &Plant Breeding
35.	Mr Nand Lal Meena	Scientist	Biochemistry
36.	Dr Sapna	Scientist	Biochemistry
DIVISION OF GERMPLASM CONSERVATION			
37.	Dr Veena Gupta	Principal Scientist & Head (Act.)	Economic Botany
38.	Dr Neeta Singh	Principal Scientist	Plant Physiology
39.	Dr Anjali KakKoul	Principal Scientist	Economic Botany
40.	Dr Chitra Devi Pandey	Principal Scientist	Seed Science &Technology
41.	Dr Sushil Pandey	Principal Scientist	Seed Science &Technology
42.	Dr Sherry Rachel Jacob	Senior Scientist	Seed Science &Technology
43.	Dr J Aravind	Scientist	Plant Genetics
44.	Dr Padmavati G Gore	Scientist	Economic Botany & PGR
45.	Dr Harish GD	Scientist	Genetics &Plant Breeding
46.	Dr Badal Singh	Scientist	Economic Botany & PGR
DIVISION OF PLANT QUARANTINE			
47.	Dr V Celia Chalam	Principal Scientist	Plant Pathology
48.	Dr Kavita Gupta	Principal Scientist	Agril. Entomology
49.	Dr Moolchand Singh	Principal Scientist	Agronomy
50.	Dr Zakaullah Khan	Principal Scientist	Nematology
51.	Dr Jameel Akhtar	Principal Scientist	Plant Pathology
52.	Dr Bharat H. Gawade	Senior Scientist	Plant Nematology
53.	Dr Pradeep Kumar	Scientist	Agril. Biotechnology
54.	Mrs Raj Kiran	Scientist	Plant Pathology
55.	Dr Pooja Kumari	Scientist	Plant Pathology
56.	Sh Bharat Raj Meena	Scientist	Plant Pathology
TISSUE CULTURE AND CRYOPRESERVATION UNIT			
57.	Dr Anuradha Agrawal	Principal Scientist & OIC	Economic Botany
58.	Dr SK Malik	Principal Scientist	Economic Botany
59.	Dr Sangita Bansal	Principal Scientist	Agriculture Biotechnology
60.	Dr Sandhya Gupta	Principal Scientist	Economic Botany
61.	Dr Vartika Srivastava	Scientist	Fruit Science
62.	Dr Gowthami R	Scientist	Genetics &Plant Breeding
63.	Dr Era Vaidya Malhotra	Scientist	Agriculture Biotechnology
64.	Dr Subhash Chander	Scientist	Economic Botany & PGR
DIVISION OF GENOMIC RESOURCES			
65.	Dr Gurinderjit Randhawa	Principal Scientist & Head (Act.)	Plant Physiology
66.	Dr MC Yadav	Principal Scientist	Genetics/Cytogenetics
67.	Dr Mukesh Kumar Rana	Principal Scientist	Plant Breeding
68.	Dr Rakesh Singh	Principal Scientist	Biotechnology
69.	Dr AmbikaBaldev Gaikwad	Principal Scientist	Biotechnology
70.	Dr Lalit Arya	Principal Scientist	Plant Biochemistry
71.	Dr Manjusha Verma	Principal Scientist	Plant Biochemistry
72.	Dr Sundeep Kumar	Principal Scientist	Biotechnology
73.	Dr Rajesh Kumar	Principal Scientist	Plant Biotechnology
74.	Dr Amit Kumar Singh	Senior Scientist	Biotechnology
75.	Dr R Parimalan	Senior Scientist	Biotechnology
76.	Dr S Rajkumar	Senior Scientist	Genetics/Cytogenetics

S. No.	Name	Designation	Discipline
77.	Dr Yashin Jeshima K	Senior Scientist	Genetics
78.	Sheel Yadav	Scientist	Biotechnology- Plant Science
79.	Dr Monika Singh	Senior Scientist	Agril. Biotechnology
80.	Dr DP Wankhede	Senior Scientist	Plant Genetics
NBPGR, REGIONAL STATION, HYDERABAD			
81.	Dr Anitha Kodaru	Principal Scientist &Incharge	Plant Pathology
82.	Dr SR Pandrawada	Principal Scientist	Economic Botany
83.	Dr Natarajan Sivaraj	Principal Scientist	Economic Botany
84.	Dr ParameswariBalasubramanium	Senior Scientist	Plant Pathology
85.	Dr L. Saravanan	Senior Scientist	Agricultural Entomology
86.	Dr P Pranusha	Scientist	Plant Genetics
87.	Dr PrasannaHolajjer	Senior Scientist	Nematology
88.	Dr BhaskarBajaru	Scientist	Plant Pathology
NBPGR, REGIONAL STATION, AKOLA			
89.	Dr Dinesh Chand	Principal Scientist	Economic Botany & PGR
90.	Dr Sunil Sriram Gomashe	Senior Scientist	Genetics &Plant Breeding
NBPGR, REGIONAL STATION, BHOWALI			
91.	Dr Mamta Arya	Scientist & OIC	Plant Genetics
92.	Dr Krishna Madhav Rai	Scientist	Fruit Science
NBPGR, REGIONAL STATION, CUTTACK			
93.	Dr Diptiranjan Pani	Principal Scientist	Economic Botany
94.	Dr RC Mishra	Principal Scientist	Economic Botany
NBPGR, REGIONAL STATION, SHIMLA			
95.	Dr Mohar Singh	Principal Scientist	Plant Breeding
96.	Mr Rahul Chandora	Scientist	Economic Botany & PGR
97.	Dr Narendra Negi	Scientist	Fruit Sciences
NBPGR, REGIONAL STATION, THRISSUR			
98.	Dr Joseph John K	Principal Scientist	Economic Botany
99.	Dr M Latha	Principal Scientist	Plant Breeding
100.	Dr K Pradheep	Principal Scientist	Economic Botany
101.	Dr Thrimalaisamy PP	Senior Scientist	Plant Pathology
102.	Dr Suma A	Scientist	Economic Botany
NBPGR, REGIONAL STATION, SRINAGAR			
103.	Dr Sheikh Mohd Sultan	Principal Scientist	Economic Botany
104.	Dr Susheel Kumar Raina	Senior Scientist	Genetics &Plant Breeding
NBPGR, REGIONAL STATION, JODHPUR			
105.	Dr Kartar Singh	Scientist	Plant Pathology
106.	Dr Neelam Shekhawat	Scientist	Genetics &Plant Breeding
NBPGR, REGIONAL STATION, RANCHI			
107.	Dr Shashi Bhushan Choudhury	Senior Scientist	Genetics &Plant Breeding
108.	Dr Shephalika Amrapali	Scientist	Economic Botany & PGR
NBPGR, REGIONAL STATION, SHILLONG			
109.	Dr Julius Uchoi	Scientist	Horticulture-Fruit Science
110.	Dr Subarana Hajong	Scientist	Economic Botany & PGR
	On deputation		
111.	Dr JC Rana	Principal Scientist	Genetics &Plant Breeding

(ii) Technical staff in position as on 31st December 2022

S.No.	Name	Designation
Division of Plant Exploration & Germplasm Collection		
1	Dr NS Panwar	Chief Technical Officer
2	Smt Rita Gupta	Senior Technical Officer
3	Sh Omprakash Dhariwal	Technical Officer
4	ShAnkurTomar	Technical Assistant
Germplasm Exchange and Policy Unit		
5	Sh SP Singh	Chief Technical Officer
6	Sh Surender Singh	Chief Technical Officer
7	Sh PC Binda	Technical Officer
8	Sh SK Ojha	Senior Technician
Division of Plant Quarantine		
9	Sh AK Maurya	Chief Technical Officer
10	Sh DS Meena	Chief Technical Officer
11	Sh Naresh Kumar	Technical Assistant
12	Dr Sadhna	Technical Assistant
Division of Germplasm Evaluation		
13	Sh BL Meena	Chief Technical Officer
14	Sh Babu Ram	Assistant Chief Technical Officer
15	Dr BS Panwar	Assistant Chief Technical Officer
16	Sh YS Rathi	Assistant Chief Technical Officer
17	Sh OS Ahlawat	Senior Technical Officer
18	Sh RK Sharma	Senior Technical Officer
20	Sh SS Bhoj	Technical Officer
21	Sh Sunil Kumar	Senior Technical Assistant
Division of Genomic Resources		
22	Dr Sanjeev Kumar Singh	Assistant Chief Technical Officer
23	Sh D Gautam	Assistant Chief Technical Officer
24	Sh Rohtash Singh	Technical Assistant
25	Kushaldeep Kaur Sodhi	Technical Assistant
26	Akansha Bajpai	Technical Assistant
27	Sh Manish Tomar	Technical Assistant
Division of Germplasm Conservation		
28	Dr AD Sharma	Chief Technical Officer
29	ShRajvir Singh	Assistant Chief Technical Officer
30	Smt Smita Lenka Jain	Assistant Chief Technical Officer
31	Sh Satya Prakash Sharma	Technical Officer
32	Smt Nirmala Dabral	Technical Officer
33	Anjali	Senior Technical Assistant
34	Sh Lal Singh	Technical Assistant
35	Mrs Neha Sharma	Technical Assistant
Tissue Culture and Cryopreservation Unit		
36	ShAnangpal Singh	Assistant Chief Technical Officer
37	Sh Dharam Pal Singh Meena	Senior Technical Officer
38	Sh Ramesh Chandra	Technical Officer
39	Sh Suresh Chandra Mali	Technical Assistant
Agricultural Knowledge Management Unit		
40	Sh Rajiv Gambhir	Chief Technical Officer
41	Sh VK Mandal	Technical Assistant
42	Shivangi Mathur	Technical Assistant
Library		
43	Smt Sangita Tanwar	Assistant Chief Technical Officer
44	Sh Om Prakash	Technical Officer
Director Technical Cell		
45	Sh AK Sharma	Senior Technical Assistant
Vehicle Cell		
46	ShBrahm Prakash	Technical Officer (Driver)
47	Sh Wazir Singh	Senior Technical Assistant (Driver)
48	Sh Balwant Singh	Technical Officer (Driver)
49	Sh Ranjit Singh	Senior Technical Assistant (Driver)
50	Sh Ram Balak Rai	Technical Assistant (Driver)
51	Sh Khuswinder Kumar	Senior Technician (Driver)
Regional Station, Akola		
52	Sh Rakesh Lather	Technical Assistant
Regional Station, Bhowali		
53	Sh Gopal Singh	Technical Assistant (Driver)
54	Sh Anuj Kumar Sharma	Technician
Regional Station, Hyderabad		
55	Sh MV Reddy	Technical Assistant (Driver)
Regional Station, Jodhpur		
56	ShBhatta Ram	Technical Officer
57	Sh Dharam Raj Meena	Technical Assistant
58	Mrs Chanchal Gaina	Technical Assistant
59	Sh Gordhan Gena	Technical Assistant
Base Centre, Ranchi		
60	Sh Ashwini Kumar	Technical Assistant
61	Sh Narendra Ram	Technical Officer (Driver)
Regional Station, Shimla		
62	Sh Dayal Singh	Senior Technical Assistant
63	Sh Ram Chander	Senior Technical Assistant
Regional Station, Thrissur		
64	Sh S Mani	Assistant Chief Technical Officer
65	Sh R Ashokan Nair	Assistant Chief Technical Officer
66	Smt A Indra Devi	Assistant Chief Technical Officer

(iii) Administrative Staff in Position as on 31st December 2022

S.No.	Name	Designation
1.	Shri PK Jain	Chief Admn. Officer (Sr. Grade)
2.	Sh Prasenjit	Administrative Officer
3.	Sh Sushil Kumar	Administrative Officer
4.	Smt Sangeeta Gambhir	Assistant Administrative Officer
5.	Sh Yogesh Kumar Gupta	Assistant
6.	Sh KC Kundu	Assistant
7.	Sh Sandeep Gaur	Assistant (on Lien)
8.	Ms SanjooVerma	Assistant Administrative Officer
9.	Sh Dev Kumar	UDC
10.	ShUmesh Kumar	LDC
Accounts Section		
11	Sh Prashant Sharma	Comptroller
12	Sh Pawan Kumar Gupta	Sr FAO
13	Smt Yashoda Rani	Assistant Administrative Officer
14	Sh Mahavir Singh Yadav	Assistant Administrative Officer
15	Smt Madhu Chawla	Assistant
Stores		
16	Smt Poonam Singh	Senior Administrative Officer
17	Sh Dinesh Sharma	Assistant
Purchase		
18	Sh Avdhesh Kumar	Assistant Administrative Officer
19	Sh Sanjay Dangwal	Assistant
Audit Section		
20	Sh Surender Kumar	Assistant Administrative Officer
21	Sh Prabal Das Gupta	Assistant
22	Sh Sunil Kumar	LDC
Pension & Records		
23	Smt Amrita Negi	Assistant Administrative Officer
Director's Cell		
24	Smt Kanchan Khurana	Personal Secretary
Prof. PGR & GCD		
25	Sh Ganga Nand	Personal Secretary
Division of Plant Exploration & Germplasm Collection		
26	Smt Urmila Singh	Personal Secretary
Division of Germplasm Evaluation		
27	Smt Neelam Khatri	Personal Secretary
28	Sh Kush Kumar Bhargava	LDC
Hindi Unit		
29	Sh Ashutosh Kumar Tiwari	Assistant Director (Official languages)
Security		
30	Sh UC Sati	Security Officer
Dispatch Section		
31	ShAnant Swaroop	LDC
Regional Station, Akola		
32	Sh Purushottam Dhoke	Assistant
33	Smt Smita D Karale	UDC
Regional Station, Bhowali		
34	Sh NS Patwal	Assistant Administrative Officer
35	Sh GC Arya	T-1
Base Centre, Cuttack		
36	Sh SK Lal	Assistant
Regional Station, Hyderabad		
37	Smt Radha Rani	Assistant
38	Sh M Srinivasa Rao	Assistant Administrative Officer
39	Sh P Suleiman	Assistant
40	Sh MB Keshhwa Raju	T-1
Regional Station, Jodhpur		
41	Smt Leela Sharma	Assistant
Regional Station, Shimla		
42	Smt Pratibha Bhatt	Assistant Administrative Officer
43	Sh Sukhdev	T-1
44	Sh Inder Singh	T-1
Regional Station, Shillong		
45	Smt Lakshmilian Kharnary	Assistant

(iv) Skilled Supporting Staff in Position as on 31st December 2022

S. No.	Name
	Director's Cell
1	Sh Surender Kumar
2	Sh Hari Chand Paswan
	Division of Plant Exploration & Germplasm Collection
3	Smt Manju Devi
4	Smt Sharda Devi
	Germplasm Exchange and Policy Unit
5	Sh Arun Kumar
	Division of Plant Quarantine
6	Sh Sat Narayan Thakur
	Division of Germplasm Evaluation
7	Sh Mahesh Ram
8	Sh Brahm Dev Paswan
9	Sh Ram Kalit Rai
10	Sh Yatish Chandra
11	Smt Rukmani
12	Sh Suresh Ram
13	Sh Om Prakash
	Division of Genomic Resources
14	Smt Agya Devi
15	Sh Ramesh Chand
	Tissue Culture and Cryopreservation Unit
16	Sh Chandeshwar Rai
17	Sh Nand Kishor
18	Smt Geeta Devi
	Agricultural KnowledgeManagement Unit
19	Sh Lalu Rai
	AICRN-PC
20	Sh MahadevMaurya
	Library
21	Sh Umesh Kumar
	Accounts Section
23	Sh Sanjeev Paswan

S. No.	Name
	Audit Section
24	Sh Yogesh Kumar
	Establishment
25	Sh Roshan Lal
	Experimental Farm, Issapur
26	Sh Dhir Singh
27	Sh Mahabir Singh
	Regional Station, Akola
28	Sh RC More
29	Sh RP Barsee
30	Sh AD Godlinga
31	Sh MB Nikose
	Regional Station, Bhowali
32	Sh Anand Kumar
33	Smt Tulsi Devi
	Base Centre, Cuttack
34	Sh Sarangdhar Barik
	Regional Station, Hyderabad
35	Mohd. Mazhar Pasha
36	Sh M Shankar
37	Sh E Satyanarayan
38	Sh M Srinivas
	Regional Station, Jodhpur
39	Sh DS Rajpurohit
	Base Centre, Ranchi
40	Sh Vijay Kumar
	Regional Station, Shimla
41	Sh Paras Ram
42	Sh Rohit
43	Sh Dalip Singh
	Regional Station, Shillong
44	Sh AK Deka
	Regional Station, Thrissur
45	Sh MK Prakaseen

20.7 Staff transferred /Superannuated/New Appointments/Promotions

20.7.1 Appointments/Joining

Dr. Venkatesan K., Senior Scientist, joined Regional Station Thrissur on Sept. 09, 2022.

Dr. Kirti Rani, Scientist, joined Regional Station Jodhpur on Oct. 3, 2022.

Sh. Lokesh Kumar, T-5 transferred joined DGE w.e.f. 16.11.2022

20.7.2 Retirements

Dr. Joseph John K., (Pr. Scientist & OIC) at Regional Station Thrissur superannuated on Mar. 31, 2022

Dr. J.C. Rana, (Principal Scientist) superannuated (VRS) on Apr. 15, 2022

Dr. G.J. Randhawa, (Principal Scientist) superannuated on Aug. 31,2022

Dr. Anjula Pandey, (Principal Scientist) superannuated on Oct. 31,2022

Sh. Y. S. Rathi, Chief Technical Officer (T-9) superannuated on Jan.31,2022
Sh. Abhay Sharma, Technical Officer (T-5) superannuated on Feb. 28,2022
Sh. Rohtas Singh, Senior Technical Assistant (T-4) superannuated on Mar. 31, 2022
Sh. Balwant Singh, Technical Officer (T-5) superannuated on Apr.31, 2022
Sh. Ranjeet Singh Mehra, Technical Officer (T-5) superannuated on Jun. 30, 2022

20.7.3 Promotions

Dr. Vijay Singh Meena, Scientist (SS), Regional Station Jodhpur promoted to Level 12 (RPG 8000) w.e.f. 22.04.2020
Dr. Narender Negi, Scientist, Regional Station Shimla promoted to Level 11 (RPG 7000) w.e.f. 01.01.2020
Dr. Krishna Madhav Rai, Scientist, Regional Station Bhowali promoted to Level 11 (RPG 7000) w.e.f. 01.01.2019
Dr. Mamta Singh, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.01.2020
Dr. Neelam Shekhawat, Scientist, Regional Station Jodhpur promoted to Level 11 (RPG 7000) w.e.f.05.07.2020
Ms. Gowthami R., Scientist promoted to Level 11 (RPG 7000) w.e.f. 05.07.2020
Dr. S.K. Bishnoi, Ex-Scientist, promoted to Level 11 (RPG 7000) w.e.f. 15.12.2017
Dr. Harish G.D., Scientist promoted to Level 11 (RPG 7000) w.e.f. 01.01.2018
Dr. Yasin Jeshima K., Scientist promoted to Level 12 (RPG 8000) w.e.f. 21.04.2020
Dr. DP Wankhede, Scientist, promoted to Level 12 (RPG 8000) w.e.f. 01.01.2022
Dr. Sunil ShriramGomashe, Scientist, Regional Station Akola promoted to Level 13A (RPG 9000) w.e.f. 23.06.2021
Dr. Shashi Bhushan Choudhary, Sr. Scientist, Regional Station Ranchi promoted to Level 13A (RPG 9000) w.e.f. 21.04.2021
Dr. S.K. Raina, Sr. Scientist, Regional Station Srinagar promoted to Level 12 (RPG 8000) w.e.f.20.04.2019
Dr. Kartar Singh, Scientist, Regional Station Jodhpur promoted to Level 11 (RPG 7000) w.e.f. 05.07.2020
Mrs. Raj Kiran, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.01.2021
Dr. P.P. Thirumalaisamy, Sr. Scientist, Regional Station Thrissur promoted to Level 13A (RPG 9000) w.e.f. 21.04.2021
Dr. Pooja Kumari, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 05.07.2021
Ms. S. Nivedhita, Scientist, Regional Station Hyderabad promoted to Level 11 (RPG 7000) w.e.f. 01.01.2021
Dr. Badal Singh, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.01.2021
Sh. Rahul Chandora, Scientist, Regional Station Shimla promoted to Level 11 (RPG 7000) w.e.f. 05.07.2021
Dr. Kuldeep Tripathi, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.07.2019
Dr.Pavan Kumar Malav, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.01.2021
Dr. Padmavati Ganpat Gore, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.01.2021
Dr. Ravi Kishore Pamarthi, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 01.07.2021
Dr. Suma A., Scientist, Regional Station Thrissur promoted to Level 11 (RPG 7000) w.e.f. 15.09.2018
Dr. Subarna Hajong, Scientist, Regional Station Shillong promoted to Level 11 (RPG 7000) w.e.f. 01.01.2020
Dr. Vikender Kaur, Scientist (SS), promoted to Level 12 (RPG 8000) w.e.f. 01.01.2022
Dr. Amit Kumar Singh, Sr. Scientist, promoted to Level 13A (RPG 9000) w.e.f. 26.06.2020
Dr. R. Parimalan, Sr. Scientist, promoted to Level 13A (RPG 9000) w.e.f. 10.02.2021
Dr. Chet Ram, Scientist, promoted to Level 11 (RPG 7000) w.e.f. 10.02.2016
Dr. Monika Singh, Scientist (SS), promoted to Level 12 (RPG 8000) w.e.f. 23.01.2021
Dr. Sherry Rachel Jacob, Sr. Scientist, promoted to Level 13A (RPG 9000) w.e.f. 12.06.2019
Dr. Ruchi Bansal, Scientist (SS) promoted to Level 12 (RPG 8000) w.e.f. 27.04.2020
Ms. PranushaPulivendula, Scientist, Regional Station Hyderabad promoted to Level 11(RPG 7000) w.e.f. 01.01.2018
Dr.PrasannaHolajjar, Scientist, Regional Station Hyderabad promoted to Level 12 (RPG 8000) w.e.f. 20.04.2019
Dr.Gawade Bharat Hanamant, Scientist, promoted to Level 12 (RPG 8000) w.e.f. 01.01.2022
Dr. M. Abdul Nizar, Scientist, promoted to Sr. Scientist w.e.f. 13.02.2017
Sh. M.B Keshav Raju, SSS promoted to T-1 w.e.f. Feb. 2022
Sh. Shukh Dev, SSS promoted to T-1 w.e.f. Feb. 2022
Sh. Inder Singh, SSS promoted to T-1 w.e.f. Feb. 2022
Sh. Girish Chand Arya, SSS promoted to T-1 w.e.f. Feb. 2022
Sh. Ramesh Chand SSS promoted to T-1 w.e.f. Apr. 2022
Sh. MahadevMourya, SSS promoted to T-1 w.e.f. Feb. 2022
Sh. Balwant Singh, STA (T-4) promoted to TO (T-5)w.e.f. May, 2022
Sh. Braham Parkash, STA (T-4) promoted to TO (T-5)w.e.f. May, 2022
Sh. Ranjeet Singh, STA (T-4) promoted to TO (T-5)w.e.f. May, 2022
Sh. Ram Kumar Sharma, STA (T-4) promoted to TO (T-5)w.e.f. Jul. 2022
Smt. SangitaTanwar, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Sept. 2022
Smt. Rita Gupta, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Sept. 2022

