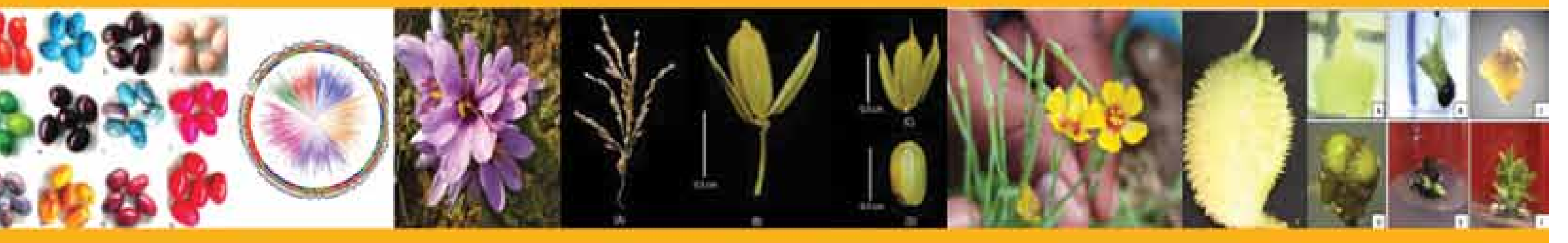
वार्षिक प्रतिवेदन

Annual Report

2021



भाकृअनुप–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो

पूसा कैम्पस, नई दिल्ली–110012

ICAR-National Bureau of Plant Genetic Resources

Pusa Campus, New Delhi-110012

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भाकृअनुप
ICAR

रा पा आ सं ब्यूरो
NBPGR

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भा.कृ.अनु.प.–राष्ट्रीय पादप आनुवंशिक संसाधान ब्यूरो
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NBPGR

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

PREFACE

I am pleased to put forth Annual Report 2021 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 2021.

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.

In these tough times we received unwavering support of ICAR and I gratefully acknowledge the leadership of Dr T Mohapatra, the Hon'ble Secretary, DARE and Director General, ICAR; Dr TR Sharma, DDG (Crop Science); and Dr DK Yadava, ADG (Seeds), for their 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 2021.

May 20, 2022
New Delhi

Ashok Kumar
Director (Acting)

LIST OF ACRONYMS

ABD	Augmented Block Design
mM	Micro Mole
ACC.	Accession
AEBAS	Aadhar Enabled Biometric Attendance System
ArMV	Arabis mosaic virus
AVRDC	Asian Vegetable Research and Development Centre
CBD	Convention on Biodiversity
CBDP	CAAT box- derived polymorphism
CEBPOL	Centre for Biodiversity Policy & Law
CFU	Colony-Forming Unit
CGIAR	Consultative Group for International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CNGC	Cyclic nucleotide-gated channels
CSIR	Council of Scientific & Industrial Research
CWRs	Crop Wild Relatives
DAC&FW	Department of Agriculture, Cooperation & Farmers Welfare
DAS-ELISA	Double Antibody Sandwich Enzyme-Linked Immunosorbent Assay
DNA	Deoxyribonucleic Acid
DV	Droplet Vitrification
EC	Exotic Collection
ECS	Embryonic Cell Suspension
ED	Encapsulation-dehydration
EMC	Equilibrium moisture content
EST-SSR	Expressed Sequence Tag- Simple Sequence Repeats
EV	Encapsulation-vitrification
FAO	Food and Agriculture Organization
FGB	Field Genebank
FV	Farmer's Varieties
GEQIS	Germplasm Exchange & Quarantine Information System
GHU	Germplasm Handling Unit
GMO	Genetically Modified Organism
GPA	Global Plan of Action
GST	Goods and Service Tax
IC	Indigenous Collection
ICARDA	International Centre for Agricultural Research in Dry Areas
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ISO	International Organization for Standardization
ISSR	Inter-Simple Sequence Repeat
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ITS	Internal Transcribed Spacer
IVAG	In Vitro Active Genebank
IVGB	In Vitro Base Genebank
LAMP	Loop Mediated Isothermal Amplification
LAN	Local Area Network