Smt. Nirmala Dabral, TO (T-5) promoted to STO(T-6) w.e.f. Sept. 2022

Sh. Devender Kumar Nerwal, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Sept. 2022

Sh. Wazir Singh, STA (T-4) promoted to TO (T-5)w.e.f. Nov. 2022

Sh. Vijay Kumar Mandal, STA (T-4) promoted to TO (T-5)w.e.f. Dec. 2022

Sh. Dayal Singh, STA (T-4) promoted to TO (T-5)w.e.f. Dec. 2022

Sh. Manish Tomar, STA (T-4) promoted to TO (T-5)w.e.f. Dec. 2022

Dr. B. S. Panwar, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Jan. 2022

Dr. Y. S. Rathi, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Jan. 2022

Mrs. Indira Devi A, ACTO (T-7/8) promoted to CTO (T-9) w.e.f. Jun. 2022

20.7.4 Transfers

Dr. K.K. Gangopadhyay, Principal scientist transferred to IARI w.e.f. 24.08.2022

Dr. Dinesh Chand, Principal scientist transferred to ICAR w.e.f. 08.08.2022

Dr. Anuradha Agrawal, Principal scientist transferred to ICAR w.e.f. 25.04.2022

Dr. Ruchi Bansal, Scientist, SS transferred to IARI w.e.f. 31.03.2022

20.8 Awards/Honours and Prizes

Awards

- Dr. Monika Singh received Young Women Scientist Award (Agricultural Biotechnology) by Royal Association for Science-Led Socio-Cultural Advancement (RASSA) and Sardarkrushinagar Dantiwada Agricultural University (SDAU) in National Conference on Natural Farming for Sustainable Agriculture and National Prosperity (11-13 Nov 2022) at SDAU, Palanpur
- Dr Yasin JK was awarded "Distinguished scientist award -2022" during national conference on Horticulture at Krishnankoil, Tamil Nadu, India
- Dr. Sapna received "Young Scientist Award" and "Best Poster Award" in the 7th International Conference on "Opportunities and Challenges in Agriculture, Environment & Biosciences for Global Development OCAEBGD-2022" from 29th-31st Oct'2022 at Goa organized jointly by CAU, Pasighat and Don Bosco College, Goa.
- Drs. Sivaraj, S R Pandravada, V Kamala and P Saidaiah were conferred with Dr S. K. Vasal Award for the year 2021 for efficient use of PGR instituted by the ISPGR, New Delhi (August, 2022)
- Dr S R Pandravada was selected for Fellowship of Indian Society of Oilseeds Research.
- Dr S R Pandravada was conferred with Life time achievement award by the Science & Technology Society for Integrated Rural Improvement, Telangana.
- Dr N Sivaraj received the Distinguished Scientist Award during the International Conference (AAVASILES-2022) organised by the ICAR-Indian Grassland and Fodder Research Institute, Regional Station, Srinagar, JK, ICAR-National Agricultural Higher Education Project, Birsa Agricultural University, Ranchi, Jharkhand & National Agriculture Development Cooperative Ltd. (NADCL) (28-30 September, 2022)
- Dr Prasanna Holajjer received "Agricultural Scientist Award -2022" by Dr B Vasantharaj David Foundation, Chennai during 4th National Conference on "Recent Advances in Agriculture and Allied Sciences and Pharmaceutical and Environmental Sciences' held at Chennai on 1st October, 2022 for significant contribution in the field of Nematology.
- Dr L Saravanan received Research Excellence Award 2022 from Institute of Scholars, Bengaluru.
- Dr B Parameswari, Senior Scientist received S. Sinha Memorial Young Scientist award of Indian Phytopathological Society, New Delhi.
- Dr Pragya conferred with Fellow of Society for Horticultural Research & Development, Ghaziabad during 2nd Indian Horticulture Summit 2022 at NAU, Navsari, Gujarat, April 27-29, 2022
- Dr. SK Yadav conferred with Fellow of of Indian Society of Plant Genetic Resources (FISPGR) on 20th October 2022.
- Raina SK received "Distinguished Scientist Award" on the occasion of 3 Days International Conference "*Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022)*" September 28-30, 2022, ICAR-Indian Grassland and Fodder Research Institute, Regional Research Station, Srinagar, ICAR-National Agricultural Higher Education Project, Birsa Agricultural University, Ranchi and National Agriculture Development Cooperative Ltd. Baramulla, held at Gandhi Bhawan, University of Kashmir, India.
- One Indian Patent no. 407257 Title: Microbial method for production of protein isolate/ concentrate from oilseed cakes/meals. Inventors: DN Yadav, Sangita Bansal, RK Singh, SN Jha.
- Dr. Sandhya Gupta elected vice chair of Division of Plant Genetic Resources & Biotechnology of International Society of Horticultural Science (ISHS), Belgium for 4 years in August 2022 for the second time.
- Drs Sandhya Gupta and Sangita Bansal were nominated as Subject Editor (Tissue Culture, Organogenesis, Micro-propagation) for the year 2022 in Journal VEGETOS (An international Journal of Plant Research and Biotechnology in January 2022.

Best Oral presentation

- Dr. K Pradheep, Principal Scientist was awarded Best Oral Presentation for the topic entitled "Survey and collection of plant genetic resources from Andaman & Nicobar Islands representing Indo-Burma and Sundaland biodiversity hotspots during the 1st National Conference on Plant Genetic Resources Management. 22-24, November, 2022, held at New Delhi.

- Dr. Suma A., Scientist was awarded Best Oral Presentation for the paper entitled "Development, generation advancement and preliminary characterization of Abelmoschus amphidiploids" in the National Symposium on Horticultural Crops of Humid Tropics for Nutritional and Livelihood Security (NSHCHT)-2022 from 02-03 December, 2022 at CHES (ICAR-IIHR), Chettalli, Karnataka
- Dr Prasanna Holajjer received Best Oral Presentation award for the paper presentation on "Post-entry quarantine inspection of exotic crop germplasm for prevention of entry of pests of quarantine significance into India" in IPSCONF2022 held during March 23-26, 2022 at SKNAU, Jobner-Jaipur, Rajasthan, India
- Dr B Parameswari received Best Oral Presentation award as co author for the presentation titled Natural screening for ScYLV resistance in Saccharum hybrids based on symptom phenotyping and viral titer quantification in 7th IAPSIT International Sugarcane Conference/Sugarcon 2022 organized at IISR, Lucknow from 16-19th October, 2022.
- Dr. Vijay Singh Meena received award of Best Oral Presentation for the presentation of work *Shelf-life evaluation of ber (Ziziphus mauritiana L.) germplasm in arid region of India* .in International Conference on "Advances in Smart Agriculture and Biodiversity Conservation for Sustainable Development (SABCD-2022), March, 4-6, 2022, Jaipur National University, Jaipur, Rajasthan.
- Dr. Kartar Singh received award of Best Oral Presentation for the presentation of work entitled "Molecular characterization of '*Candidatus*phytoplasmaasteris' related strain associated with fenugreek little leaf and witches' broom and screening of fenugreek germplasm for disease resistance" in "8th International Conference on Plant Pathology: Retrospect and Prospect", during 23-26 March, 2022 at S.K.N. Agricultural University Jobner Jaipur, Rajasthan, India.
- Dr. Kartar Singh received award of best oral presentation for the presentation of work entitled "Evaluation of clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) germplasm: Search of new genetic stocks for crop improvement" in 5th International Conference on Advances in Smart Agriculture and Biodiversity Conservation for Sustainable Development (SABCD-2022)", during 04-06 March, 2022 at Jaipur National University, Jaipur, Rajasthan, India.
- Jameel Akhtar was awarded Best Oral Presentation for the presentation entitled 'Seed is a vehicle for transboundary movement of fungal pathogens: A quarantine concern' by J Akhtar, P Kumar, R Kiran, BR Meena, Sadhana, AK Maurya and VC Chalam during National e-Conference on 'Biotic stress management strategies for achieving crop production and climate resilience' organized by the Society of Plant Protection Science, New Delhi at ICAR- National Centre for Integrated Pest Management, New Delhi on May 19-21, 2022
- Pardeep Kumar was awarded Best Oral Presentation for the presentation entitled 'Development of multiplex PCR for simultaneous detection of three seed-borne fungal pathogens of rice' by P Kumar, J Akhtar, R Kiran, BR Meena, Sadhana, S Kaushik, R Tiwari and VC Chalam during National e-Conference on 'Biotic stress management strategies for achieving crop production and climate resilience' organized by the Society of Plant Protection Science, New Delhi at ICAR- National Centre for Integrated Pest Management, New Delhi on May 19-21, 2022.
- AradhikaTripathi was awarded Best Oral Presentation for the presentation entitled 'Development of duplex PCR assay for simultaneous detection of *Diaporthe phaseolorum* and *D. longicolla* infecting soybean' by A Tripathi, J Akhtar and VC Chalam during National e-Conference on 'Biotic stress management strategies for achieving crop production and climate resilience' organized by the Society of Plant Protection Science, New Delhi at ICAR- National Centre for Integrated Pest Management, New Delhi on May 19-21, 2022.
- Dr DP Wankhede et al was awarded Best Oral Presentation for the presentation entitled entitled "Genetic dissection of flowering time, maturity and plant height in *Linum usitatissimum* L. using multi-locus genome wide association study in ISPP North Zonal Seminar-2022 on Inter-Disciplinary Research Strategies for Climate Resilient Agriculture" held at ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal, on 25th June 2022.
- Dr Vartika Srivastava secured Third Best Oral Award for her paper entitled Conservation studies in recalcitrant seeded *Prunus napaulensis* (Ser.) Steud.: an important indigenous underutilized fruit tree of North-eastern India" during the 2nd Indian Horticulture Summit-2022, April 27-29 2022 at Navsari Agricultural University, Navsari, Gujarat.
- Dr Vartika Srivastava received Best Oral Presentation award for her paper entitled "*Ex situ* conservation studies in *Garcinia indica*: a recalcitrant seeded indigenous underutilized fruit tree" in national conference on underutilized horticultural genetic resources: conservation and utilization (NCUHGR-2022) from 3-4 June, 2022 conducted virtually by ICAR-Central Island Agricultural Research Institute, Port Blair.
- Dr Era Vaidya Malhotra awarded Best Oral Presentation Award for paper entitled 'Long term

conservation of *Vanilla planifolia* 'Andrews' using droplet vitrification based cryopreservation technique' during the 1st National Conference on Plant Genetic Resources Management (NCPGRM 2022)', November 22-24, 2022 at NASC Complex, New Delhi.

Best Poster presentation

- Mallikarjun Biradar, Sherry Rachel Jacob, Arun Kumar MB, Vignesh M, JyotiKumari, AshvinkumarKatral, Sundeep Kumar and Veena Gupta received best poster award for 'Redundancy Assessment for Management of Genebank Collections-A Case Study in Maize' during the National maize Conference held at Udaipur , Rajasthan from 23- 25 Feb, 2022.
- Chithra Devi Pandey and Sushil Pandey received best poster award for 'Vegetable Genetic Resources: Conservation and Use' in the Technical Session III: Conservation through Utilization during the 1st National Conference on Plant Genetic Resources Management during November 22-24, 2022, organized by the Indian Society of Plant Genetic Resources, New Delhi.
- Krishna M Rai, Mamta Arya and Veena Gupta received best poster award for 'Genetic resources of wild edible plants in high altitude of Chamoli district of Uttarakhand' during the 1st National Conference on Plant Genetic Resources Management during November 22-24, 2022, organized by the Indian Society of Plant Genetic Resources, New Delhi.
- Drs. P Pranusha, N Sivaraj, S R Pandravada and S.Nivedhitha were awarded Best poster Award in Virtual National Conference on Underutilized Horticultural Genetic Resources: Conservation and Utilization (NCUHGR-2022) conducted by ICAR-Central Island Agricultural Research Institute, Port Blair.
- Dr Pragya received Best Poster Award for poster entitled Access and utilization of cucurbit genetic resources for nutritional security presented in 1st National Conference on Plant Genetic Resources Management at NASC, New Delhi from November 22-24, 2022
- Siddhant Ranjan Padhi et al received Best Poster Award for poster entitled "NIRS Prediction Modelling for Simultaneous Multi-trait Assessment in Diverse Cowpea (*Vigna unguiculata* (L) Walp) Germplasm", during 22nd International Congress of Nutrition held from December 06-11, 2022 at Tokyo, Japan
- Racheal John et al received Best Poster Award for poster entitled "Mining Nutri-dense Accessions from Assam Collections of Rice", during 22nd International Congress of Nutrition held from December 06-11, 2022 at Tokyo, Japan.
- Dr. Sapna received "Best Poster Award" in the National Conference on Maize for Resources Sustainability Industrial Growth and Farmers prosperity on 23-25 Feb'2022 organized by the Maize Technologists Association, India (MTAI), held at Udaipur, Rajasthan, India.
- DP Wankhede et al. received "Best Poster Award" in the 1st National Conference on Plant Genetic Resources Management at NASC, New Delhi from November 22-24, 2022
- Sangita Bansal et al received Best Poster Award for paper entitled "Studies on seed morphometry and desiccation-freezing tolerance in Indian Madder (*Rubiacordifolia*)" during 1st National Conference on Plant Genetic Resources Management, November 22-24, 2022. Indian Society of Plant Genetic Resources, New Delhi, India.

Other recognitions

- Yasin JK was selected as Associate of The Linnean Society of London by the Royal Linnean Society, UK
- Dr L Saravanan was granted with Indian Patent for the invention entitled A process and kit for insect facilitated controlled pollination in oil palm by Patent Office, Govt. of India on 21 January 2022
- Dr Sherry Rachel Jacob, Senior Scientist and Dr Suma A, Scientist were awarded first prize in the debate competition on the topic "Are the international instruments of biodiversity conservation successful in building a shared future for all life?" organized by ICAR-NBPGR, New Delhi on the occasion of celebration of International Day for Biological Diversity on 22nd May, 2022.
- Dr. Kuldeep Tripathi received SERB- International Travel Support Award 2022 for participating in "TROPag, Brisbane Australia (31 October, 2022 to 02 November, 2022)
- Dr MC Yadav was nominated as IMC member, of ICAR-Directorate of Mushroom Research, Solan (H.P.) w.e.f. April, 2018 to July, 2024: Attended Institute Management Committee meeting of ICAR-Directorate of Mushroom Research, Solan, Himachal Pradesh on 26th February, 2022 by virtual mode.
- 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 Member, APS Collections and Germplasm Committee, American Phytopathological Society, USA
- Dr V Celia Chalam was recognized as Expert Member, Accreditation Panel, National Certification System for Tissue Culture-raised Plants, DBT, Govt. of India
- Dr V Celia Chalam was recognized as Expert Member, Inter-Ministerial Committee for Certification of BSL-3 Facilities, DBT, Government of India
- Dr V Celia Chalam was recognized as Expert Member, National Network of Plant Health Management, NIPHM, Hyderabad
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- Copyright Reg. No. SW-15900/2022: APTRANSDB: ANDROGRAPHIS TRANSCRIPTS & SSR DATABASE. Authors: Rakesh Singh, Akshay Singh, Ajay Kumar Mahato, Rajesh Kumar, Amit K. Singh, Sundeep Kumar, Soma S. Marla, Ashok Kumar and Nagendra K. Singh
- One Indian Patent no. 407257 Title: Microbial method for production of protein isolate/ concentrate from oilseed cakes/meals. Inventors: DN Yadav, Sangita Bansal, RK Singh, SN Jha.
- Dr. Sandhya Gupta elected vice chair of Division of Plant Genetic Resources & Biotechnology of International Society of Horticultural Science (ISHS), Belgium for 4 years in August 2022 for the second time.

Best paper awards

- Yukta Sarap, SwapnilKatekar, Sunil Gomashe, Dinesh Chand (2022) Commercial Utilization and Pharmacological Importance of Anjan; *Hardwickia binate*. Agriculture and Food: e-News letter. 4 (6):367-368.
- Swapnil Katekar, JayshriPapade, Sunil Gomashe, Dinesh Chand (2022) Important Health Benefits and Production Technology of Custard Apple; *Annona squamosa*. Agriculture and Food: e-News letter. 4 (6):361-363.

20.9 Publications

20.9.1 Research papers

Aakash Yadav, Tilak Chandra, Sundeep Kumar (2022). Evaluation of differentially expressed genic marker linked resistance gene analog (RGAs) effective at seedling stage against spot blotch in wheat. *Cereal Research Communications*.

Aditi Kundu, Abhishek Mandal, Anirban Dutta, Supradip Saha, Archana P. Raina, Ranjeet Kumar, Amalendu Ghosh. (2022). Nanoemulsification of *Kaempferia galanga* essential oil: Characterizations and molecular interactions explaining fungal growth suppression. *Process Biochemistry* 121: 228–239

Agrawal A, N Sharma, S Gupta, S Bansal, V Srivastava, EV Malhotra, S Chander, R Gowthami and K Singh (2022). Biotechnological applications for plant germplasm conservation at ICAR-National Bureau of Plant Genetic Resources, India – recent achievements. Acta Hortic 1339: 29-42. DOI 10.17660/ActaHortic.2022.1339.5

Agrawal A, R Gowthami, S Chander and V Srivastava (2022) Sustainability of In Vitro Genebanks and Cryogenebanks. Indian J Plant Genet Resour 35(3): 180-184.

Aggarwal, S.K., Hooda, K.S., Bagaria, P.K., Kaur, Harleen, Gogoi, Robin, Chauhan, Prashant and Singh, R.P. 2022. Multiple modules for the management of banded leaf and sheath blight of maize in India. *Indian Phytopath*.

Ahlawat SP, KC Bhatt, DP Semwal, K Pradheep and OP Dhariwal (2022). Exploration and Collection of Plant Genetic Resources in India: Status and Priorities. *Indian J. Plant Genet. Resour*. 35(3): 117–123.

Anjula Pandey and Pragya Ranjan (2022) Hortfact sheet. Arya melon: At a glance. Indian Horticulture. Volume 67 No. 6.

Arya L, RK Narayanan, A Kak, C D Pandey, M Verma and V Gupta (2022) ISSR marker based genetic diversity in *Morinda* spp. for its enhanced collection, conservation and utilization. *Genet Resour Crop Evol*. 69: 1585–1593.

Arya Rajesh Kumar, Ravi Kumar, Jagbir Singh Hooda, Jhabar Mal Sutaliya, Gajraj Singh Dahiya, Vandana, Hanuman Lal Raiger, Satish Kumar Yadav, Ranjit Kaur Gill, Jay Lal Mehto, Jitendra Kumar Tiwari, Chander Bhan Yadav, Md. Khabruddin Deen, Rakesh Punia, Kushal Raj, Roshan Lal, Pawan Kumar, R. N. Tripathi, Gurpreet Singh and S. P. Singh (2022) Pre-Breeding Evaluation of Germplasm for Hybridization and Screening of Resulting Transgressive Elite Genotypes Faba Bean for Yield and its Attributes for Semi-Arid Regions of India *Ekin-J.Crop Breed.Genet.*8(1):17-26, 2022

Aski, M., Mehra, R., Mishra, G. P., Singh, D., Yadav, P., Rai, N., ...& Dikshit, H. K. (2022). Genotypic variation in root architectural traits under contrasting phosphorus levels in Mediterranean and Indian origin lentil genotypes. *PeerJ*, *10*, e12766.

Balaji, B., Dharani, E., Shricharan, S., Shakespear, S., Singh, A., Pillai, M.A. and Yasin, J.K., (2022). Genome editing for speed breeding of horticultural crops. *Journal of Agri Search*, 9(3), pp.196-200.

Bansal S, A Kumar; AA Lone; MH Khan; EV Malhotra; R Singh (2022) Development of novel Genome-wide simple sequence repeats (SSR) markers in Bunium persicum. *Industrial Crops and Products*. 178. 114625.

Bansal S, Kumar A, Lone AA, Khan MH, Malhotra EV, Singh R. 2022. Development of novel genome-wide simple sequence repeats (SSR) markers in *Bunium persicum*. Industrial Crops and Products.

Bartwal, A., John, R., Padhi, S.R., Suneja, P., Bhardwaj, R*., Wankhede, D.P. and Archak, S., (2022). NIR Spectra Processing for Developing Efficient Protein Prediction Model in Mungbean. *Journal of Food Composition and Analysis*, p.105087.

Bhadoria, Prakash, Manoj Shrivastava, Ashish Khandelwal, Ruma Das, Sapna Langyan, Bharti Rohatgi, and Renu Singh (2022). "Preparation of modified rice straw-based bio-adsorbents for the improved removal of heavy metals from wastewater." *Sustainable Chemistry and Pharmacy* 29: 100742.

Bhanushree N, BS Tomar, J Akhtar and P Saha (2022). Identification of new resistant varieties to *Phomopsis* fruit rot of eggplant (*Solanum melongena*). *Indian J Agri Sci.* 92(9): 1143-1147.

Bhaskar, K.A., Al-Hashimi, A., Meena, M., Meena VS, Langyan Sapna et al. (2022). Conservation agricultural practices for minimizing ammonia volatilization and maximizing wheat productivity. *Environ Sci Pollut Res*.

Bhawna Bonthala, M.Z.Abdin, Lalit Arya, Chithra D.Pandey, Vedprakash Sharma, Priya Yadav and Manjusha Verma (2022) Genome wide SSR markers in bottle gourd: development, characterization, utilization in assessment of genetic diversity of National Genebank of India and synteny with other related cucurbits. *Journal of Applied Genetics* 63:237–263.

Bhutia, N.D., Sureja, A.K., Munshi, A.D., Verma, M., Arya, L., Gopala Krishnan, S., Gurung, B. (2022). Morphological and molecular characterization of Satputia (Luffa hermaphrodita Singh & Bhandari) revealed substantial diversity for use in breeding programme. *Genet Resour Crop Evol* 69: 2485–2500.

Bibwe, B., Mahawar, M. K.,Jalgaonkar, K., Meena, V. S., & Kadam, D. M. (2022). Mass modeling of guava (cv. Allahabad safeda) fruit with selected dimensional attributes: Regression analysis approach. *Journal of Food Process Engineering*, e13978.

Brahmi Pratibha, Vandana Tyagi, Pragya and Anuradha Agrawal (2022) Policies Impacting Access to Plant Genetic Resources in Last Four Decades. *Indian J. Plant Genet. Resour*. 35(3): 213–217.

Budhlakoti N, Kushwaha AK, Rai A, Chaturvedi KK, Kumar A, Pradhan AK, Kumar U, Kumar RR, Juliana P, Mishra DC and Kumar S (2022). Genomic Selection: A Tool for Accelerating the Efficiency of Molecular Breeding for Development of Climate-Resilient Crops. *Front. Genet.* 13: 832153.

Chalam VC, Kavita Gupta, MC Singh, Z Khan, J Akhtar, BH Gawade, Pooja Kumari, Pardeep Kumar BR Meena, AK Maurya and DS Meena (2022). Role of plant quarantine in preventing entry of exotic pests. *Indian J. Pl. Genet. Resour* 35(3): 141-146 DOI 10.5958/0976-1926.2022.00057.2

Chandra Puran, KuldeepTripathi, Pragya, Sunil Archak, VandanaTyagi and Pratibha Brahmi (2022) ITPGRFA: an Appraisal as a Prelude to the Ninth Session of the Governing Body 2022, New Delhi. *Indian J. Plant Genet. Resour*. 35(2): 159–168.

Chandrashekara, C., Mishra, K.K., Stanley, J., Subbanna, A.R.N.S., Hooda, K.S., Pal, R.S, Bhatt, J.C. and Pattanayak, A. 2022. Management of diseases and insect-pests of French bean in Northwestern Indian Himalayan region using integrated approaches. *Front. Plant Sci.*, 19 December 2022

Chaurasia S, Kumar A, Singh AK (2022). Comprehensive Evaluation of Morpho-Physiological and Ionic Traits in Wheat (*Triticum aestivum* L.) Genotypes under Salinity Stress. Agriculture. 12(11): 1765.

Chet Ram, C., Danish, S., Kesawat, M.S., Panwar, B. S., Verma, M., Arya, L., Yadav, S., Sharma, V.P. (2022). Genome-wide comprehensive characterization and expression analysis of TLP gene family revealed its responses to hormonal and abiotic stresses in watermelon (*Citrullus lanatus*). *Gene* 844.

Chethan C.R., Dubey R.P., Chander S., Pawar D., Ghosh D. and Singh P.K. (2022) Harnessing the full potential of low-dose high-potency (LDHP) herbicide molecules by standardized spraying technique in rice and wheat. Indian Journal of Weed Science (2022) 54(2): 146-150.

Chethan C.R., Tewari V.K., Shrivastava A.K., Nare B., Kumar S.P., Dubey R.P., Singh P.K., Ghosh D., Chander S. and Dasari S. (2022). Optimization of Potato Sprout Orientation Angle and Effective Weed Management Practice to Produce Higher Economical Tuber Yield from Cut Tuber Planting. Potato Research https://doi.org/10.1007/s11540-022-09578-5.

Chongtham, S.K., Devi, E.L., Samantara, K. et al. (2022). Orphan legumes: harnessing their potential for food, nutritional and health security through genetic approaches. *Planta* 256, 24.

Das A, Yadav R.K., Bhardwaj R, Harshwardhan Choudhary H and Khade Y.P. 2022 Study of heterotic potential for important antioxidant and nutritional traits in okra (Abelmoschus esculentus) *Indian Journal of Agricultural Sciences* 92 (8): 986–990.

Das, A., Yadav, R.K., Choudhary, H., Lata, S., Singh, S., Kumar, C., Kumari, S., Boopalakrishnan, G., Bhardwaj, R. and Talukdar, A., (2022). Population structure, gene flow and genetic diversity analyses based on agro-morphological traits and microsatellite markers within cultivated and wild germplasms of okra [Abelmoschus esculentus (L.) Moench.]. *Genetic Resources and Crop Evolution*, *69*(2), pp.771-791.

Dasari, S, D Pawar , CR Chethan , PK Singh , S Sondhia , S Chander and MC Singh (2022) Indian quarantine weeds invasiveness assessment using bio-security tool: Weed Risk Assessment. *Indian J. Weed Sci.* 54(2): 110-115.

David L Jordan, Greg S Buol, Rick L Brandenburg, Dominic Reisig, Jerry Nboyine, Mumuni Abudulai, Richard Oteng-Frimpong, Moses Brandford Mochiah, James Y Asibuo, Stephen Arthur, Richard Akromah, Wezi Mhango, Justus Chintu, Sergio Morichetti, Juan A Paredes, Joaquin H Monguillot, Kuldeep Singh Jadon, Barbara B Shew, Poonam Jasrotia, PP Thirumalaisamy, G Harish, Holajjer P, Nataraja Maheshala, Greg MacDonald, David Hoisington, James Rhoads (2022) Examples of Risk Tools for Pests in Peanut (Arachis hypogaea) Developed for Five Countries Using Microsoft Excel, *Journal of Integrated Pest Management*, 13 (1) 20, 1-15, Deepak DA, Malhotra EV, Shankar M and Agrawal A. 2022. Improved micropropagation protocol and molecular marker based genetic stability assessment of black pepper (Piper nigrum L.). Indian Journal of Plant Genetic Resources 35(2): 264-274.

Devindrappa M, A Kamra, M Grover, B Gawade (2022) Nematicidal rhizobacteria with plant growth-promoting traits associated with tomato in root-knot infested polyhouses. *Egypt. J. Biol. Pest Control* 32:51.

Dubey SC, VD Sharma, VK Prajapati, J Akhtar and A Kandan (2022) Phenotypic variability, race profiling and molecular diversity analysis of India populations of *Fusarium oxysporum* f. sp. *lentis* causing lentil wilt. *Folia Microbiol.* 76(5): 757-775.

Dutta H, Mishra GP, Aski MS, Bosamia TC, Mishra DC, Bhati J, Sinha SK, Vijay D, C. T. MP, Das S, Pawar PA-M, Kumar A, Tripathi K, Kumar RR, Yadava DK, Kumar S and Dikshit HK (2022) Comparative transcriptome analysis, unfolding the pathways regulating the seed-size trait in cultivated lentil (*Lens culinaris* Medik.). Front. Genet. 13:942079. doi: 10.3389/fgene.2022.942079.

Elangovan Maruthamuth, Karnam Venkatesh, AmasiddhaBellundagi, Sushil Pandey and Chithra Devi Pandey (2022) Assessment of variability in sorghum (*Sorghum biocolor* (L.Moench) germplasm for agro-morphological traits. *Electronic Journal of Plant Breeding* 13(2):1-10.

Elangovan Maruthamuth, Karnam Venkatesh, Sushil Pandey and Chithra Devi Pandey (2022) International Year of Millets 2023: Opportunity of Enhancing the Use of Indian Millets Germplasm. *Indian J. Plant Genet. Resour. 35(3): 90-94.*

Gangappa ND, C Singh, MK Verma, M Thakre, AMV Sevanthi, R Singh, M Srivastav, Raghunandan K, C Anusha, V Yadav, A Nagaraja (2022) Assessing the genetic diversity of guava germplasm characterized by morpho-biochemical traits. *Frontiers in Nutrition*. 9: 1017680.

Gautam, Raj K., Sapna Langyan, S. Vimla Devi, Rakesh Singh, D. P. Semwal, Sharik Ali, G. S. Mangat et al. (2022). "Genetic resources of sticky rice in India: status and prospects." *Genetic Resources and Crop Evolution* 1-12.

Gautam, RK, Langyan S, S. Vimla Devi, Singh R, Semwal D P, Ali S, Mangat G S, Sarkar S, Bagchi TB, Roy S, Senguttuvel P, Bhuvaneswari S, Chetia S, Tripathi K, Harish GD, Kumar A, Singh K (2022) Genetic resources of sticky rice in India: status and prospects. *Genetic Resources and Crop Evolution*. 10.1007/s10722-022-01479-3.

Gawade BH, Priyanka, Z Khan, P Kumar and VC Chalam (2022) Molecular characterization of wheat seed gall nematode, *Anguina tritici*. *Indian J. Nematol.* 52(1): 28-35.

Gawade BH, S Chaturvedi, Apsara N, Z Khan, Chithra Devi Pandey, KK Gangopadhyay, SC Dubey and VC Chalam (2022). Evaluation of brinjal germplasm against root-knot nematode, *Meloidogyne incognita*. *Indian Phytopath*. 75: 449-456. https://doi.org/10.1007/s42360-022-00461-4

Gayacharan., Tripathi, K., Aski, M. S., Singh, N., Kumar, A., & Lal, H. (2022). Understanding genetic diversity in blackgram [Vigna mungo (L.) Hepper] collections of Indian National Genebank. *Genetic Resources and Crop Evolution*, *69*(3), 1229-1245.

Ghorai, PS, S Biswas, TJ Purakayastha, N Ahmed, TK Das, R Prasanna, BH Gawade, K Bhattacharyya, K Sinha, P Singh, S Das (2022). Indicators of soil quality and crop productivity assessment at a long-term experiment site in the lower Indo-Gangetic plains. *Soil Use and Management*, 00, 1–18. https://doi.org/10.1111/sum.12847

Gore PG, V Gupta, R Singh, K Tripathi, R Kumar, G Kumari, Latha M, HK Dikshit, Kamala V, A Pandey, N Singh, KV Bhat, RM Nair and A Pratap (2022). Understanding the genetic diversity of an underutilized Indian legume, *Vigna stipulacea* (Lam.) Kuntz., using morphological traits and microsatellite markers and identification of trait-specific germplasm. *PLoS ONE* 17(1): e0262634.

Gowda MT, BR Meena, N Krishnan, M Manjunath, C Sellaperumal, AB Rai, A Singh, C Manimurugan, J Patil and KK Pandey (2022) Antimicrobial peptides producing native *Bacillus* spp. for the management of root-knot nematode *Meloidogyne incognita* infecting okra (*Abelmoschus esculentus* L. Moench) *Biol. Control,* 171: 104951.

Gupta Archi, Bijendra Singh1, Mukesh Kumar, V.R. Sharma, Charupriya Chauhan, Sanghamitra Rout, Satish K. Yadav (2022) Combining Ability and Heterosis Analysis for Seed Yield and Yield Related Traits in Table Pea [*Pisum sativum* (L.) var. *hortense*] 10.18805/LR-4978

Gupta OP, Singh AK, Singh A, Singh GP, Bansal KC, Datta SK (2022) Wheat Biofortification: utilizing natural genetic diversity, genome-wide association mapping, genomic selection, and genome editing technologies. *Front Nutr*. 9: 826131. doi: 10.3389/fnut.2022.826131.

Gupta S and VK Biraji (2022) In vitro propagation of Artocarpus lakoocha Roxb.: effect of meta-topolin on shoot parameters. Acta Hortic. 1339. ISHS 2022. DOI 10.17660/ActaHortic.2022.1339.2.

Halder J, HR Sardana, MK Pandey, BR Meena and MN Bhat (2022) Synthesis and area-wide validation of IPM technology and its economic analysis for eggplant (*Solanum melongena*) *Indian J. Agril. Sci.*92 (9): 1124–1128

Haque, Md. Ashraful, Marwaha, Sudeep, Arora, Alka, Deb, Chandan Kumar, Nigam, Sapna, Tanuj, Misra and Hooda, K.S. (2022). A lightweight convolutional neural network for recognition of severity stages of maydis leaf blight disease of maize. *Front. Plant Sci.* 13: 1077568.

Haque, Md. Ashraful, Marwaha, Sudeep, Deb, Chandan Kumar, Nigam, Sapna, Arora, Alka, Hooda, K.S., Soujanya, P.L., Aggarwal, S.K., Lall, Brejesh, Kumar, Mukesh, Islam, Shahnawazul, Panwar, Mohit, Kumar, Prabhat and Agrawal, R.C. (2022). Deep learning based approach for identification of diseases of maize crop. *Scientific Reports*.

Hedau, N.K., Shri Dhar, Chaudhari, G.V., Agarwal, P.K., Bhatt, J.C., Tuti, M., Hooda, K.S., Mishra, K.K., Pal, R.S. 2022. VL Cherry Tomato 1: a nutritionally rich cherry tomato cultivar. *Current Sci*. 123(1):21-22

Hemavati Ranebennur, Kiran Kirdat, Bhavesh Tiwarekar, Kirti Rawat, V. Celia Chalam, Amolkumar U. Solanke, Rashmi Yadav, Kuldeep Singh, Shivaji Sathe, Amit Yadav and G. P. Rao (2022). Draft genome sequence of '*Candidatus* Phytoplasma australasia', strain SS02 associated with sesame phyllody disease. *3Biotech* 12, 107.

Hemlata Bharti, Krishan P. Singh, Archana P. Raina and M.C. Singh. (2022). Evaluation of biochemical diversity among single and double petaled *Polianthes tuberosa* genotypes under north Indian condition. *Annals of Horticulture* 15 (1): 56-66.

Holajjer P, Bharat H. Gawade, Z Khan and N Sivaraj (2022) Prediction of potential geographic distribution of exotic nematode, Aphelenchoides fragariae in India based on MaxEnt ecological niche modelling. *Indian Journal of Plant Protection*, 50 (1): 51-55.

Holajjer P, Bhaskar Bajaru, B Parameswari, N Sivaraj, M Srinivas Rao and K Anitha (2022) Pathogenicity and reproductive potential of root-knot nematode, Meloidogyne incognita on Dragon fruit (Hylocereus spp.). Journal- Biological Forum – An International Journal, 14(1): 1606-1609.

Holajjer P, Joseph KJ, Pandravada SR, Sivaraj N and Kodaru A. (2022) Screening of Abelmoschus Gene Pools for Sources of Resistance to RootKnot Nematode, *Meloidogyne incognita*. *Indian Journal of Nematology* 52 (1): 16-20.

Jain P, Singh A, Iquebal MA, Jaiswal S, Kumar S, Kumar D and Rai A (2022). Genome-Wide Analysis and Evolutionary Perspective of the Cytokinin Dehydrogenase Gene Family in Wheat (Triticum aestivum L.). *Front. Genet*. 13: 931659. DOI: 10.3389/fgene.2022.931659

John, R., Bhardwaj, R., Jeyaseelan, C., Bollinedi, H., Singh, N., Harish, G.D., Singh, R., Nath, D.J., Arya, M., Sharma, D. and Singh, S., (2022). Germplasm variability-assisted near infrared reflectance spectroscopy chemometrics to develop multi-trait robust prediction models in rice. *Frontiers in Nutrition*, (IF – 6.59).

John, Racheal, R. Bhardwaj, C. Jeyaseelan, H. Bollinedi, N. Singh, Harish G.D., R Singh, D. Nath, M. Arya, D. Sharma, S. Singh, J. John K, M. Latha, J.C. Rana, S.P. Ahlawat, A. Kumar (2022). Germplasm Variability Assisted NIRS Chemometrics to Develop Multi-Trait Robust Prediction Models in Rice. *Frontiers in Nutrition*. 946255. doi: 10.3389/fnut.2022. 946255

John, Racheal; Bhardwaj, Rakesh; Jeyaseelan, Christine; Bollinedi, Haritha; Singh, Neha; Harish, GD; Singh, Rakesh; Nath, Dhrub Jyoti; Arya, Mamta; Sharma, Deepak;. (2022). Germplasm variability-assisted near infrared reflectance spectroscopy chemometrics to develop multi-trait robust prediction models in rice. *Frontiers in Nutrition*.

Joseph John K, K Pradheep and E Roshini Nayar (2022). Plant Taxonomy and Biosystematics in PGR Collecting and Conservation. Indian *J. Plant Genet. Resour*. 35(3): 131–135.

K Singh, VS Meena, N Shekhawat, HR Mahla, G Krishnan, and V Gupta(2022). Identification of early maturing and leaf determinate growth habit type accessions of cluster bean (*Cyamopsis tetragonoloba* L. Taub.) Journal of Agriculture and Ecology. / doi.org/10.53911/ JAE.2022.14220.

Kartar Singh, Jameel Akhtar, Neelam Shekhawat, Vijay Singh Meena, Ashish Gupta,Bharat Raj Meena, Rashmi Yadav, Veena Gupta and Ashok Kumar (2022). Identification of new source of resistance against white rust. *Journal of Oilseed Brassica,* 13 (2): 1-6, July 2022. (NAAS rating: 4.77).

Kaur C, Sethi M, Devi V, Chaudhary DP, Phagna RK, Singh A, Bhushan B, Langyan Sapna, Rakshit S (2022) Optimization of Protein Quality Assay in Normal, opaque-2 and Quality Protein Maize. Front. Sustain. Food Syst.

Kaur V, Aravind J, Manju, Jacob SR, Kumari J, Panwar BS, Pal N, Rana JC, Pandey A and Kumar A (2022) Phenotypic Characterization, Genetic Diversity Assessment in 6,778 Accessions of Barley (Hordeum vulgare L. ssp. vulgare) Germplasm Conserved in National Genebank of India and Development of a Core Set. *Front. Plant Sci*.13:771920. doi: 10.3389/fpls.2022.771920.

Khan Z, K Tripathi, BH Gawade, VC Chalam (2022). Report on severe infestation of root-knot nematode, *Meloidogyne incognita* on tuberous *Vigna vexillata* (L.) *Pantnagar J. Res*. 20(1):53-57.