LMO	Living modified organism
LN	Liquid Nitrogen
LTS	Long Term Storage
M &AP	Medicinal and Aromatic Plants
MEA	Ministry of External Affairs
MH	Madras Herbarium
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
MRE	Mean Relative Error
mT	Metatopolin
MTA	Material Transfer Agreement
MTS	Medium Term Storage
NGB	National Genebank
NGO	Non-Governmental Organization
NGTL	Network of GMO Testing Laboratories
NHCP	National Herbarium of Cultivated Plants
NIRS	Near-Infrared Spectroscopy
NPGS	National Plant Germplasm System
PCM	Presidency College Madras
PCR	Polymerase Chain Reaction
PEQ	Post-entry Quarantine
PEQI	Post-entry Quarantine Inspection
PEQIA	Post-entry Quarantine Inspection Area
PGR	Plant Growth Regulators
PGRC	Plant Germplasm Registration Committee
PGRFA	Plant Genetic Resources for Food and Agriculture
PIC	Polymorphism Information Content
PPA	Plant Protection Advisor
PPM	Parts Per Million
PRA	Participatory Rural Appraisal
PVS2	Plant Vitrification Solution 2
RBD	Randomized Block Design
RKN	Root-knot Nematode
RT-PCR	Reverse Transcription (or Real-Time) Polymerase Chain Reaction
SCoT	Start Codon Targeted Polymorphism
SEM	Scanning Electron Microscopy
SEM	Standard Error of Estimate/moisture
SGSV	Svalbard Global Seed Vault
SM	Shoot Meristem
SMTA	Standard Material Transfer Agreement
SNP	Single Nucleotide Polymorphism
SOP	Standard Operating Procedure
SPS	Sanitary and Phyto-Sanitary
SSR	Simple Sequence Repeats
ST	Shoot Tip
TaGI	Triticum aestivum Gene Indices
TBT	Technical Barriers to Trade
TSP	Tribal Sub-plan
TSS	Total Soluble Solids
UIDAI-RD	Unique Identification Authority of India-Registered Devices
UPGMA	Unweighted Pair Group Mean Average
V	Vitrification
WEUP	Wild Economically Useful Plants
WIEWS	World Information and Early Warning System
WRA	Weed Risk Assessment
ZE	Zygotic Embryo

कार्यकारी सारांश

भाकृअप–राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो ने 2021 के दौरान विभिन्न पादप आनुवंशिक संसाधनों का प्रबंधन जैसे– पादप अन्वेषण और जननद्रव्य संग्रहय, जननद्रव्य विनिमयय, पादप संगरोधय, जननद्रव्य लक्षण वर्णन और मूल्यांकनय, जननद्रव्य का एक्स–सीटू, इन–सीटू और इन–विट्रो संरक्षण, डीएनए फिंगरप्रिंटिंग, जीनोमिक संसाधनों का उत्पादन और जीएम पहचान– 21 संस्थागत रूप से वित्तपोषित कार्यक्रमों और 42 बाह्य वित्तपोषित परियोजनाओं के अंतर्गत की गयी प्रगति का संक्षेप में विवरण यहां दिया गया है:

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2021 में, देश भर में कुल 38 अन्वेषण किए गए और 20 राज्यों (असम, अरुणाचल प्रदेश, बिहार, छत्तीसगढ़, गुजरात, हरियाणा, हिमाचल प्रदेश, जम्मू और कश्मीर, झारखंड, कर्नाटक, मध्य प्रदेश, महाराष्ट्र, मेघालय, ओडिशा, पंजाब, राजस्थान, सिक्किम, उत्तराखंड, उत्तर प्रदेश, पश्चिम बंगाल, लद्दाख लक्षद्वीप) में स्थित 76 जिलों से विभिन्न कृषि–बागवानी फसलों, फसलों के जंगली प्रजातियों और अन्य आर्थिक प्रजातियों की 2,600 प्रविष्टियां एकत्र की गईं। इनमें से 942 प्रविष्टियां आईसीएआर–एनबीपीजीआर मुख्यालय, नई दिल्ली द्वारा भारत के 14 राज्यों में किए गए 18 अन्वेषणों के माध्यम से एकत्र की गईं।