Korattukudy, C.A., Samy, A.P.L.M.A., Rengasamy, K., Devadhasan, S., Shunmugavel, S., Yasin, J.K. and MA Pillai, (2022). Genetic diversity analysis in blackgram (Vigna mungo) genotypes using microsatellite markers for resistance to Yellow mosaic virus. Plant Protection Science, 58(2), pp.110-124.

Krishna Kant Mishra, Lakshmi Kant, Jyoti Kumari and Ashok Kumar. (2022). Mining of the national gene bank collection identifies resistance sources for loose smut of wheat in Northern Himalayan conditions. *Indian Phytopathology*, 75(8).

Kumar A, Langyan Sapna, Yadav R, Kumar A, Singh R. (2022). Sesame Protein: Role in Food and Nutrition Security, 10(01):

Kumar A, Tripathi K and Jyoti Kumari (2022) Large-scale Characterization for Management and Utilization of Indian National Genebank Collections. Indian Journal of Plant Genetic Resources. 35(3): 147–150.

Kumar P, J Akhtar, R Kiran, BR Meena, Sadhana and VC Chalam (2022) Phylogenetic analysis and species level identification of seed-borne *Bipolaris, Exserohilum* and *Curvularia*. *IndianPhytopath*. 76:

Kumar R, C Kumar, R Jain, A Maurya, A Kumar, A Kumari, R Singh (2022) Molecular cloning and in-silico characterization of NAC86 of Kalmegh (Andrographis paniculata). Indian Journal of Horticulture 79(1):9-14.)

Kumar S, Jacob SR, Mir RR, Vikas VK, Kulwal P, Chandra T, Kaur S, Kumar U, Kumar S, Sharma S, Singh R, Prasad S, Singh AM, Singh AK, Kumari J, Saharan MS, Bhardwaj SC, Prasad M, Kalia S and Singh K (2022) Indian Wheat Genomics Initiative for Harnessing the Potential of Wheat Germplasm Resources for Breeding Disease-Resistant, Nutrient-Dense, and Climate-Resilient Cultivars. Front. Genet. 13:834366. DOI: 10.3389/fgene.2022.834366

Kumar Suneel, AK Pradhan, U Kumar, GS Dhillon, S Kaur, N Budhlakoti, DC Mishra, AK Singh, R Singh, J Kumari, VV Kumaran, VK Mishra, PK Bhati, S Das, R Chand, K Singh and S Kumar (2022) Validation of Novel spot blotch disease resistance alleles identified in unexplored wheat (Triticum aestivum L.) germplasm lines through KASP markers. BMC Plant Biology. 22.618.

Kumari G, Shanmugavadivel PS, Lavanya GR, Tiwari P, Singh D, Gore PG, Tripathi K, Madhavan Nair R, Gupta S and Pratap A (2022), Association mapping for important agronomic traits in wild and cultivated Vigna species using cross-species and cross-genera simple sequence repeat markers. Front. Genet. 13:1000440. doi: 10.3389/fgene.2022.1000440.

Kumari J, Mahatman KK, Sharma S, Singh AK, Adhikari S, Bansal R, Kaur V, Kumar S and Yadav MC (2022). Recent advances in different omics mechanism for drought stress tolerance in rice. *Russian Journal of Plant Physiology*, 69:18.

Kumari N., Jhar BK., Bara N., Choudhary SB. (2022). Evolving contours of changing climate and its perception by farming community in hilly region: A micro study from Jharkhand, India. Agricultural Mechanization in Asia, 53 (04): 7463-7475.

Kumari, Jyoti, Gayacharan, Sheelamary, Tej Pal Singh, Ashok Kumar, Ashutosh Kumar, Nikhil Malhotra and Mohar Singh (2022). Evaluation and identification of drought tolerant wild annual *Cicer* accessions for enhancing genetic gains towards chickpea improvement. Indian J. Genet. Plant Breed. 82(4): 430-430.

Kumari Pooja, SP Singh, KK Gangopadhyay, VC Chalam, CD Pandey and SK Yadav (2022) Standardization of artificial screening technique for okra enation leaf curl disease resistance in wild okra (*Abelmoschus moschatus* ssp. *Moschatus*) germplasm. *Indian J. Agricul. Sci*. 92(10): 1214–1218.

Kumari, S, Wankhede DP, Murmu S, Maurya R, Jaiswal S, Rai, A, Archak S (2022) Genome-Wide Identification and Characterization of Trihelix Gene Family in Asian and African Vigna Species. Agriculture 12, 2172. doi.org/10.3390/agriculture12122172

Kuriachen, P., Devi, A., Sam, A.S. , Suresh Kumar, Jyoti Kumari, A. Suresh & Girish K. Jha *(2022)*. Wheat yield responses to rising temperature: insights from northern plains of India. *Theor Appl Climatol* 150, 1157–1172 (2022).

Lal, S., Sharma O.C., Singh, D.B., Verma, M.K., Mir, J.I., Rai, K.M. (2022). Characterization of peach (Prunus persica) genotypes for physic-chemical and yield attributed grown under temperate environment. Current Horticulture. DOI:10.5958/24557560.2022.00012.7.

Langyan S, Bhardwaj R, Radhamani J, Yadav R, Gautam RK, Kalia S and Kumar A (2022) A Quick Analysis Method for Protein Quantification in Oilseed Crops: A Comparison With Standard Protocol. *Front. Nutr.*9:892695

Langyan S, R Bhardwaj, J Kumari, SR Jacob, I S Bisht, S R Pandravada, A Singh, P B Singh, Z A Dar, A Kumar and J C Rana (2022) Nutritional diversity in native germplasm of maize collected from three different fragile ecosystems of India. Frontiers in Nutrition. 9: 812599. doi: 10.3389/ fnut.2022.812599.

Langyan, S., Yadava, P., Khan, F.N., Bhardwaj, R*., Tripathi, K., Bhardwaj, V., Bhardwaj, R., Gautam, R.K. and Kumar, A. (2022). Sustainability of Major Pulses: A Comprehensive Review of Nutritional and Food Consumption Studies with Future Perspectives. *Frontiers in Sustainable Food Systems*, p.241.

Langyan, Sapna, Pranjal Yadava, Tarun Belwal, and Tanushri Kaul, eds. “Sustaining protein nutrition through plant-based foods: A paradigm shift.” (2022). (Editorial). *Frontiers in Sustainable Food System*.

Laxmisha, K.M., Semwal, D.P., Gupta, V., Katral, A., Bisht, I.S., Mehta, P.S., Arya, M., Bhardwaj, R. and Bhatt, K.C. (2022). Nutritional profiling and GIS-based grid mapping of Job’s tears (Coix lacryma-jobi L.) germplasm. *Applied Food Research*, 2(2) p.100169.

Madkami, S.K., Moharana, A., Misra, R.C. and Barik, D.P. (2022) Rapid *in vitro* plant regeneration from nodal explant of *Mucuna gigantea*—An endangered medicinal legume. *Int J Pharm Sci* 13 (4):

Malhotra EV, Jain R, Tyagi S, Venkat Raman K, Bansal S and Pattanayak D. 2022. Identification of dynamic microRNA associated with systemic defence against Helicoverpa armigera infestation in Cajanus scarabaeoides. Pest Management Science https://doi.org/10.1002/ps.6941

Malhotra EV, Jain R, Tyagi S, Venkat Raman K, Bansal S, Aminedi R and Pattanayak D. 2022. Comparative analysis of herbivory responsive miRNAs to delineate pod borer (Helicoverpa armigera) resistance mechanisms in Cajanus cajan and its wild relative Cajanus scarabaeoides. Plant Cell Reports 41: 1147–1161.

Malhotra, Nikhil; Sharma, Paras; Sood, Hemant; Chandora, Rahul; Arya, Mamta; Rana, Jai Chand; Singh, Mohar. (2022). Agro-morphological characterization and nutritional profiling of traditional Himalayan crop landraces for their promotion toward mainstream agriculture. Frontiers in Plant Science. 13.

Meena PD, J Akhtar, AK Gupta, BR Meena, S Mehta, K Monika, GS Saharan and N Mehta (2022) *Alternaria-Brassica* pathosystem: development and perspective. *J. Oilseed Brassica*, 13(2): 65-89.

Meena V.S. Gora J.S. Singh, A. Ram C., Meena, N.K. Pratibha, A. Rouphael, Y. Basile, B. Kumar, P. (2022) Underutilized Fruit Crops of Indian Arid and Semi-Arid Regions: Importance, Conservation and Utilization Strategies. *Horticulturae,* 8, 171.https://doi.org/10.3390/horticulturae802017.

Mhetre, Vishal B., V.B. Patel, S.K. Singh, Gyan P. Mishra, M.K. Verma, Chavlesh Kumar, Anil Dahuja, Sanjeev Kumar, R Singh and M. Wasim Siddiqui (2022) Secondary metabolites and transcriptomic analyses reveal the pathways influencing berry qualities in grapevine cv. Flame Seedless treated with bioregulators under the hot subtropical region. Food Chemistry: Molecular Sciences. 5:100116.

Mishra, G.P., Aski, M.S., Tontang, M.T., Choudhary, P., Tripathi, K., Singh, A., Kumar, R.R., Thimmegowda, V., Stobdan, T., Kumar, A. and Bhardwaj, R. (2022). Morphological, Molecular, and Biochemical Characterization of a Unique Lentil (Lens culinaris Medik.) Genotype Showing Seed-Coat Color Anomalies Due to Altered Anthocyanin Pathway. *Plants*, *11*(14), p.1815.

Misra R.C., Raina A.P. and Ahlawat S.P. (2022) Note on *Ocimum africanum* Lour.: New distributional record of wild basil for Odisha and central India. *e - planet* 20 (1):33-39

Misra, R.C., Karmakar P., Dehury, S., Dash, S.K. and Ahlawat, S.P. (2022)New record of three taxonomic varieties of wild okra (*Abelmoschus* Medik.) for Eastern India. *Vegetos* (Springer).

Mohar Singh, Reena Mehra, Sanjeev Kumar, Nikhil Malhotra and Salej Sood (2022). Evaluation and identification of advanced lentil interspecific derivatives resulted in development of early maturing and high yielding cultivars under Indian agro-ecological conditions. *Front. Plant Sci*. 13: 936572.

Mohar Singh, Tapan Kumar, Salej Sood, Nikhil Malhotra, Upasana Rani, Sarvjeet Singh, Inderjit Singh, Sandeep Kumar and Sanjeev Kumar (2022). Identification of chickpea interspecific derivatives against agro-morphological and major biotic traits. *Front. Plant Sci.* doi: 10.3389/fpls.2022.941372.

Nalla, M.K., Sharma, V.K., Srivastava, A. *et al*. (2022). Molecular tagging of fertility restoration (*Rf*) gene in sweet pepper (*Capsicum annuum* var. *grossum*). *Vegetos.* 35, 903–909.

Nawade, B.; Kumar, A.; Maurya, R.; Subramani, R.; Yadav, R.; Singh, K.; Rangan, P. (2022). Longer Duration of Active Oil Biosynthesis during Seed Development Is Crucial for High Oil Yield -Lessons from Genome-Wide In Silico Mining and RNA-Seq Validation in Sesame. *Plants* 2022, 11(21), 2980;

Netravati, Saji Gomez, Berin Pathrose, Meagle Joseph, Mini Raj N, Suma A and Shynu M. (2022) Comparison of Anthocyanin Pigment Extraction Techniques to Evaluate the Free Radical Scavenging Capacity of Butterfly Pea (*Clitoriaternatea* L.) Flower. *Biological Forum – An International Journal* 14(3): 995-998.

Netravati, Saji Gomez, Berin Pathrose, Mini Raj N, Meagle Joseph, Shynu M and Suma A (2022). Assessment of free radical scavenging activity of Mangosteen (*Garcinia mangostana* L.) fruit peel anthocyanin pigment obtained through different extraction methods. *The Pharma Innovation Journal* 11(9): 1333-1336.

Nikhil Malhotra, Paras Sharma, Hemant Sood, MamtaArya, Rahul Chandora, Jai Chand Rana and Mohar Singh (2022). Agro-morphological characterization and nutritional profiling of traditional Himalayan crop landraces for their promotion towards mainstream agriculture. *Front. Plant Sci*. doi 14:6744211.

Padamavati Gore, Subarna Johng, Mohar Singh, Neeta Singh and Veena Gupta (2022). Evaluation and validation of bold seeded accession in rice bean. Indian J. Plant Genet. Resour. 35(1): 1-3.

Padhi SR, Bartwal A, John R, Tripathi K, Gupta K, Wankhede DP, Mishra GP, Kumar S, Archak S and Bhardwaj R (2022) Evaluation and Multivariate Analysis of Cowpea [Vigna unguiculata (L.) Walp] Germplasm for Selected Nutrients—Mining for Nutri-Dense Accessions. *Front. Sustain. Food Syst.* 6:888041. doi: 10.3389/fsufs.2022.888041

Padhi SR, John R, Bartwal A, Tripathi K, Gupta K, Wankhede DP, Mishra GP, Kumar S, Rana JC, Riar A and Bhardwaj R (2022) Development and optimization of NIRS prediction models for simultaneous multi-trait assessment in diverse cowpea germplasm. Front. Nutr. 9:1001551. doi: 10.3389/fnut.2022.1001551

Padmavati G Gore, Neeta Singh and Veena Gupta (2022) Grain Legumes Diversity of Indian National Genebank: A Potential Resource for Food and Nutritional Security. *Indian Journal of Plant Genetic Resources* 35(3): 191-193.

Paliwal R, R Singh, DR Choudhury, G Tiwari, A Kumar, KC Bhatt and Rita Singh (2022) Molecular Characterization of Tinospora cordifolia (Willd.) Miers Using Novel g-SSR Markers and Their Comparison with EST-SSR and SCoT Markers for Genetic Diversity Study. *Genes*. 13. 2042

Pallabika Gogoi, Paras Sharma, Anwesha Mahajan, Giridhar Goudar, Anil Kumar, M. Sreedhar, Mohar

Singh and T. Longwah (2022). Exploring the nutritional potential, anti-nutritional components and carbohydrate fractions of Indian pigmented maize. Food Chemistry Advances, doi.org/10.1016/j.focha.2022.100176.

Panda RR, A Pandey, S Gupta and KC Bhatt (2022) Use of Fruit and Seed Characters for Identification of Edible Artocarpus species in India. IJPGR (accepted).

Pandey A, PK Malav, DP Semwal, S Chander, R Gowthami and KM Rai (2022) Repository of Allium Genetic Resources at ICAR-NBPGR: Prospects and Challenges for Collection and Conservation. Indian J Plant Genet Resour 35(3): 185-190.

Pandey A, V Devi, S Nivedhitha, RK Pamarthi, R Gupta, R Singh, SP Ahlawat and K Singh (2022) Towards Strengthening the National Herbarium of Cultivated Plants with Rice Landrace Diversity. *Indian J. Plant Genet. Resour.* 35(1): 11-20.

Pandey Anjula, Pragya Ranjan, Pavan Kumar Malav, J K Ranjan, Amalendu Ghosh, Supriya Mandal, S P Ahlawat , O P Dhariwal, P K Singh, Chithra Devi Pandey, B S Tomar and Ashok Kumar (2022) Characterization and evaluation of "Arya" melon (*Cucumis melo*) for Agromorphological traits and screening against ToICNDV. *Indian Journal of Agricultural Sciences* 92 (11):120-123.

Pandravada SR, N Sivaraj, M Thirupathi Reddy, V Kamala, P Pranusha, P Saidaiah and K Anitha (2022) Genetic resources of leafy vegetables in Telangana: Diversity, Distribution and conservation. Journal of Plant Development Sciences 14(2):147-155.

Pandravada SR, N Sivaraj, V Kamala, P Pranusha, P and K Anitha (2022) Genetic resources of small millets in Telangana: Diversity, distribution and conservation. Journal of Plant Development Sciences, 14 (10): 819-826.

Panigrahi SK, Tripathi K, Singh R, Kumar R, Sanghamitra P, Wankhede DP, Singh N, Dubey KKD and Gupta K (2022) Evaluation of black gram (*Vigna mungo*) genepool against *Callosobruchus maculatus* and diversity analysis inter se. Indian Journal of Agricultural Sciences 92 (7): 915–9. https://doi.org/10.56093/ijas.v92i7.122390.

Parameswari B, B Bajaru, L Karthikaiselvi, N Sivaraj, SK Mangrauthia, S Nagalakshmi, H Prasanna, M Srinivas, VC Chalam and K Anitha (2022) First report of the association of *Zygocactus Virus X* with dragon fruit (*Hylocereus* spp.) plants from Telangana, India. *Plant Disease* 1:1-2

Parameswari B, B Bhaskar,, L Karthikaiselvi, N Sivaraj, P Pranusha, B Prathibha, SK Mangrauthia, L Saravanan, V Celia Chalam and K Anitha K (2022) Interception of Bean common mosaic virus in bambara groundnut accessions imported from Ghana through RT-PCR. *Indian Journal of Plant Protection* 50: 2 & 3.

Paras Sharma, Giridhar Goudar,Anil Kumar Chandragiri, R. Ananthan, K. Subhash, Anitha Chauhan, T. Longwah, Mohar Singh, Rakesh Bhardwaj, Swarup Kumar Parida, Amit Kumar Singh, Gayacharan and Debasis Chatopadhyay (2022). Assessment of diversity in anti-nutrient profile, resistant starch, minerals and carbohydrate components in different rice bean accessions. *Food Chemistry*, doi.org/10.1016/j.foodchem. 2022 134835.

Parimalan, R. (2022) Can genomics tools assist in gaining insights from the aquatic angiosperms to transform crop plants with multiple carbon concentrating mechanisms to adapt and yield better in challenging environment? *Plant Physiology Reports*, 27(4): 580-589.

Parimalan, R., Maurya, R., Singh, S. (2022). Can omic tools help generate alternative newer sources of edible seed oil? *Plant Direct*, 6(6): e399.

Parimalan, R., Pradheep, K., Mahalingam, A., and Senthilraja, G. (2022). Decline in occurrence and distribution of Sesamum prostratum, a crop wild relative of sesame, along the Eastern coastal region of India. *Ind. J. Plant Genet. Res.*, 35(1): 4-10.

Parimalan, R., Wankhede, DP., Rajkumar, S., Chinnusamy, V., Malik, SK., Baig, MJ., Singh, K., and Henry, R. (2022). Evolution of an intermediate C4 photosynthesis in the non-foliar tissues of the Poaceae. *Photosynthesis Research*, 153: 125-134.

Pooja Kumari, S P Singh, K K Gangopadhyay, V Celia Chalam, Chithra Devi Pandey and Satish Kumar Yadav (2022) Standardization of artificial screening technique for okra enation leaf curl disease resistance in wild okra (*Abelmoschus moschatus* ssp. *Moschatus*) germplasm *Indian J. Agr. Sci.* 92 (10): 1214–1218, October 2022/Article https://doi.org/10.56093/ijas.v92i10.124278

Pooja, B.K., Sethi, S., Bhardwaj, R., Joshi, A., Bhowmik, A. and Grover, M., Investigation of physicochemical quality and textural attributes of muffins incorporated with pea pod powder as a source of dietary fiber and protein. *Journal of Food Processing and Preservation*, p.e16884.

Prabakaran S and V Gupta, 2022 Assessment of morphological variability and diversity analysis in *Abrusprecatorius* (L.)germplasm conserved at National Gene Bank, NBPGR. *The Pharma Innovation* 11 (10): 1164-1172.

Pradheep K, SP Ahlawat, S Nivedhitha and Veena Gupta (2022) Crop Wild Relatives in India: Inventorization, Prioritization and Conservation. *Indian Journal of Plant Genetic Resources*, 35 (3): 124-130

Pradheep, K., M. Latha, E. Roshini Nayar, and K. V. Bhat (2022). "Misidentification of Macrotyloma sar-garhwalensis RD Gaur & LR Dangwal and its implication in horsegram germplasm management." *Genet. Resour. Crop Evol.*69: 939-948.

Pragya Ranjan, Pratibha Brahmi, Vandana Tyagi, JK Ranjan, Vartika Srivastava, SK Yadav, SP Singh, Surender Singh, PC Binda, SK Singh and Kuldeep

Singh (2022) Global interdependence for fruit genetic resources: status and challenges in India. *Food Security*- Springer

Pranusha P, N Sivaraj, B Parameswari, Pratibha Brahmi and K Anitha (2022) Variability in seed traits and chlorophyll spectrum of exotic bambara nut germplasm. *Journal of Plant Development Sciences* 14 (3): 355-360.

Pranusha P, N Sivaraj, R Parmeshwari, Pratibha Brahmi and K Anitha (2022) Variability in seed traits and chlorophyll spectrum of Bambara nut germplasm. *J. Plant Deve. Sci.* 14(3) 355-360

Prasad G, Mittal S, Kumar A, Chauhan D, Sahu TK, Kumar S, Singh R, Yadav MC and Singh AK (2022). Transcriptome Analysis of Bread Wheat Genotype KRL3-4 Provides a New Insight Into Regulatory Mechanisms Associated With Sodicity (High pH) Tolerance. *Front. Genet.* 12:782366. DOI: 10.3389/fgene.2021.782366

Prasad NHP, A Kumar, SK Lal, P Shah, J Akhtar and SK Jha (2022) Assessment of relative performance of different genotypes of brinjal against fruit rot infection by artificial inoculation of *Phomopsis vexans*. *The Pharma Inn. J.* 11(11): 221-224.

Priyadarshi M., Sharma, A., Chaturvedi, K. K., Bhardwaj, R. (2022). Development and Comparison of Regression Models for Determination of Starch in Chickpea Using NIR Spectroscopy. International Journal of Agriculture, Environment and Biotechnology. 15(03): 683-691. DOI: 10.30954/0974-1712.03.2022.4

Priyadarshi M., Sharma, A., Chaturvedi, K. K., Bhardwaj, R., Lal, S.B., Farooqi, M. S., Kumar, S., Mishra, D. C., Singh M., (2022). Machine Learning Algorithms for Protein Physicochemical Component Prediction Using Near Infrared Spectroscopy in Chickpea Germplasm. *Indian J. Plant Genet. Resour.* 35(1): 44–48.

Priyadarshi M., Sharma, A., Chaturvedi, K. K., Bhardwaj, R., Lal, S.B., Farooqi, M. S., Kumar, S., Mishra, D. C., Singh M., (2022). Comparing Various Machine Learning Algorithms for Sugar Prediction in Chickpea using Near-infrared Spectroscopy. *Legume Research*. DOI 10.18805/LR-4931.

Priyadarshi, M.B., Sharma, A., Chaturvedi, K.K., Bhardwaj, R. and Singh, M. (2022). development and comparison of regression models for determination of starch in chickpea using NIR spectroscopy. *International Journal of Agriculture, Environment and Biotechnology*. 15(3) 683-691

Puran Chandra, Tripathi K, Pragya, Sunil Archak, Vandana Tyagi and Pratibha Brahmi (2022). ITPGRFA: an Appraisal as a Prelude to the Ninth Session of the Governing Body 2022, New Delhi. *Indian J. Plant Genet. Resour.* 35(2): 159–168 (2022) 159 DOI 10.5958/0976-1926.2022.00016.X.

R.C. Misra, A. P. Raina and S. P. Ahlawat. (2022). Note on *Ocimum africanum* Lour. :New distributional record of wild basil for Odisha and central India. *e-planet*, 20 (1): 33-39

Raghunandan K, Tanwar J, Patil SN, Chandra AK, Tyagi S, Agarwal P, Mallick N, Murukan N, Kumari J, Sahu TK, Jacob SR, Kumar A, Yadav S, Nyamgoud S, Vinod, Singh AK, Jha SK. (2022) Identification of Novel Broad-Spectrum Leaf Rust Resistance Sources from Khapli Wheat Landraces. *Plants*. 11(15): 1965.

Raina A.P. and Misra R.C. (2022). Essential oil composition of *Hedychium* species from India. *Medicinal Plants – Int J Phytomedicines and Related Industries* 14(2): 334-339.

Raina A.P. and Misra R.C. (2022). *Zingiber zerumbet* (L.) Roscoe ex Smith: A potential source of zerumbone rich essential oil. *Medicinal Plants: Int J Phytomedicines and Related Industries* 14 (1): 162-168.

Raja MT, K Nithya, B Parameswari and R Viswanathan (2022) Ultrasensitive nano-gold labelled, duplex lateral flow immunochromatographic assay for early detection of sugarcane mosaic viruses. *Scientific Reports* 12: 4144.

Ramya KR, Tripathi K, Pandey A, Barpete S, Gore PG, Raina AP, Khawar KM, Swain N and Sarker A (2022) Rediscovering the Potential of Multifaceted Orphan Legume Grasspea- a Sustainable Resource with High Nutritional Values. *Frontiers in Nutrition*, 8: 826208.

Ranebennur Hemavati, K Rawat, A Rao, P Kumari, VC Chalam, N Meshram and GP Rao (2022) Transmission efficiency of a '*Candidatus* Phytoplasma australasia'(16SrII-D) related strain associated with sesame phyllody by dodder, grafting and leafhoppers. *European J. Pl. Path.* 164: 193-208 https://doi.org/10.1007/s10658-022-02550-6

Ranebennur Hemavati, K Kirdat, B Tiwarekar, K Rawat, VC Chalam, AU Solanke, R Yadav, Kuldeep Singh, S Sathe, A Yadav and GP Rao (2022) Draft genome sequence of 'Candidatus Phytoplasma australasia', strain SS02 associated with sesame phyllody disease. *3 Biotech* 12: 107.

Ranjan P, P Brahmi, V Tyagi, JK Ranjan, V Srivastava, SK Yadav, SP Singh, Surender Singh, PC Binda, SK Singh, K Singh (2022) Global interdependence for fruit genetic resources: status and challenges in India. Food Sec. 14: 591–619. https://doi.org/10.1007/s12571-021-01249-6.

Ranjeet R. Kumar, Neha Singh, Sapna Langyan, T. Vinutha, Veda Krishnan, Suneha Goswami, Bhupinder Kumar, Shankar L. Jat, L. N. Yogeesh, Sumer P. Singh, Gyan P. Mishra, C. Tara Satyavathi, Archana Sachdev and Shelly Praveen (2022). Nutritional supremacy of pearl- and foxtail millets: assessing the nutrient density, protein stability and shelf-life of flours in millets and cereals for developing nutri-stable foods. *Journal of Plant Biochemistry and Biotechnology*.

Rashmi Yadav, Partha Ray Choudhury, Anjali Kak Kaul, Veena Gupta, Ashok Kumar and Devendra K Yadava (2022). Status of Genetic Resources in Oilseed Crops and Their Potential Use for Making India Atmanirbhar in Edible Oils. *Indian J. Plant Genet. Resour*. 35(3): 85–89.

Renu Singh, Sapna Langyan, Bharti Rohtagi, Sibananda Darjee, Ashish Khandelwal, Manoj Shrivastava, Richa Kothari, Har Mohan, Shubham Raina, Japleen Kaur, Anita Singh (2022). Production of biofuels options by contribution of effective and suitable enzymes: Technological developments and challenges. Materials Science for Energy Technologies. 5: 294-310.

Renu Singh, Sapna Langyan, Seema Sangwan, Priyanka Gaur, Fatima Nazish Khan, Pranjal Yadava, Bharti Rohatgi, Manoj Shrivastava, Ashish Khandelwal, Sibananda Darjee, Pramod Kumar Sahu (2022). Optimization and production of alpha-amylase using Bacillus subtilis from apple peel: Comparison with alternate feedstock. *Food Bioscience*, 49: 101978,.

RK Arya, JS Hooda, SK Kaushik, S Kumar, HL Raigar, RK Gill, JL Mahto, JK Tiwari, CB Yadav, R Kumar, GS Dahiya, JM Sutaliya, K Raj, R Punia & P Kumar. 2022. Development of new promising varieties of faba bean through traditional pedigree method for commercial cultivation in plain zone of India. *Indian Journal of Traditional Knowledge*. 21(4): 895-904.

S herry Rachel Jacob, Aradhana Mishra, Joseph John K, Veena Gupta (2022) Rapid Viability Test- A tool to aid conservation efforts in *Zanthoxylum rhetsa*(Roxb.) DC. *Journal of Tropical Forest Science* 35(1): 1–9.

Sachin Kumar Verma, Shikha Mittal, Gayacharan, Dhammaprakash Pandhari Wankhede, Swarup Kumar Parida, Debasis Chattopadhyay, Geeta Prasad, Dwijesh Chandra Mishra, Mohar Singh, Kuldeep Singh and Amit Kumar Singh (2022). Transcriptome analysis reveals key pathway and candidate genes controlling seed development and size in rice bean (*Vigna umbellata*). *Front. Genet*. 12:791355, doi: 10.3389/fgene.

Sagar, V., Bhardwaj, R., Devi, J., Singh, S.K., Singh, P.M. and Singh, J., 2022. The inheritance of betalain pigmentation in Basella alba L. *South African Journal of Botany*.

Sahu TK, Singh AK, Mittal S, Jha SK, Kumar S, Jacob SR, Singh K (2022). G-DIRT: a web server for identification and removal of duplicate germplasms based on identity-by-state analysis using single nucleotide polymorphism genotyping data. Briefings in Bioinformatics 23 (5): bbac348, DOI : org/10.1093/ bib/bbac348.

Saidaiah Pidigam, A Geetha, K Nagaraju, S R Pandravada, M Suhail Khan, M Rajasekhar, N Sivaraj and T Vishnukiran (2022) Breeding approaches for the development of nutraceutical vegetables: A Review. *Annals of Phytomedicine* 11(2): 1-10.

Saisupriya P, P Saidaiah and SR Pandravada (2022) Analysis of genetic variability, heritability and genetic advance for yield and yield related traits in chilli (Capsicum annuum L.). *International Journal of Bio-resource and Stress Management*. 13(4): 387-393.

Saisupriya P, P Saidaiah and SR Pandravada (2022) Assessment of genetic divergence for yield and yield related traits in chilli (*Capsicum annuum* L.) germplasm. *Journal of Plant Genetic Resources*, 35 (2): 217-223.

Salej Sood, Vinay Bhardwaj, SK Kaushik, Sanjeev Sharma, Dalamu, Mehi Lal and Manoj Kumar. (2022). Identification of superior parental lines based on BLUP breeding values in potato (*Solanum tuberosum* L.). *Indian J. Genet. Plant Breed*. 82(2): 200-207.

Sapna Langyan, Pranjal Yadava, Fatima Nazish Khan, Zahoor A Dar, Renu Singh, Ashok Kumar (2022). Sustaining Protein Nutrition through Plant-Based Foods. *Frontiers in Nutrition*.

Sapna Langyan, Pranjal Yadava, Sanjula Sharma, Navin Chandra Gupta, Ruchi Bansal, Rashmi Yadav, Sanjay Kalia, Ashok Kumar (2022). Food and nutraceutical functions of Sesame oil: an underutilized crop for nutritional and health benefits, *Food Chemistry* 389: 132990.

Sapna Langyan, Rakesh Bhardwaj, Jyoti Kumari, Sherry Rachel Jacob, Ishwari Singh Bisht, S. R. Pandravada, Archana Singh, P. B. Singh, Zahoor A. Dar, Ashok Kumar, and J. C. Rana. (2022). Nutritional diversity in native germplasm of maize collected from three different fragile ecosystems of India. *Frontier in Nutrition*. DOI: 10.3389/fnut.2022.812599.

Saravanan L and N Sivaraj (2022) Modelling potential spread of oilpalm bagworm *Metisa plana* (Lepidoptera: Psychidae). *Journal of Plant Development Sciences* 14(3):285-293.

Saravanan L, S Nivedhitha, P Pranusha, N Sivaraj, SR Pandravada, A Padmasri and K Anitha (2022) Evaluation of black gram and green gram genotypes for the resistance against Callosobruchus chinensis (L.) and correlation with seed physical parameters. *The Pharma Innovation Journal*, 11 (11): 2596-2601.

Saravanan L, S Nivedhitha, P Pranusha, N Sivaraj, SR Pandravada, A Padmasri and K Anitha (2022) Evaluation of cowpea (Vigna unguiculata (L.) Walp.) germplasm against pulse beetle, Callosobruchus chinensis (L.) and correlation with morphological seed characters. *Legume Research*. DOI: 10.18805/ LR-4986.

Saroha A, D Pal, SS Gomashe, Akash, Vikender Kaur, S Ujjainwal, S Rajkumar, J Aravind, J Radhamani, R Kumar, D Chand, A Sengupta and DP Wankhede (2022) Identification of QTNs Associated With Flowering Time, Maturity, and Plant Height Traits in *Linum usitatissimum* L. Using Genome-Wide Association Study. *Front. Genet*. 13:811924.

Saroha, A., Pal, D., Kaur, V. Kumar S, Bartwal A, J. Aravind, J. Radhamani, S. Rajkumar, Kumar R, Gomashe SS, Sengupta A, Wankhede DP (2022). Agro-morphological variability and genetic diversity in linseed (*Linum usitatissimum* L.) germplasm accessions with emphasis on flowering and maturity time. *Genet Resour Crop Evo*.

Sethi, S., Joshi, A., Seth, K., Bhardwaj, R., Yadav, A. and Grover, M. (2022). Phytonutrient content, antioxidant potential and acceptability of muffins functionalized with soy and citrus industry waste. *Journal of Food Processing and Preservation*, p.e16606.

Sharma N, EV Malhotra, R Chandra, R Gowthami, SM Sultan, S Bansal, M Shankar and A Agrawal (2022). Cryopreservation and genetic stability assessment of regenerants of the critically endangered medicinal plant Dioscorea deltoidea Wall. ex Griseb. for cryobanking of germplasm. In Vitro Cell Dev Biol-Plant 58: 521–529.

Sharma R, Singh M and Randhawa G (2022) Efficient molecular method/s for detection of Bt brinjal Event 142. *Current Science*, 122 (4): 464-468

Shekhawat, N., Meena, V.S., Singh, K., Rani, K. and Gupta, V. (2022). Studies on Genetic Variability, Heritability and Geneti Advance for Morphological Traits in Fenugreek (*Trigonella foenum-graecum* L.) for Arid Climate of Rajasthan. *Legume Research*. DOI: 10.18805/LR-5046.

Shekhawat, N., Sharma, H and Shekhawat, R. S. (2022). Assessment of agro-morphological and molecular diversity among Indian mustard (*Brasssica juncea*) genotypes. *Indian Journal of Agricultural Science,* 92 (7): 821-824.

Shekhawat, N., Sharma, Hand Chandrawat, K. S. (2022). Heterosis and combining ability analysis for yield and its component traits in Indian mustard (*Brassica juncea* L.). *Indian Journal of Agricultural Sciences* 92 (8): 952-956.

Shilpa P., U. Sreelatha, J.S. Minimol, Mini Sankar and A. Suma (2022). Evaluation of growth parameters and yield attributes of marigold genotypes under humid tropical plains. *Journal of Tropical Agriculture* 60(1): 87-93

Shivran M, N Sharma, AK Dubey, SK Singh, N Sharma, RM Sharma, N Singh and R Singh (2022) Scion–Rootstock Relationship: Molecular Mechanism and Quality Fruit Production. *Agriculture*. 12, 2036.

Shweta Kumari, Ujjainwal S, Singh N., Archak S, Wankhede D.P (2022). Development of Genic Simple Sequence Repeat Markers as Novel Genomic Resources in Dolichos Bean (Lablab purpureus L.) *Indian J. Plant Genet. Resour*. 35(1): 80–84 (2022) DOI 10.5958/0976-1926.2022.00012.2

Shyam Kumar Sharma, Nikhil Malhotra and Mohar Singh (2022). Plant genetic resources for crop improvement: The North-Western Himalayan perspective. *Indian J. Plant Genet. Resour*. 35(3): 151-153.

Sibananda Darjee, Manoj Shrivastava, Sapna Langyan, Geeta Singh, Rakesh Pandey, Avadhesh Sharma, Ashish Khandelwal, Renu Singh (2022). Integrated nutrient management reduced the nutrient losses and increased crop yield in irrigated wheat. *Archives of Agronomy and Soil Science*. 12: 0365-0340.

Singh A, Verma SK, Prasad G, Kumar A, Sharma PC, Singh AK (2022) Elucidating genetic diversity and population structure in jamun [Syzygium cumini L.(Skeels)] using morpho-physiological traits and CAAT box-derived polymorphism. *South Afri J Bot*. 51, 454:464

Singh AK, SK Raina and M Kumar *et al* (2022) Modulation of GmFAD3 expression alters abiotic stress responses in soybean. *Plant Molecular Biology* 110: 199-218

Singh B, Chaudhury R., Rai K M, Bhatt K C, Gupta Veena, Negi N, Singh Shivani and Ahlawat S P (2022). Seed physiological studies in six wild *Prunus* species of Indian Himalayas: implications for their cryobanking. *Vegetos*, 1-17.

Singh D, H Singh, MC Singh, C Kant, BP Singh and RP Singh (2022). Biological Control of Weeds using Different Means. *International J. Tropical Agricul*. 40(3-4): 411-417.

Singh J, R Agarwal, BM Bhasyal, K Darshan, BR Meena, J Yadav, MS Saharan and Z Hussain (2022) Temporal transcriptome of tomato elucidates the signalling pathways of induced systemic resistance and systemic acquired resistance activated by *Chaetomium globosum*. *Front. Genet.* 13

Singh J, R Agarwal, BM Bhasyal, K Darshan, BR Meena, J Yadav, S Aditya and Z Hussain (2022) Different delivery methods of biocontrol agent *Chaetomium globosum*. *J. Community Mobilization Sustain. Dev.* 17(2): 420-428.

Singh K, J Akhtar, N Shekhawat, VS Meena, A Gupta, BR Meena, R Yadav, V Gupta and A Kumar (2022) Identification of new source of resistance against white rust. *J. Oilseed Brassica,* 13(2): 100-104.

Singh M, Kaur K, S Sharma, A Paliwal, M Singh, R Aminedi, V Kaur & G Randhawa (2022) Assessment of risk of GM contamination in flaxseed accessions imported from Canada: a case study to restrict the unauthorized GM events from entering India. *Plant Genetic Resources: Characterization and Utilization*, 20(1), 76-78.

Singh MC, BS Phogat and VC Chalam (2022) Growth and yield analysis under amaranth based inter-cropping system. *International J. Tropical Agricul*. 40(3-4): 419-422.

Singh MC, VC Chalam, D Singh, S Kumar and S Gnansambandhan (2022) Risk associated with the weed seeds in imported grain. *Indian J. Weed Sci.* 54(4): 370-375.

Singh N, Ujinwal M, Langyan Sapna, Sayyed RZ, El Enshasy HA, Kenawy AA (2022) Genome-wide exploration of sugar transporter (sweet) family proteins in Fabaceae for Sustainable protein and carbon source. *PLoS ONE* 17(5): e0268154. https://doi.org/10.1371/journal.pone.0268154

Singh R and R Kumar (2022) Genomic Resource Generation in Medicinal and Aromatic Plants. *Indian J. Plant Genet. Resources* 35(3): 204–212.

Singh R, Langyan Sapna, Sangwan S, Rohtagi B, Khandelwal A and Shrivastava M (2022) Protein for human consumption from oilseed cakes: A review. *Front. Sustain. Food Syst.*

Singh R., Mahato A.K., Singh A., Kumar R., Singh, A.K.; Kumar, S.; Marla, S.S.; Kumar, A.; Singh, N.K.(2022). Tino Transcript DB: A Database of Transcripts and Microsatellite Markers of Tinospora cordifolia, an Important Medicinal Plant. *Genes* 13: 1433. https:// doi.org/10.3390/ genes13081433

Singh, Nisha, Priyanka Jain, Megha Ujinwal, and Sapna Langyan. "Escalate protein plates from legumes for sustainable human nutrition." Frontiers in Nutrition 9 (2022). *Front Nutr*. 2022; 9: 977986. Published online 2022 Nov 4. doi: 10.3389/fnut.2022.977986

Singh, R.K., Bhardwaj, R., Sureja, A.K., Kumar, A., Singh, A., Hazarika, B.N., Hussain, S.M., Singh, A., Lego, Y.J. and Rallen, O. (2022). Livelihood resilience in the face of multiple stressors: biocultural resource-based adaptive strategies among the vulnerable communities. *Sustainability Science*, *17*(1), pp. 275-293.

Singh, R.K., Singh, A., Kumar, S., Sheoran, P., Jat, H.S., Sharma, P.C., Sharma, D.K., Hazarika, B.N., Bhowmik, S.N., Sureja, A.K. and Bhardwaj, R. (2022). Experimental co-production of knowledge to adapt to environmental change in northern India. *Environmental Science & Policy*, *136*, pp. 357-368.

Singh, S., Kaur, A., Kakkar, P., Dhar, S., Madduru, D., Yasin, J.K., Banerjee, A. and Suravajhala, R., (2022). Post-COVID-19 Pandemic Impact Assessment of Bioinformatics and Women Bioinformaticians: A Realm of Possibilities or Gloom-Ridden The Open COVID Journal, 2(1).

Sivaraj N, SR Pandravada, Anuradha Agrawal, V Kamala, V. Celia chalam and K Anitha (2022) Application of Geographical Information System for PGR Management. *Indian J. Plant Genet. Resour*. 35(3): 136–140.

Sivaraj N, SR Pandravada, V Kamala, K Anitha, S Backiyarani, MS Saraswathi, P Durai and S Uma (2022). Ecological Niche modelling for Manoranjitham, a endemic and threatened banana cultivar of Eastern Ghats, South India. *Journal of Plant Development Sciences* 14(1): 1-9.