कुल 702 हर्बेरियम नमूनों (16 अप्रतिनिधित्व वाले टैक्सा सहित) को संसाधित किया गया और नेशनल हर्बेरियम ऑफ कल्टीवेटेड प्लांट्स (NHCP), नई दिल्ली में जोड़ा गया। भारत से एक नई जंगली एलियम प्रजाति (एलियम नेगियानम) की पहचान का समर्थन करने के लिए रूपात्मक, साइटोलॉजिकल और आणविक साक्ष्य तैयार किए गए और एक अलग टैक्सोनॉमिक स्थिति की पुष्टि की गई। चने की 16,246 स्वदेशी प्रजातियों (सिसर एरीटिनम), मटकी की 1,556 प्रजातियों (विग्ना एकोनिटिफोलिया) और राइसबीन की 2,327 प्रजातियों का भू–संदर्भ और मानचित्रण किया गया।

vdkyk क्षेत्रीय स्टेशन ने वर्ष के दौरान चार अन्वेषण और संग्रह कार्यक्रम चलाए और महाराष्ट्र और मध्य प्रदेश राज्यों के जिलों से विभिन्न फसल प्रजातियों और जंगली प्रजातियों के कुल 317 प्राप्तियों को एकत्र किया गया। क्षेत्रीय स्टेशन Hkkokyh ने एक राष्ट्रीय अन्वेषण योजना में 53 अलग–अलग संग्रह किए। बेस सेंटर dVd में, तीन अन्वेषण मिशन चलाए गए और ओडिशा और छत्तीसगढ़ से जंगली चावल, जंगली फसल रिश्तेदार, दालें, बाजरा और मूल्यवान औषधीय और सुगंधित पौधे युक्त 311 परिग्रहण एकत्र किए। जंगली भिंडी की तीन टैक्सोनोमिक किस्मों एबेलमोस्कस एंगुलोसस वं. ग्रैंडिफ्लोरस, ए. ट्यूबरकुलैटस वं. डेल्टॉइडेफोलिअस और ए. ट्यूबरकुलैटस वं. ट्यूबरकुलैटस की उपस्थिति पहली बार ओडिशा से रिपोर्ट की गई और पूर्वी भारत के लिए नया वितरण प्रमाणित हुआ। क्षेत्रीय स्टेशन tkekiqj ने सीकर, नागौर जिलों (राजस्थान) और भिवानी जिला (हरियाणा) से औषधीय और सुगंधित पौधों के संग्रह के लिए आईसीएआर–डीएमएपीआर, आनंद, औषधीय और सुगंधित पौधों पर एआईसीआरपी और बेटलवाइन सेंटर एग्रीकल्चर यूनिवर्सिटी जोधपुर के सहयोग से एक अन्वेषण किया और 38 जननद्रव्य एकत्र किए। क्षेत्रीय स्टेशन jkph ने अनाज, दलहन, सब्जी, तिलहन और फसल जंगली रिश्तेदारों के 179 प्राप्तियों को इकट्ठा करने के लिए झारखंड में दो अन्वेषण कार्यक्रम आयोजित किए। f'kykx स्टेशन ने बहु–फसलों के लिए दीमा हसाओ, असम और साइट्रस प्रजातियों के लिए गारो हिल्स, वेस्ट खासी हिल्स और ईस्ट जयंतिया हिल्स में दो अन्वेषण और संग्रह दौरे किए। f'keyk क्षेत्रीय स्टेशन ने हिमाचल प्रदेश के चंबा के सलूनी ब्लॉक और जम्मू–कश्मीर में डोडा के भद्रवाह ब्लॉक से विभिन्न कृषि–बागवानी फसलों के लिए दो अन्वेषण किए और कुल 192 प्रविष्टियां एकत्र की गईं। Jhuxj क्षेत्रीय स्टेशन ने दो अन्वेषण और जननद्रव्य संग्रह कार्यक्रम चलाए और कश्मीर के विभिन्न क्षेत्रों से कृषि–बागवानी फसलों और फसल जंगली प्रजातियों (सीडब्ल्यूआर) के कुल 150 प्राप्तियों को एकत्र किया गया। f='kj स्टेशन पर, तमिलनाडु, कर्नाटक और वाल्मीकि टाइगर रिजर्व, बिहार के जिलों को कवर करते हुए चार अन्वेषण मिशनों में जननद्रव्य के 394 नमूने एकत्र किए। मोमोर्डिका और ट्राइकोसेंथेस में से प्रत्येक के एक नए टैक्सोन का वर्णन किया गया।

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प्रतिवेदन अवधि के दौरान परीक्षण के लिए जननद्रव्य के 34,031 प्राप्तियों (40,934 नमूनों) और सीजीआईएआर नर्सरी के 16565 प्रविष्टियों (1,26,108) नमूनों सहित 50,596 प्रविष्टियों (1,67,042 नमूनों) का आयात किया गया। आईसीएआर–सीआईएमएमवाईटी परियोजना के तहत गेहूं के कुल 700 नमूने (बोलीविया को 350 और बांग्लादेश को 350) निर्यात किए गए। 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 के कुल 13, 448 नमूनों की आपूर्ति की गई। इसके अलावा, 40,615 नमूनों की आपूर्ति पुनर्जनन/गुणन/रूपात्मक लक्षण वर्णन/प्रारंभिक मूल्यांकन/टैक्सोनॉमिक पहचान/डीएनए फिंगरप्रिंटिंग/व्यवहार्यता परीक्षण के लिए की गई थी। 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 और तकनीकी इनपुट प्रदान किए गए।