Sneha Adhikari, Jyoti Kumari, Sherry Rachel Jacob, Pramod Prasad, O. P. Gangwar, Charu Lata, Rajnikant Thakur, Amit Kumar Singh, Ruchi Bansal, Sundeep Kumar, S. C. Bhardwaj, Subodh Kumar (2022). Landraces-potential treasure for sustainable wheat improvement. *Genet Resour Crop Evol*. 69:499–523 DOI: 10.1007/s10722-021-01310-5

Sofi PA, Mir RR, Gull M, Shafi S, Zaffar A, Gani S, Tripathi K (2022) Characterization of cowpea landrace diversity of Kashmir: pattern of variation for morphological and yield traits and resistance to mosaic virus. *Range Management and Agroforestry* 43(1): 25-32.

Srivastava V, Bhatt KC & Agrawal A (2022). In vitro medium-term conservation of Garcinia indica: a tropical recalcitrant seeded fruit tree of India. In Vitro Cell.Dev.Biol.-Plant (2022). https://doi.org/ 10.1007/s11627-022-10288-3

Srivastava V, S Hajong, R Chandora, A Agrawal (2022) Desiccation and freezing tolerance of recalcitrant seeds and embryonic axes of Prunus napaulensis (Ser.) Steud.: a crop wild relative of cherry. Genet Resour Crop Evol 69: 1571–1583. https://doi.org/ 10.1007/s10722-021-01320-3

Subarna Hajong, Krishnappa Rangappa, Harish Ganjalagatta Dasaiah, Prabha Moirangthem, Uday Sankar Saikia, Bijoya Bhattacharjee, Sudhir Pal Ahlawat and Basant Kumar Kandpal (2022) Genotypic variability and physio-morphological efficiency of buckwheat (*Fagopyrum* spp.) under moisture stress at mid-altitudes of Meghalaya (India) *Crop & Pasture Science* DOI:10.1071/CP22062.

Suma A, M A Alfia, K Joseph John, K Pradheep, G D Harish, P PThirumalaisamy and M Latha (2022) On the development of descriptors in small bitter gourd (*Momordica charantia*L. var. *muricata* (Willd.) Chakrav). *Genet Resour Crop Evol*: 70:289–308

Suma A., Joseph J. K., M Latha, M. A. Alfia and A. C. Asna (2022). Characterization of small bitter gourd germplasm collections from various agro-ecological zones of India. *Indian J. Hortic*. 79(3): 280-286

Suma, A., Francies RM., Radhakrishnan,VV., Sureshkumar,P. and Eldho Varghese (2022) Elucidating the Response of Rice Genotypes to Iron Toxicity through Hydroponics. *Indian J. Plant Genet. Resour*. 35 (1): 66-72.

Suma, A., M. A. Alfia, K. Joseph John, K. Pradheep, G. D. Harish, P.P. Thirumalaisamy and M. Latha. On the development of descriptors in small bitter gourd (*Momordica charantia* L. var. *muricata* (Willd.) Chakrav). *Genet Resour Crop Evol*.

Talavar Basavaraja, L. Manjulatha, Rahul Chandora, Mohar Singh, Santosha Rathod, Vikas Dubey, Farindra Singh and Narendra Pratap Singh (2022). Assessment of phenotypic diversity and multi-locational screening against bean common mosaic virus disease resistance in dry bean germplasm. *Plant Genetic Resources*: Cambridge, doi.org/10.1017/ S14796374850012.

Tomar, M., Bhardwaj, R*., Verma, R., Singh, S.P., Krishnan, V., Kansal, R., Yadav, V.K., Praveen, S. and Sachdev, A. (2022). Interactome of millet-based food matrices: A review. *Food Chemistry*, p.132636.

Tripathi K, Sadhukhan R, Das A, Jana K, Semwal DP, Kumar A, Sarker A and Ahlawat SP (2022). An expedition collection of Khesari (*Lathyrus sativus* L.) landraces from parts of West Bengal. *Indian Journal of Traditional Knowledge* 21(2): 395-403.

Tripathi, K, Pamarthi RK, Gore, PG, Nagaraju S, Latha M, Gayacharan, Ahlawat SP, Rana JC, Pratap A and Kumar A (2022) Identification and development of key descriptors for phenotypic characterization of tuber cowpea [*Vigna vexillata* (L.) A. Rich.]. *Genetic Resources and Crop Evolution* 69: 1375–1389.

Verma SK, Mittal S, Gayacharan, Wankhede DP, Parida SK, Chattopadhyay D, Prasad G, Mishra DC, Joshi DC, Singh M, Singh K and Singh AK (2022) Transcriptome Analysis Reveals Key Pathways and Candidate Genes Controlling Seed Development and Size in Ricebean (*Vigna umbellata*). *Front. Genet.* 12:791355. doi: 10.3389/fgene.2021.791355

Verma SK, Singh CK, Taunk J, Gayacharan , Chandra Joshi D, Kalia S, Dey N and Singh AK (2022). Vignette of Vigna domestication: From archives to genomics. *Front. Genet.* 13:960200. doi: 10.3389/fgene.2022.960200

Verma, R., Singh, N., Tomar, M., Bhardwaj, R., Deb, D. and Rana, A. (2022). Deciphering the growth stage specific phytochemical diversity patterns in Murraya koenigii (L.) Spreng. using multivariate data analysis. *Frontiers in Plant Science*, 13:963150:

Vikas VK, Pradhan AK, Budhlakoti N, Mishra D, Chandra T, Bhardwaj SC, Kumar S, Sivasamy M, Jayaprakash P, Nisha R, Shajitha P, Peter J, Geetha M, Mir R, and Singh K, Kumar S (2022). Multi-locus genome-wide association studies (ML-GWAS) reveal novel genomic regions associated with seedling and adult plant stage leaf rust resistance in bread wheat (*Triticum aestivum* L.). *Heredity* DOI: 10.1038/s41437-022-00525-1

Viswanathan R, SP Singh, R Selvakumar, Dinesh Singh, Y P Bharti, M L Chhabra, B. Parameswari, Anuradha Sharma, Md. Minnatullah (2022) Varietal Break Down to Red Rot in the Sugarcane Variety Co 3 0238 Mimics Vertifolia Effect: Characterizing New *Colletotrichum falcatum* Pathotype CF13. Sugar Tech.

Meena VS, R Yadav, HL Raiger, K Singh, R Parimalan, N Shekhawat and V Gupta (2022). Morphological characterization of sesame germplasm in semi arid conditions of Delhi, *Annals of arid zone*, 61(2): 135-138.

Wankhede DP, Singh R, Rajkumar S (2022) Genomic Tools in Plant Genetic Resource Management. *Indian Journal of Plant Genetic Resources* 35(3):194-199.

Yadav B, Kaur V, Narayan OP, Yadav SK, Kumar A and Wankhede DP (2022). Integrated omics approaches for flax improvement under abiotic and biotic stress: Current status and future prospects. *Front. Plant Sci.* 13: 931275.

Yadav DN, S Tushir, S Sethi, NA Mir, R Wadhwa, Sangita Bansal (2022). A superior approach for production of protein isolates from de-oiled soy meal and its comparison with conventional method. International Journal of Food Science and Technology 57: 6245-6254.

Yadav, R., Kalia, S., Rangan, P., Pradheep, K., Rao, G.P., Kaur, V., Pandey, R., Rai, V., Vasimalla, C.C., Langyan, S. and Sharma, S., (2022). Current Research Trends and Prospects for Yield and Quality Improvement in Sesame, an Important Oilseed Crop. *Frontiers in Plant Science*, *13*, pp.863521.

20.9.2 Books

Anjali Kak, Veena Gupta, Sunil Archak and A Kumar. (2022) Seventy five unique trait specific germplasm identified by ICAR-National Bureau of Plant Genetic Resources. N. Delhi 84 P.

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. ISBN 978-81-952644-7-6.

Chalam VC, Kavita Gupta, MC Singh, Z Khan, Jameel Akhtar, Bharat Gawade, Pardeep Kumar, Pooja Kumari, Bharat Raj Meena, AK Maurya and DS Meena (2022) *75 Quarantine Pests Intercepted Ensuring Crop Biosecurity*. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, 84 p. (Submitted)

Malik SK, Sangita Bansal, RK Kakoti, and SP Ahlawat (2022). Collection, conservation and morpho-phenological characterization of citrus germplasm of North East region. Information Brochure. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India.

Malik SK, Sangita Bansal, RK Kakoti, J Uchoi and SP Ahlawat (2022). Management of Citrus Genetic Resources: SOPs for collection and conservation. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India. pp. viii+68.

Raghavendra KV, S Subash, O Navik, GK Rao, R Gowthami and S Sharma (2022). Genetic and molecular approaches for management of potato viral diseases and their vectors. In: Chakravarthy AK (eds) Genetic methods and tools for managing crop pests. Springer, Singapore. Pp. 361-387.

Tyagi Vandana, Pratibha Brahmi, SK Yadav, Pragya, Puran Chandra and Ashok Kumar (2022), 75 unique introductions in plant genetic resources. ICAR-NBPGR, New Delhi XI+ 78

20.9.3 Chapters in books, review articles, proceedings, bulletin, manuals, etc

Arya, L., Singh, M., Singh, A.K., Verma, M. (2022). Paradigm Shift from Genetics to Genomics: Characterization of Diversity and Prospects of Molecular Markers. In: Kumar, A., Sood, S., Babu, B.K., Gupta, S.M., Rao, B.D. (eds) The Finger Millet Genome. Compendium of Plant Genomes. Springer, Cham.

Boopathi T, Kavita Gupta, SP Singh, S Subramanian and SC Dubey (2022) Molecular Characterization and Genetic Interventions in an Invasive Spiralling Whitefly *Aleurodicus dispersus* Russell In: *Genetic Methods and Tools for Managing Crop Pests* AK Chakravarthy (Ed) Springer Nature Singapore Pte Ltd. ISBN 978-981-19-0263-5. pp 537-557.

Chander S, B Kumar, K Kumar *et al.* (2022). Male Sterility in Maize: Retrospect, Status and Challenges. Plant

Male Sterility Systems for Accelerating Crop Improvement. pp. 43-55.

Dikshit HK, Mishra GP, Aski MS, Tripathi K, Bansal R, Pratap A, Gupta S and Kumar S (2022). Lentil Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore

Gore, PG, Gowthami R, Tripathi K, Malav P, Tyagi V, Singh and Gupta V (2022). Genetic Resources. In: Galanakis, C.M. (eds) Environment and Climate-smart Food Production. Springer, Cham. pp. 109-149.

Gupta Kavita and Dubey SC (2022) Phytosanitary Standards and International Exchange of Potato. In: Chakrabarti, S.K., Sharma, S., Shah, M.A. (eds) Sustainable Management of Potato Pests and Diseases. Springer, Singapore

Gupta S (2022). *In Vitro* Propagation and Conservation of *Fragaria* Species In: Strawberry. Nesibe EK (Ed.) Intechopen, London, UK, pp 1-14. DOI: http://dx.doi.org/10.5772/intechopen.103095. (Online published).

Kaur, G., Sharma, S., Langyan, S., Kaur, J., Yadava, P., Banga, S.S. (2022). Advanced Breeding for Oil and Oil Cake Quality in Brassica juncea. In: Kole, C., Mohapatra, T. (eds) The *Brassica juncea* Genome. Compendium of Plant Genomes. Springer, Cham.

Kumar P, J Akhtar and R Kiran (2022). Effect of seed-borne pathogens in quality seeds production. *In:* Evergreen Technologies for Indian Agriculture, R Tiwari, DS Tomar and SK Kaushik (eds.), Narendra Publishing House, Delhi, pp 422-436.

Mahin Haque, Sapna, Renu Singh, Ayasha Nadeem, Saiema Rasool, Javaid A. Wani, Andleeb Khan, Mohammad Ashafaq, Hafiz A. Makeen, Uzma Zehra, Chapter 19 - Nigella sativa: A promise for industrial and agricultural economic growth, Editor(s): Andleeb Khan, Muneeb Rehman, Black Seeds (Nigella Sativa), Elsevier, 2022, Pages 439-460, ISBN 9780128244623.

Manjunath M and P Holajjer (2022) Bioinoculants for horticultural production systems. In training manual "Natural Resource Management for Sustainable Dryland Horticulture" (Edited by AGK Reddy, B. Renuka Rani, Josily Samuel, Pushpanjali and Jagati Yadagiri). Published by ICAR-Central Research Institute for Dryland Agriculture, Hyderabad and National Institute of Agricultural Extension Management, Hyderabad. Pp. 114-118.

Meena PD, J Akhtar, AK Gupta, BR Meena, S Mehta, K Monika, GS Saharan and N Mehta (2022) *Alternaria-Brassica* pathosystem: development and perspective. *J. Oilseed Brassica*, 13(2): 65-89.

Mishra GP, Dikshit HK, Tripathi K, Aski MS, Pratap A, Dasgupta U, Nair RM and Gupta S (2022). Mungbean Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore.

Monika, N Yadav, Mamta, N Kumar, A Kumar, Sarita Devi, Vikender Kaur, S Kumar and SS Arya (2022). Arbuscular Mycorrhizal Fungi: A Potential Candidate for Nitrogen Fixation. In: Vaishnav, A., Arya, S., Choudhary, D.K. (eds) Plant Stress Mitigators. Springer, Singapore. Pp 217-234. https://doi.org/10.1007/978-981-16-7759-5_11

Meena NL, R. Bhardwaj,O.P Gupta, V. S. Meena, A. Singh and A. Tyagi (2022). Application of high-throughput structural and functional genomic technologies. Bioinformatics in Agriculture (Edited by P. Sharma, D. Yadav and R. K. Gaur).Academic Press, Elsevier, London Wall, London EC2Y 5AS, U.K.

Parihar AK, Yadav R, Lamichaney A, Mishra RK, Chandra A, Gupta DS, Tripathi K, Hazra KK and Dixit GP (2022). Field Pea Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore.

Pradheep K (2022) Wild relatives of tuber crops and minor tubers in India. In: P Murugesan, V Chandra, AVV Koundinya and V Pandey (Eds). *Sustainable exploitation of genetic resources of under-utilized tuber crops*, ICAR-CTCRI, Sreekaryam, Thiruvananthapuram pp 18-24.

Ram, K., Devi, S., Singh, A., Kaur, V., Kumar, J., Arya, S.S. (2022). Microorganisms: The Viable Approach for Mitigation of Abiotic Stress. In: Vaishnav, A., Arya, S., Choudhary, D.K. (eds) Plant Stress Mitigators. Springer, Singapore. Pp 323-339.

Rashmi Yadav, Padmavati Ganpat Gore, Veena Gupta, Saurabh and Kadambot H.M. Siddique. (2022). Quinoa (Chenopodium quinoa Willd.)da smart crop for food and nutritional security. In: Muhammad Farooq and Kadambot H.M. Siddique (eds) Neglected and Underutilized Crops. Academic Press, Elsevier ISBN: 978-0-323-90537-4. Pp. 23-39

Sakkiah, S., Lee, K. W., Selvaraj, C., Singh, B. K., eds. (2022). Novel Therapeutic Interventions Against Infectious Diseases: COVID-19. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88974-846-4. ISBN 978-2-88974-846-4

Sherry Rachel Jacob, Sundeep Kumar and Jyoti Kumari (2022) Wheat Genetic Resources of India. Scientific India, April 2022 Issue.

Singh M, EV Malhotra, V Srivastava, J Ahlawat (2022) Structure and organization of plant nuclear genome. In: *Singh, R.L., Mondal, S., Parihar, A., Singh, P.K. (eds) Plant Genomics for Sustainable Agriculture*. Springer, Singapore. pp. 15-40.

Singh M, R Aminedi, P Palit & G Randhawa (eds). 2022. Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. Published by ICAR-NBPGR, New Delhi under DBT funded "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material". pp. XV+86.

Singh SK, S Pradhan, H Krishna, M Alizadeh, C Kumar, NV Singh, AK Jadhav, D Ramajayam, R Dev and R

Singh (2022) Development of Abiotic Stress Resistant Grapevine Varieties. In: Kole, C. (eds) Genomic Designing for Abiotic Stress Resistant Fruit Crops. Springer, Cham.

Singh, MC, VC Chalam, D Singh, D Sreekanth and S Kumar. (2022). Weed risk assessment: A tool to assess potential invasiveness of new plants. *Technological glimpses on weeds and their management*. Directorate of Weed Research, Jabalpur (MP). Pp. 26-30.

Singh, Renu, Sapna Langyan, Mahin Haque, and Manoj Shrivastava. "Bioeconomy: Scope Current Status and Challenges." Biomass, Bioenergy & Bioeconomy (2022): 233-248.

Sivaraj N, SR Pandravada, V Kamala, Siva Ramamoorthy, and K Anitha (2022) Plant Genetic Resources Management in the Framework of Policy Developments. In: Siva Ramamoorthy, Inocencio Jr. Buot and Rajasekaran Chandrasekaran (Eds.) Plant Genetic Resources, Inventory, Collection and Conservation. Springer, Singapore. Pp. 389-410

Sundeep Kumar, Amit Kumar Singh, Ruchi Bansal, Jyoti Kumari, Sunish Kumar Sehgal (2022). Effect of Climate Change on Crop Productivity: Current Status and Steps Towards Fulfilling the Yield Gaps (2022). Published in: Sanger et al. (eds.). Handbook of Research on Green Technologies for Sustainable Management of Agricultural Resources, Publisher: Engineering Science Reference (an imprint of IGI Global), 701 E. Chocolate Avenue Hershey PA, USA 17033, DOI: 10.4018/978-1-7998-8434-7.ch002

Tripathi, K., Gore, P.G., Ramya, K.R., Sarker, A. (2022). Grass Pea an Inherent Abiotic Stress-Tolerant Legume: Current Status and Future Scope Under Changing Environment. In: Jha, U.C., Nayyar, H., Agrawal, S.K., Siddique, K.H.M. (eds) Developing Climate Resilient Grain and Forage Legumes. Springer, Singapore.

Veeranagappa, P, Manu B, Ganesh Prasad, M. Blair W, Hickok D, Naveena NL, Manjunath L and Tripathi K (2022). Advanced Breeding Strategies for Abiotic Stress Tolerance in Cowpea. In: Kole, C. (eds) Genomic Designing for Abiotic Stress Resistant Pulse Crops. Springer, Cham. pp. 115-144.

Viswanathan R, N Geetha, A Anna Durai, P T Prathima, C Appunu, B Parameswari, K Nithya, T Ramasubramanian and A Selvi (2022) Genomic Designing for Biotic Stress Resistance in Sugarcane. In: Kole C. (eds) Genomic Designing for Biotic Stress Resistant Technical Crops. Springer, Cham

Yadava, D.K., Rashmi Yadav, Harinder Vishwakarma, Yashpal, Sangita Yadav, Navinder Saini and Sujata Vasudev (2022). Genetic Diversity Characterization and Population Structure in *Brassica juncea*. In: Kole, C., Mohapatra, T. (eds) The Brassica juncea Genome. Compendium of Plant Genomes. Springer, Cham Online ISBN: 978-3-030-91507-0; Print ISBN: 978-3-030-91506-3 pp. 73-84

Yasin, J.K., Khan, M., Wani, S.H., Pillai, M.A., Verma, N., Pandey, P. and Singh, K., 2022. Genomics in Crop Improvement: Potential Applications, Challenges and Future Prospects. Agricultural Biotechnology: Latest Research and Trends, pp.329-349.

20.9.4 Manuals / research bulletin / information bulletin/ brochure

Akhtar J, P Kumar, BR Meena, R Kiran, A Tripathi, AK Maurya and Sadhana (2022) Detection and identification of plant pathogenic fungi and bacteria in exotic plant genetic resources. *In:* 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. pp 58-64.

Chalam VC, K Gupta, J Akhtar, Z Khan, K Kalaiponmani, A Tripathi, P Yadav and A Kumar (eds). (2022) 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 at ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012. XXII + 233 p.

Chalam VC, K Gupta, J Akhtar, Z Khan, MC Singh, BH Gawade, P Kumari, P Kumar, R Kiran, BR Meena, AK Maurya and DS Meena (2022) Biosecurity and Biosafety: Concepts, International and National Framework for Safe Transboundary Movement of Transgenics. *In:* 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. 17-27pp

Chalam VC, K Gupta, Z Khan, J Akhtar, MC Singh, BH Gawade, P Kumari, P Kumar, BR Meena, AK Maurya, DS Meena, K Kalaiponmani, A Tripathi and P Yadav (2022) 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 et al., organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi. pp 14-23.

Chalam VC, Kavita Gupta, Z Khan, J Akhtar, MC Singh, BH Gawade, P Kumari, P Kumar, BR Meena, R Kiran, AK Maurya, DS Meena, K Kalaiponmani, A Tripathi and Priya Yadav (2022) 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 et al., organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi. 14-23pp.

Chalam VC, P Kumari, K Kalaiponmani, P Yadav and AK Maurya (2022) Detection and Identification of Viruses in Quarantine *In:* 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. pp 71-79.

Gawade BH and Z Khan (2022) Detection and identification of plant parasitic nematodes in quarantine. *In:* 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. pp 211-215.

Gawade BH, VC Chalam, K Gupta, MC Singh, Z Khan, J Akhtar, P Kumar, BR Meena, R Kiran, AK Maurya, DS Meena and Sadhana (2022) 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 et al., organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi. pp 140-148.

Gupta K, SC Dubey (2022). Phytosanitary Standards and International Exchange of Potato. In: Chakrabarti, S.K., Sharma, S., Shah, M.A. (eds) Sustainable Management of Potato Pests and Diseases. Springer, Singapore.

Gupta Kavita and V Celia Chalam (2022) Pest Risk Analysis: Concepts and Methodology. In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, K Gupta, J Akhtar, Z Khan, K. Kalaiponmani, A Tripathi and P Yadav and A Kumar organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR from 2-11 August, 2022. pp pp 105-112.

Gupta Kavita, DS Meena and SK Panigrahi *(2022)* Detection and Identification of Insect and Mite Pests in Exotic Germplasm and Salvaging of Infected/Infested PGR In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, K Gupta, J Akhtar, Z Khan, K. Kalaiponmani, A Tripathi and P Yadav and A Kumar organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR from 2-11 August, 2022. pp 197-202.

Gupta Kavita, DS Meena, Aaqib Ali and SH Yadav (2022) Detection and Identification of Insects and Mites in Quarantine In: *Training Manual of Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues*. (eds) Chalam VC, Kavita Gupta, J Akhtar, Z Khan and Ashok Kumar organized under DBT-sponsored project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR. pp 51-57

Joshi, Monika A., Yadav, Sangita and Gupta Veena. 2022. Practical Manual on Seed Developmental Biology. Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi. pp. 103.

Khan Z and BH Gawade (2022) Detection of plant parasitic nematodes in quarantine. *In:* 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. 80-85pp.

Kumar P, A Tripathi R Kiran, BR Meena, Sadhana and J Akhtar (2022) Molecular detection and identification of plant pathogens in quarantine.*In:* 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. pp 65-70.

Kumari P, AK Maurya, K Kalaiponmani, P Yadav and VC Chalam (2022) Practicals on Detection and Identification of Viruses in Quarantine *In:* 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. pp 216-222.

Meena BR, A Tripathi, P Kumar, R Kiran, Sadhana and J Akhtar (2022) Detection and identification of plant pathogenic fungi and bacteria. *In:* 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. pp 203-210.

Pratibha Brahmi (2022) Regulations and Policies to Access Genetic Resources for Research *in* Monika Singh, Raghavendra Aminedi, Paramita Palit, Gurinderjit Randhawa (eds). 2022. Training Manual of Genetically Engineered (GE) Plants: Biosafety

Considerations, Policies, Challenges and Detection Strategies. July 19-25, 2022, organized under DBT funded "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" at ICAR- NBPGR, New Delhi 9-16 pp

Randhawa G (2022). GM Detection in the Indian context: Requirement & strategies. *In: Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies*. eds. Singh *et al*., ICAR-NBPGR, New Delhi. pp. 39-48.

Rana MK, Bhat KC, Tyagi V, Akhtar J, Mohapatra KP, Tripathi K (2022) Abstracts Book of the 1st National Conference on Plant Genetic Resources Management, November 22-24. Indian Society of Plant Genetic Resources, New Delhi, India, 199 p.

Singh M, K Kaur & G Randhawa (2022) Method development, validation and utilization of GM diagnostics. *In:* Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. eds. Singh *et al*., ICAR-NBPGR, New Delhi. pp. 49-53.

Singh M, P Palit & R Aminedi (2022) GM Detection Research Facility at ICAR-NBPGR and DNA-based procedures for detection of genetically modified organisms. *In:* Training Manual of Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues. eds. Chalam *et al*., ICAR-NBPGR, New Delhi, pp. 223-233.

Singh M, P Palit, K Kaur, R Aminedi & Shiwani (2022) Rapid GM detection methods employing loop-mediated isothermal amplification and lateral flow strip assay. *In:* Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. eds. Singh *et al*., ICAR-NBPGR, New Delhi. pp. 81-86.

Singh M, R Aminedi, K Kaur, P Palit & Shiwani (2022) DNA extraction from seeds/ food products for GMO testing. *In:* Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. eds. Singh *et al*., ICAR-NBPGR, New Delhi. pp. 66-72.

Singh M, R Aminedi, P Palit, K Kaur & Shiwani (2022) PCR- and real-time PCR based GM detection. *In:* Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. eds. Singh *et al*., ICAR-NBPGR, New Delhi. pp. 73-80.

Singh, MC (2022) Detection and Identification of Weeds in Plant Quarantine. *In:* Training Manual of *'Biosecurity and Biosafety: Policies, Diagnostics Phytosanitary Treatments and Issues'* (eds) Chalam VC et al., organized under DBT- project "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material at ICAR-NBPGR, New Delhi. pp 86-89.

Tyagi Vandana, Pratibha Brahmi, Pragya and Puran Chandra (2022) Exchange procedures for Germplam including Transgenics in Chalam V C, Kavita Gupta, Jameel Akhtar, Z Khan, K Kalaiponmani, Aradhika Tripathi, Priya Yadav and Ashok Kumar (eds) 2022. Training Manual of Biosecurity and Biosafety: Policies, Diagnostics in Phytosanitary Treatments and Issues organized under DBT sponsored project National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant material August 2-11, 2022, ICAR-NBPGR, New Delhi 45-49.

Tyagi Vandana, Pratibha Brahmi, Pragya, Puran Chandra (2022) Regulatory Issues for Importing Transgenic Seeds/Planting Material in Monika Singh, Raghavendra Aminedi, Paramita Palit, Gurinderjit Randhawa (eds). 2022. Training Manual of Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies. July 19-25, 2022, organized under DBT funded "National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material" at ICAR- NBPGR, New Delhi-110012. 16a-16d pp.

Vikender Kaur (2022). Brochure showing activities of the project "Minor Oilseeds of Indian Origin: Leveraging genetic resources for accelerated genetic improvement of linseed using comprehensive genomics and phenotyping approaches". ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, 6p.

20.9.5 Reports

20.9.6 Plant germplasm reporter

20.9.7 e-publications

Bhaskar B, B Parameswari, M Shiva Kumar Reddy, L Karthikai Selvi, P Holajjer, SK Mangrauthia, N Sivaraj and K Anitha (2022) Colletotrichum truncatum isolate DF1 small subunit ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and large subunit ribosomal RNA gene, partial sequence. NCBI Accession No: OP311830.

Bhaskar B, B Parameswari, M Shiva Kumar Reddy, L Karthikai Selvi, P Holajjer, N Sivaraj and K Anitha (2022) Colletotrichum siamense isolate DF1 small subunit ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and large subunit ribosomal RNA gene, partial sequence. NCBI Accession No: OP557122.

Bhaskar B, B Parameswari, M Shiva Kumar Reddy, L Karthikai Selvi, P Holajjer, N Sivaraj and K Anitha (2022) Colletotrichum truncatum strain DF1 actin (ACT) gene, partial cds. NCBI Accession No: OP683828.

Bhaskar B, B Parameswari, M Shiva Kumar Reddy, L Karthikai Selvi, P Holajjer, N Sivaraj and K Anitha

(2022) Colletotrichum siamense strain DF1 actin (ACT) gene, partial cds. NCBI Accession No: OQ079947.

Raiger HL, N. Prajapati, Ashok Kumar and V. S. Meena (2022). Susask Khetron Mai Kalingada Utpadan Badane ki Takniki. Extention folder, AIRCN on potential crops: pages 2

Jayshri N. Papade, Swapnil Katekar, Sunil Gomashe, Dinesh Chand (2022) Potency of *Aegle marmelos* - An Underutilized Fruit Crop. Agriculture and Food: e-News letter. 4 (4):313-314.

Jayshri N. Papade, Swapnil Katekar, Sunil Gomashe, Dinesh Chand (2022) Drumstick a Potential Source to Combat Malnutrition and Disease. Agriculture and Food: e-News letter. 4 (4):309-310.

Jayshri N. Papade, Swapnil Katekar, Sunil Gomashe, Dinesh Chand (2022) Physiological Disorders of Mango; *Mangifera indica*. Agriculture and Food: e-News letter. 4 (6):364-366.

KC Bhatt, SP Ahlawat, RS Rathi, Anjula Pandey, DP Semwal and K Pradheep (2022) 75 Unique Plant Germplasm Collections by the ICAR-NBPGR. ICAR-National Bureau of Plant Genetic Resources, New Delhi, India, p i-viii + 100 ISBN: Hardcopy: 978-81957700-3-8 e-book: 978-81-957700-4-5.

Mahendra Kumar Saran, Damaram, Hari Dayal Choudhary and Kartar Singh (2022). Khejri ki utpadan takneek. Agri-articles 02(01): 46-51.

Mahendra Kumar Saran, Damaram, Hari Dayal Choudhary and Kartar Singh (2022). Khumbi ki utpadan takneek. Agri-articles 02(01): 37-45.

Manoj J. Patokar, Sunil S. Gomashe, Yukta Sarap, Dinesh Chand (2022) Safflower: Improved Crop Management Practices. Agriculture and Food: e-News letter. 4 (4):311-312.

Nandan Tayade, Gomashe S.S., Chand D. and Pradip Wankhade:The Regime of Plant Genetic Resources: Collection, Characterization, Conservation and Utilization., Agriculture and Food, e-newsletter, volume 4, issue 4, April, 2022, (311)

Pradheep K, SP Ahlawat, S Nivedhitha, Veena Gupta and Kuldeep Singh (2021) Crop Wild Relatives in India: Prioritisation, Collection and Conservation. ICAR-National Bureau of Plant Genetic Resources, New Delhi 110 012, pages i-viii +180.

Pranusha P, SR Pandravada, N Sivaraj B Bhaskar, S Nivedhitha, B Parameshwari, L Saravanan, Prasanna Holajjer and Anitha K (2022) Vyavasaaya jeeva vaividhyam parirakshanalo jeevavaividhya yajamaanya committelu- Chattaparamaina hakkulu. ICAR-NBPGR Regional Station, Hyderabad. 1-4 p.

Senthilraja G, A Mahalingam, A Rao, P Kumar, P Kumari, R Hemavathi, GP Rao and VC Chalam (2022) Sesame phyllody phytoplasma clone TN1 16S ribosomal RNA gene,partial sequence (Accession No. OP143674).

Senthilraja G, A Mahalingam, A Rao, P Kumar, P Kumari, R Hemavathi, GP Rao and VC Chalam (2022) Sesame phyllody phytoplasma clone TN2 16S ribosomal RNA gene, partial sequence (Accession No. OP143675).

Senthilraja G, A Mahalingam, A Rao, P Kumar, P Kumari, R Hemavathi, GP Rao and VC Chalam (2022) Sesame phyllody phytoplasma clone TN3 16S ribosomal RNA gene, partial sequence (Accession No. OP143676).

Sheela, Mamta Singh, DP Wankhede, BL Meena and Vikender Kaur (2022) Linseed: A Prospective Minor Oilseed Crop. *Agrospheres:e-Newsletter,* 3(4): 19-22

Sherry Rachel Jacob (2022) Climate Change and its Impact on Seed Quality. *Agriculture & Food Newsletter,*May Issue, ISSN: 2581 – 8317, 4(5), 405-406.

Sherry Rachel Jacob and Veena Gupta (2022) (May). Importance of Crop Wild Relatives in Crop Improvement. *Kerala Karshakan e-journal*, 9(11): 26-30. Published by Farm Information Bureau, Department of Agriculture, Kerala.

Sherry Rachel Jacob, Sundeep Kumar and Jyoti Kumari (2022) Wheat Genetic Resources of India. *Scientific India*, April 2022 Issue, https://scind.org/article/Wheat-Genetic-Resources-of-India

Suma A, Joseph John K, Alfia MA, Harish GD, Berin Pathrose, Thirumalaisamy PP and Latha M 2022. Teasel gourd: A new vegetable crop with rich nutritional potential for crop diversification in Kerala. Kerala Karshakan e-journal. Jan, 2022.

Swapnil Katekar, Jayshri Papade, Sunil Gomashe, Dinesh Chand (2022) Important Health Benefits and Production Technology of Custard Apple; *Annona squamosa*. Agriculture and Food: e-News letter. 4 (6):361-363.

Swapnil Katekar, Pavan Wathore, Sunil Gomashe, Dinesh Chand (2022) Nutritional Importance and Breeding Aspects of Underutilized Crop; Finger Millet. Agriculture and Food: e-News letter. 4 (4):321-322.

Thirumalaisamy PP, A Rao, P Kumari, P Kumar, R Hemavathi, GP Rao and VC Chalam (2022) Sesame phyllody phytoplasma clone PT1 16S ribosomal RNA gene, partial sequence (Accession No. OP143678).

Vijay Singh Meena, Neelam Shekhawat and Kartar Singh (2022). Saal bhar rasoi me kaise rakhe aonla. MARUMEGH Kisaan E- Patrika 7(3) PP. 4-6.

Vijay Singh Meena, Neelam Shekhawat, Nirmal Kumar Meena, and Kartar Singh (2022). Karonda: A fruit to solution of malnutrition of rural population. MARUMEGH Kisaan E- Patrika.7(1) PP. 39-44

Vijay Singh Meena, Nirmal Kumar Meena, Neelam Shekhawat, Kartar Singh, Manoj Kumar Mahawar, Kirti Jagoankar, Pankaj Kumar Kannaujia and Narender Negi (2022). Indigenous fruit resources for nutritional security of India. Indian Horticulture,67(3): 40-45

Yukta Sarap, Manoj J. Patokar, Sunil S. Gomashe, Dinesh Chand (2022) Safflower: Important Pest and their Management. Agriculture and Food: e-News letter. 4 (4):315-318.

Yukta Sarap, Swapnil Katekar, Sunil Gomashe, Dinesh Chand (2022) Commercial Utilization and Pharmacological Importance of Anjan; *Hardwickia binate*. Agriculture and Food: e-News letter. 4 (6):367-368.

नंदन तायडे, सुनिल गोमाशे, दिनेश चंद आणिप्रदिप वानखडे (2022) नाचणी : सुधारीत लागवड, काढणी पश्चात तंत्रज्ञान, मुल्य वर्धण आणि आहारा तीलपोष्टी का महत्त्वः ॲग्रोटच, अप्रैल इशू (11).

नीलम शेखावत, विजय सिंह मीणा, करतार सिंह, धमेन्द्र कुमार जिंघेल, विजय कुमार कुशवाहा, सत्येन्द्र एवं हिमांशु पाण्डेय(2022). तारामीरा की उन्नत वैज्ञानिक खेती/एग्री आर्टिकल्स (कृषि लेखों के लिए ईपत्रिका) वर्ष 02, अंकः 03 (मई –जून, 2022).

20.9.8 Popular articles / publication in conference (abstract / extended summaries)

Anjali Kak and V Gupta (2022) Plant Germplasm Registration Notice. *Indian Journal Of Plant Genetic Resources*.35(1) 2022 106-145.

Anjula Pandey, K Pradheep, K C Bhatt, R K Pamarthi, Rita Gupta, A Tomar, P K Kannaujia and S P Ahlawat (2022). An inventory of Plant Genetic Resources Repository. National Herbarium of Cultivated Plants. Bulletin, ICAR-NBPGR, New Delhi, 36p.

Devender Singh, Vinay Kumar, Balram Jat and Vikender Kaur. (2022) अलसी की बहुउद्देशीय खेती आर्थिक के साथ स्वास्थ्य के लिए भी हितकारी Krishi Jagran. 2nd June, 2022.

Hanuman L Raiger, Veena Gupta and Ashok Kumar (2022) Mainstreaming of Potential Crops in India under National Coordinated Network Pp16

Jitendra Kumar Tiwari, Gajala Ameen, Vivek Kumar Sandilya, Sandeep Kumar and SK Kaushik. 2022. Cultivation practices of an underutilized, yet wholesome and remunerative vegetable: Spine gourd. Indian Horticulture Vol. 67 (2): 17-20.

Kartar Singh, PK Malav, VS Meena, Neelam Shekhawat, BL Roat, SP Ahlawat and Veena Gupta. Survey and exploration to document the local cucurbit vegetables in parts of southern Rajasthan. Pp51.

Kumar P, J Akhtar, BR Meena, R Kiran, and Sadhana (2022). Biopesticide - an eco-friendly way of diseases control. *Agri Articles* **2**(6):89-91.

Kumar, V. Singh, D. Jat, B. and Kaur, V. (2022). Linseed: Essential Field Practices and Cultivation Techniques. *Agricolation*, 2(4), 1-5.

Pervez R, MS Yadav, Anoop Kumar, BH Gawade, Neelam Geat, Subash Chander, D Prasad and Dinesh Singh (2022) National e-Conference on Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience 19-21 May, 2022 ICAR-NCIPM, Pusa campus, New Delhi, India, 199p.

Sivaraj N and K Anitha (2022) In Pursuit of Plant Genetic Resources Management in Telangana. Agriculture Today, Telagana special edition (June 2022) pp 54-57.

Sivaraj N, SR Pandravada, V Kamala, P Pranusha, B Bhaskar, P Holajjer, B Parameswari, L Saravanan, M S Shareef, K Anitha, D Nalini Mohan and BMK Reddy (2022) Documentation and conservation of cereal crops diversity in Andhra Pradesh. E-Newsletter, Andhra Pradesh State Biodiversity Board. Issue (2):34-39.

20.9.9 Plant germplasm reporter / brochure

20.9.10 Registration notices

HW-5074 (INGR-22068): Stable and high yielding line selected at BC4F7 generation, showed resistance to the stem rust, leaf rust and powdery mildew pathotypes prevailing in India. Stem rust, leaf rust and powdery mildew resistance genes, Sr2/Lr27/Yr30, Sr24/Lr24 and Sr36/Pm6 were pyramided in the background of HD2833 cultivar through marker assisted backcross approach. Presence of the resistance genes were carried out using molecular markers, gwm533 (Sr2+) (Spielmeyer et al., 2003), Sr24#12 (Sr24/Lr24) (Mago et al., 2005) and stm773-2 (Sr36/Pm6). Hence, can be considered promising multiple disease resistant germplasm.

IC128335 (INGR22116):IC128335 has low drought sensitivity index (-1.7 and -2.81) and less reduction (%) in thousand grain weight (-49.9 and 14.4). The germplasm line was found to be highly tolerant to drought stress (DSI = 0.45). The germplasm line is characterized with higher antioxidant activity (1.8fold), total phenolic content (1.6 fold), proline content (2.4 fold) and higher SOD activity and higher upregulation of transcription factors (qTaWRKY2 – 3.49 fold and qTaNAC2a – 2.31 fold). Therefore, this genotype can be used as a donor for enhancing drought tolerance in wheat.

IC73591 (INGR22073): Apotential genetic resource for stripe rust resistance. Showed the presence of leaf rust resistance genes, *Lr34+* (*Lr34*/*Yr18*/*Sr57*/*Pm38*), *Lr46+* (*Lr46*/*Yr29*/*Sr58*/*Pm39*) and *Lr67+* (*Lr67*/*Yr46/Sr55/Pm46/Ltn3*) also showed yield stability in above said four different locations may be considered promising multiple disease resistant germplasm and could be included in breeding program as parents for developing new durable multiple rust resistant cultivars.

INGR22036(EC499760):Lentil Bold seeded,

INGR22149(IC519933)Blackgram:Waterlogging tolerance,

INGR22037(IC241532):LentilEarly maturing accession,

INGR22038 (IC259504):*Vigna vexillata* Highly resistant to bruchid

INGR22126(IC118689): Barley, Resistance to foliar aphids,

INGR22132(IC138120): Barley high test weight coupled with early maturity in two-wowed barley

INGR22148(IC530491):BlackgramWaterlogging tolerance,

INGR22154(IC117744): Chickpea ascochta blight resistance,

INGR22165(IC422166): Brassica :White rust resistance (PDI=0)

INGR22132 (IC156122):Barley: High â-glucan (6.4 % on dry weight basis) and good starch content (65.4 % on dry weight basis),

20.9.11 Participation in radio/TV programmes:

Kartar Singh acted as an resource person for the topic "Diseases of cumin and their management" during live phone in programme at DD KISAN channel on 07.01.2022

MC Singh, Principal Scientist, participated as an expert in "Kisan Ki Baat" programme on All India Radio.

MC Singh, Principal Scientist, participated as an expert in Hello Kisan- a live TV programme on DD-Kisan channel.

Neelam Shekhawat participated in DD Kisan channel during live phone in programme "HELLO KISAN" on मेथी में वैज्ञानिक विधि से खेती कैसे करें on 14.02.2022.

SK Yadav delivered Radio Talk in Hindi on *Badalte Mausam mein Belwali sabjiyon ka prabandhan* on 15.10.2022 at All India Radio, Akashwani Bhavan, New Delhi.

SK Yadav delivered Radio Talk in Hindi on *Teji se vilupt ho rahi hain bhartiye pedon ki yah prajatiyan* on 13.12.2022 at All India Radio, Akashwani Bhavan, New Delhi

Veena Gupta participated in *AushdhionPadhoun ki kheti*, on National DD KISAN Channel, 20-April, 2022.

Vijay Singh Meena acted as an resource person for the topic "Establishment of orchard for enhancing farmers income" during live phone in programme at DD KISAN channel on 06.07.2022

20.10 Organization of germplasm field days

20.10.1 Germplasm field day on wheat and barley was organized at ICAR-NBPGR, Issapur farm, on 29thMarch, 2022 (Fig. 20.1).

Fig. 20.1: Germplasm field day on wheat and barley organised at ICAR-NBPGR, Issapur farm on 29 March, 2022

20.10.2 RS-NBPGR, Hyderabad organized a germplasm field day (Biotic stress assessment in blackgram and cowpea) on 16 April 2022 (Fig. 20.2). More than 40 researchers from 11 organizations participated in the event [ICAR-NBPGR, New Delhi-2; ICAR-Central Research Institute for Dry land Agriculture, Hyderabad-4; ICAR-Indian Institute of Pulses Research, RS, Dharwad-2; Professor Jayashankar Telangana State Agricultural University, Hyderabad-11; Acharya NG Ranga Agricultural University, Lam, Guntur-1 and RARS, Tirupathi-1; Dr YSR Horticultural University, HRS, Pandirimamidi-1; Dr Sri Konda Laxman Telangana State Horticultural University-1; Agri-Biotech Foundation, Hyderabad-3; International Crops Research Institute for SemiArid Tropics-2; World Vegetable Centre -3 and ICAR-NBPGR, Hyderabad-8] Fig. 20.2.

Fig. 20.2. Germplasm field day organised at NBPGR RS Hyderabad

20.11 PGR awareness, MGMG and TSP

20.11.1 ICAR-NBPGR organized multiple events on 5th March 2022 at Experimental Farm, Issapur, New Delhi

- The ICAR- National Bureau of Plant Genetic Resources, New Delhi organized an **Awareness Programme on "PGR for Climate Resilient Agriculture & Nutritional Security"** for local farmers under SC Sub Plan on 5th March 2022 at ICAR-NBPGR Experimental Farm, Issapur, New Delhi. Around 100 farmers attended the programme. Farmers were sensitized on importance of Biodiversity and PGR on food and nutritional security. Informative talks were delivered by resource persons of ICAR-NBPGR and KVK, Ujawa on themes related to nutritional security and management of biotic stresses. Dr. Ashok Kumar, Director, ICAR-NBPGR delivered an address on objective of programme and welcomed chief guest and other dignitaries. The Chief Guest, Dr. T Mohapatra, Secretary, DARE and DG, ICAR emphasized on organizing awareness programme regularly to make farmers aware about recent technologies and government schemes for betterment of farming community. Dr. TR Sharma, Deputy Director General (CS), ICAR and Dr SK Chaudhury, Deputy Director General (NRM), ICAR also graced the occasion as the guest of honour. Dr DK Yadava, ADG (Seeds), ICAR was special invitee of function. In this programme, small farm implements, vermicompost kit, and one seed packet of kitchen garden were distributed to 100 scheduled caste farmers beneficiary identified with the help of KVK, Ujawa, Delhi.

- **Dr. T Mohapatra, Secretary, DARE and DG, ICAR inaugurated"Field Genebank of Multipurpose Tree Species including minor fruits and perennial economic species of semi-arid region"** where he suggested to make roadmap of collecting and establishing prioritized tree species in newly established Field Genebank. He also launched the Chip based Technology for monitoring of tree germplasm a pilot project has been developed in collaboration with ICRAF and two other ICAR institutes, IIHR, Bengaluru and CAFRI, Jhansi during the occasion (Fig. 20.3). This is unique approach to manage and monitor tree germplasm through digital technology. ICAR-NBPGR have also planned to digitize and tag all the trees in the Field Genebank across the country. Dr T Mohapatra suggested that search of trait specific germplasm to meet present breeding requirements should be utmost priority of ICAR-NBPGR. At the end, Dr RK Gautam, Head, Division of Germplasm Evaluation, ICAR-NBPGR proposed formal vote of thanks.

Fig. 20.3. Launching of the Chip based Technology for monitoring of tree germplasm by Dr. T Mohapatra, Secretary, DARE and DG, ICAR

20.11.2 Grass root level Awareness Programme on Agri-biodiversity conservation cum Farmer Benefit delivery at Konda Mallepally under SC Sub Project

ICAR-NBPGR, Regional Station, Hyderabad in association with Horticultural Research Station, Sri Konda Laxman Telangana State Horticultural University, Konda Mallepally, Nalgonda district organized a Biodiversity Fair cum Grassroot Level Awareness Programme on Crop Genetic Resources Conservation on 16th March, 2022 at Konda Mallepally under the SC Sub Project. About 150 SC Farmers participated in the programme. During programme, created awareness about conservation of Agri-biodiversity and also encouraged for cultivation of local land races. Farm kits (Tarpaulin sheet, minor farm implements, torch, seeds, zinc etc.) are distributed to suitable beneficiaries. An exhibition of the diversity in native seeds in different Agri-horticultural crops was displayed during the programme for inculcating awareness on importance and indispensability of Crop Genetic Resources (Fig.20.4). Farmers-NGOs-Scientists Interaction was also organized to address the farmer's problem. Released NBPGR publication in vernacular language entitled "Vyavasaaya jeeva vaividhyam parirakshanalo jeevavaividhya yajamaanya committelu-Chattaparamaina hakkulu" by the Chief Guest, Dr. B Neeraja Prabhakar, Honourable Vice-Chancellor, SKLTSHU .

Fig. 20.4. Grass root level Awareness Programme at Konda Mallepally, Nalgonda district, Telangana State

20.11.3 RS-NBPGR, Thrissur conducted a TSP programme on "Promotion of homestead organic vegetable cultivation for nutritional security" at Kavaratti and Agatti Islands of UT of Lakshadweep Islands jointly with KVK of ICAR -CMFRI, Kavaratti on 9-10, January 2022.

20.11.4 PGR Awareness programme for students and farmers by RS-NBPGR, Hyderabad

- Thirty-one B.Sc. (Ag) students from College of Sericulture, Chikkaballapur, UAS, Bengaluru and five of BSc Botany students from St Joseph Vaz College, Cortalim, Goa visited the station during the reporting period and they were enlightened with the activities of PGR management by ICAR-NBPGR.
- Eighteen B.Sc. (Forestry) students from College of Forestry, Kerala Agrl. University, Thrissur visited the station on 21st May 2022 and they were enlightened with the activities of PGR management by ICAR-NBPGR.
- Thirty farmers from Irinjakakkuda along with Asst. Director of Agriculture, Dept. of Agriculture, Govt. of Kerala, visited the station and were enlighted with various PGR management activities of the station.
- Twenty-eight M.Sc. (Botany) students from Victoria College, Palakkad and eight MSc (Agri.) students from Division of Vegetable Sciences, College of Agriculture, Kerala Agricultural University, Thrissur visited the station on 21st and 30th June 2022 respectively and were enlightened with the activities of PGR management by ICAR-NBPGR.
- Three PG students and four PhD students of Dept. of Vegetable Sciences, College of Agriculture, Vellanikkara, Thrissur visited the station as part of the course on Breeding Vegetable Crops and got enlighted about the species diversity in the Genus *Abelmoschus*.
- Four PG students of College of Forestry, and 82 UG students of College of Agriculture, Vellanikkara, Thrissur visited the station as part of their coursework and got enlighted about the activities of the station.

20.12 Extension and awareness programme

20.12.1 World Soil Day 2022 observed at ICAR-NBPGR Issapur Experimental Farm: ICAR-NBPGR celebrated World Soil Day with farmers at its Experimental Farm, Issapur under SC-SP, on 5th December 2022 (Fig. 20.5). Twenty-eight SC farmers including women farmers, from surrounding villages, participated in the programme. An awareness programme was also conducted for the farmers in which Dr Ishwar Singh, Principal Scientist, DGE, spoke on the importance of soil in agriculture. Importance of Soil Day and soil health card scheme was explained by Dr KS Hooda, Principal Scientist, DGE. Dr Kuldeep Tripathi, OIC, Issapur Experimental Farm gave an overview of institute mandate and activities for the benefit of farming community. Dr KP Mohapatra, Principal Scientist also interacted with the farmers on multiple aspects of Plant Genetic Resources, their conservation and economic utility for the upcoming generations. Under the SC-sub plan, the farmers were also provided with a kit of 10 items that included improved varieties of vegetable seeds, ergonomically designed small farm tools and implements etc. Dr BS Panwar, Farm Manager proposed formal vote of thanks.

20.12.2 ICAR-NBPGR celebrated Van Mahostav-2022 under SC-SP: ICAR-NBPGR celebrated Van Mahostav with farmers at its Experimental Farm, Issapur under SC-SP, on 6th July 2022 (Fig. 20.6). Twenty SC farmers including women farmers, from four surrounding villages- Dhansa, Jafferpur, Samas and Mitraon, participated in the programme. Coordinators of the programme, Dr Kuldeep Tripathi and Dr K.P. Mohapatra, organised a plantation activity of multipurpose tree species on a common property land. Saplings such *as Melia azedarach, Holoptelia integrifolia, Terminalia arjuna, Syzygium cumini, Simaruba glauca, Cordia mixa* etc were planted by the participating farmers, Scientist, technical personnel and other staff members of the institute. An awareness programme was also conducted for the farmers in which Dr S.P. Ahlawat, Chief Guest of function, spoke on the importance of plant genetic resources such as specialty food, minor fruits, fodder and fuel wood tree species. Importance of Van Mahostav and tree planting as well as tree husbandry practices for successful

Fig. 20.5. World Soil Day at ICAR-NBPGR Issapur Experimental Farm

Fig. 20.6. Celebration of Van Mahostav-2022 under SC-SP

establishment of multiples tree species in the semi-arid region was explained by Dr K.P. Mohapatra, Principal Scientist, DGE. Dr R.K. Gautam, Head, DGE, gave an overview of institute mandate and activities for the benefit of farming community. Dr Kuldeep Tripathi, Scientist and Dr Puran Chandra, Scientist from the institute also interacted with the farmers on multiple aspects of Plant Genetic Resources, their conservation and economic utility for the upcoming generations. Each farmer was provided three fruit plants- Pomegranate, Guava and Lemon, to plant on their backyard with a purpose to improve nutrition of the farm family. Under the SC-sub plan, the farmers were also provided with a kit of 10 items that included improved varieties of vegetable seeds, ergonomically designed small farm tools and implements etc.

20.12.3 RS-NBPGR, Thrissur distributed planting material under SCSP programme: Hundred plants each of diverse grafted plus trees of jack fruit and mango besides banana landraces and vegetable seeds were distributed to 100 SC farmers at Kaippattor Village of Ernakulam Dist and TV puram village and Maravanthuruthu village of Kottayam Dist on 6-7th March, 2022.

20.12.4 RS-NBPGR, Thrissur conducted on-farm conservation programme on Mango: A total of 40 grafted mango plants originating from Kannapuram Mango Heritage village, Kannur were planted at Kerala Police Academy Campus, Thrissur coinciding with International Women's Day on 8th March, 2022.

20.13 Vigilance awareness week, Parthenium Day, Indian Constitution Day, International women day, Swachhata Pakhwada etc

20.13.1 Hindi Pakhwada Celebration was organized on 15 th September 2022, with the active participation of all staff members, SRFs, Project Assistants etc. Dr. Berin Pathrose, Director (Planning), Kerala Agricultural University was the Chief Guest and delivered a talk on "Importance of Hindi language in day-to-day life".

20.13.2 Celebration of Yoga Week (June 15-21, 2022) at ICAR-NBPGR, New Delhi and its regional stations

ICAR-NBPGR, New Delhi celebrated 8th International Day of Yoga-2022 by observing a Yoga Week (June 15-21, 2022) and contributed in popularization of Yoga among masses by conducting yoga related activities throughout the week by different means *viz*. print media, demonstration and practice of Yoga Asanas, Panayam and Yogic Kriyayen; Yoga Pledge, Yoga Bhajan, Prayer and Peace Recitation, Lecture on Yoga for Wellness: Stress management, Quiz competition on yoga, Declamation contest for school students and NBPGR staff, painting competition on yoga for school students and Yoga Asanas competition for school students and NBPGR staff (Fig. 20.7). A total of about 570 participants (NBPGR staff and school students from GAV International School DLF, GAV International School Palam Vihar, Prince Public School, BudhVihar, and DPS, Rohini and GAV International School, Sector-37, Gurugram) attended different yoga related activities and yoga competition throughout the week. Dr Ishwar Singh, Nodal Officer, 8th IDY-22, NBPGR, New Delhi coordinated these activities at NBPGR, New Delhi. Dr Ashok Kumar, Director, ICAR-NBPGR, New Delhi gave away the prizes to the winners with certificate of merit and momentos and participation certificate to the participants in different activities organized during the week.

Fig. 20.7. Celebration of Yoga Week (June 15-21, 2022) at ICAR-NBPGR, New Delhi

International Yoga Week: As part of the celebration of International Yoga week from 15th-21stJune, 2022, a lecture cum Yoga practice session was organized at the station on 18th June 2022. Dr. Shaji, Yoga practitioner at Nehru Yuva Kendra, Thrissur, delivered a lecture on importance of yoga in day-to-day life and also handled a yoga practice session by performing meditation and various standing and sitting asanas, with the active participation of all the staff of the station.

International Yoga Day: On the occasion of celebration of 8th International Yoga Day, an awareness session was organized for the benefit of youth as well as farmers. A Farmers awareness campaign was organized, wherein two lectures; one on 'Region Specific Agro-forestry' by Dr Jamaluddeen, Professor, College of Forestry and the other on 'Balanced Use of Fertilizers' by Dr.

Mayadevi, Assistant Professor, College of Agriculture were delivered. A total of seventeen farmers from Vellankalloor Panchayath attended the programme.

20.13.3 National Science Day celebrations

ICAR-NBPGR Regional Station, in collaboration with Association for Promotion of ethno-medicine and Traditional Crops Diversity (APETD), Hyderabad organized an Awareness Programme cum study tour for medicinal plants. Two batches of about 140 students (80 and 60), belonging to II Year BUMS course, Government Nizamia Tibbi College, Hyderabad participated in the programme along with six faculty members on 26.02.2022 and 5.03.2022, respectively. It has been conducted as part of Science Week celebrations by the organization. An exhibition of the diversity in native seeds in different Agri-horticultural crops was displayed during the programme for inculcating awareness on importance and indispensability of Crop Genetic Resources. A video show on the journey of plant genetic resources organized for the benefit student community. Visit to experimental garden of the station, medium term Storage module, museum, polyhouses were arranged as part of science week celebrations. An interactive session was also arranged with Scientist, Unani specialists and students. Students and faculty members were awarded Certificates by the dignitaries present on the occasion (Fig. 20.8).

20.13.4 ICAR-NBPGR celebrated farmers day at Issapur experimental farm of ICAR-NBPGR on Dec 23, 2022 (Fig. 20.9)

20.13.5 Germplasm expedition for *Gadmal*, a traditionally popular tribal pulse of Betul, Madhya Pradesh

Gadmal' [*Vigna mungo* (L.) Hepper], a traditional tribal pulse crop was identified for plant genetic resources value during survey conducted in the areas of Betul district of Madhya Pradesh (Fig. 20.10). Gadmal is an endemic underutilized pulse crop under the Genus Vigna that is being grown by the Gond tribes of Betul district since ancient times. As the pulse crop is highly delicious and is being used by the tribes in their several local festivities and religious events, this is recognized as promising pulse crop in the region. Many traditional uses are documented in the form of food preparation like flour being used in *chapati* and *vada* preparation. The extracted oil was also used as paste to smoothen the surface of hand grenades during earlier times. However, the area under this crop is shrinking due to severe infestation of yellow mosaic disease. The food items and recipes prepared from the Gadmal are traditionally offered to tribal Gods. ICAR-NBPGR has collected and conserved accession in National Herbarium of Cultivated Plants (NHCP) (Herbarium specimen, HS25749). The preliminary morphological, biochemical and molecular profiling of collected accessions being undertaken by us will provide avenues for better utilization and recognition of this crop. The efforts are being made for documenting the traditional knowledge and germplasm characterization for facilitating the tribal community for germplasm registration of this novel crop.

20.13.6 Participation of ICAR-NBPGR in Exhibition, Mela etc

ICAR-NBPGR, Regional Station, Akola participated in State level Agriculture Exhibition (AGROTECH- 2022) during 27-31 December 2022 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 124th birth anniversary of late Dr. Panjabrao Deshmukh during 27-31 December 2022. 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 upraised on the need to conserve our traditional seeds and diversify the cropping system by inclusion of

Fig. 20.8. Visit of students to NBPGR RS Hyderabad

Fig. 20.9. Celebration of Farmer's day at Issapur experimental farm

Fig. 20.10. Gadmal Divas celebrated at Betul, Madhya Pradesh on 22 November, 2022

minor pulses, millets and potential crops to attain nutritional and health security. More than nine lakh (9.0 lakh) farmers/students/industry people visited the exhibition during 27-31 December 2022. The farmers appreciated the efforts carried out by National Bureau of Plant Genetic Resources (NBPGR) specifically for small millets and oil seeds (Fig. 20.11).

Fig. 20.11. ICAR-NBPGR, Regional Station, Akola participated in Agriculture Exhibition

ICAR-NBPGR RS Hyderabad participated in the "Seed Mela" organised by PJTSAU, Hyderabad 24th May 2022. Diversity in native seeds in different agri-horticultural crops for inculcating awareness on importance and indispensability of crop genetic resources were showcased. Around 600 farmers visited the stall (Fig. 20.12).

Fig. 20.12. Exhibition of crop diversity in the "Seed Mela" at PJTSAU, Hyderabad

21.13.7 Other programmes

ICAR-NBPGR, RS Hyderabad celebrated Republic Day (26/01/2022), Women's day (08/03/2022), Anti-Terrorism Day (21/05/2022), International Yoga day (21/06/2022), Independence Day (15/08/2022) and Parthenium day (19/08/2022). Importance of national integrity and patriotism, cleanliness, benefits of yoga, harmful effects of Parthenium etc were highlighted during different programme (Fig. 20.13).

Fig. 20.13. Celebration of days of national importance at NBPGR RS Hyderabad

20.14.1 Distinguished visitors of NBPGR and its stations

Fig. 20.15. Live display of variability in Lentil Core set (170 acc.) at ICAR-NBPGR farm during visit of Dr Michael Baum, DDG, Research, ICARDA (17.03.22

Two groups of HDO/SMS, Department of Horticulture, Govt. of Himachal Pradesh visited ICAR-NBPGR RS Srinagar on April 20th, 2022 and April 26th, 2022 and interacted with the scientists of the station regarding temperate fruit genetic resources

Fig. 20.16. Dr Ashok Kumar, former Director, ICAR-NBGR visited ICAR-NBPGR RS Srinagar on June 4th, 2022

21.14.2 Students or external visitors to RS-NBPGR, Hyderabad

- Twenty five students from Malla Reddy Engineering College, Hyderabad visited the station on 28.02.2022 and got exposed to various activities of NBPGR
- Dr K Ashok Kumar, Director, ICAR-NBPGR, New Delhi visited station on 28.02.2022 and reviewed the on-going research activities and interacted with all staff of the station
- Dr Tilak Raj Sharma, Deputy Director General (Crop Sciences), ICAR, along with Dr M Sujatha, Director, IIOR visits ICAR-NBPGR Regional Station Hyderabad on 26.05.2022. He appreciated the scientists for implementing various externally funded projects and establishing facilities at the station.

Dr Tilak Raj Sharma, Deputy Director General (Crop Sciences), ICAR on 26.05.2022

- Dr Sudheer Daniel, Research Logistic Lead, Corteva, Dr. Bhupendra Bhatiya, Pathology Lead- Plant Breeding and Dr D C Balasundara from Corteva Agriscience interacted with the scientific staffs of the station on 9th June 2022.
- Dr Vilas Tonapi Ex-Director, IIMR, Hyderabad (felicitated by Officer In-charge) and Dr T Janakiram, Hon'ble Vice-Chancellor, Dr YSR Horticultural university, Andhra Pradesh visited the station and interacted with the scientists of the station on 10th June, 2022.
- Twenty five BSc.(Ag.) students of ANGR Agricultural University visited on 25.08. 2022 and were exposed to various activities of NBPGR
- Dr. Ashok Kumar, Director (Acting), visited the station 15.09.2022 along with Dr. Hanuman Lal Raiger, Coordinator, AICRP on Potential crops and reviewed various research activities and interacted with the staff
- Twenty six officials from Spices Board who were undergoing training at NIPHM, Hyderabad visited the station on 20.10. 2022. They were exposed to wealth of plant genetic resources available at the station and lectured about various activities of the station.

Officials from Spice Board on 20.10.22

- Sh. J. Justin Mohan IFS, Secretary, National Biodiversity Authority visited on 22.11.2022 and interacted with Scientists and visited the facilities of the station.

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