जैसा कि दिल्ली घोषणा में खाद्य और पोषण संबंधी जरूरतों को पूरा करने के लिए प्रतिबद्ध है, भारत ने समान पहुंच और लाभ साझा करने के अवसरों को सुनिश्चित करते हुए आनुवंशिक संसाधनों के आदान–प्रदान की सुविधा के लिए बहु–पार्श्व और द्विपक्षीय दोनों साधनों को अपनाया (आइची लक्ष्य–सामरिक लक्ष्य डी, लक्ष्य 17य एसडीजी 2.5)

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विभिन्न फसलों और उनके वन्य संबंधितों की परीक्षण प्रविष्टियों सहित आयातित जननद्रव्य प्राप्तियों के कुल 1,37,671 नमूनों को संगरोध निकासी के लिए संसाधित किया गया। इन नमूनों में बीज, जड़ वाले पौधे, कलम, राइजोम, सकर, बल्ब, और टिश्यू कल्चर प्लांटलेट शामिल थे। संक्रमित नमूनों (7730) में कीड़े (6550), सूत्रकृमि (429), कवक (736), वायरस (15) और खरपतवार (53) सहित कई विदेशी कीट शामिल थे। 7730 संक्रमित/संक्रमित/दूषित नमूनों में से 7623 को भौतिक–रासायनिक विधियों जैसे धूमन, एक्स–रे रेडियोग्राफी, कीटनाशक उपचार, यांत्रिक सफाई और परीक्षण के माध्यम से बचाया गया तथा 107 संक्रमित नमूनों को नष्ट कर दिया गया। विभिन्न देशों/स्रोतों से आयातित विभिन्न फलीदार फसलों के विदेशी जर्मप्लाज्म के कुल 137 नमूने पोस्ट–एंट्री क्वारंटाइन (पीईक्यू) ग्रीनहाउस में उगाए गए और वायरस से मुक्त पौधों की फसल मांगकर्ताओं को जारी की गई। इस अवधि के दौरान विभिन्न मांगकर्ताओं के स्थलों पर कुल 51 पोस्ट–एंट्री क्वारंटाइन निरीक्षण किए गए। विभिन्न फसलों के कुल 1871 नमूनों को निर्यात के लिए संसाधित किया गया, जिनमें से 37 संक्रमित नमूनों को बचाया गया, 04 प्रकार की खरपतवार प्रजातियों से दूषित 16 नमूनों को बचाया गया और 11 पादप स्वच्छता प्रमाणपत्र जारी किए गए। आयातित ट्रांसजेनिक रोपण सामग्री के 37 नमूनों के संगरोध प्रसंस्करण के परिणामस्वरूप सोयाबीन और कपास दोनों में फफूंद रोगजनकों का अवरोधन हुआ। संक्रमित बीजों को बचाया गया, टर्मिनेटर जीन की अनुपस्थिति सुनिश्चित की गईय रिलीज और पीईक्यू निरीक्षण किए जाने से पहले सभी नमूनों को बचा लिया गया था। बीज स्वास्थ्य परीक्षण के तहत, जर्मप्लाज्म संरक्षण प्रभाग से कुल 12,689 नमूने प्राप्त हुए, एसएचटी के परिणामस्वरूप, 547 नमूने कवक (520 नमूने) और बैक्टीरिया (2 नमूने) और वायरस (25 नमूने) सहित विभिन्न रोगजनकों से संक्रमित पाए गए। कुल 31 संक्रमित नमूने जिनमें 10 ट्रिटिकम एस्टिवम नमूने शामिल हैं, जो टिलेटिया से संक्रमित हैं (6) और टी. इंडिका (4), टी से संक्रमित एक होर्डियम वल्गारे नमूना वहन करता हैय टी. बार्कलेयाना से संक्रमित छह ओराइजा सैटिवा नमूनेय Ustilagopanici & frumentaceian से संक्रमित एक Echinochloa esculenta नमूना और Peronospora manshurica से संक्रमित एक Glycine maÛ नमूना खारिज कर दिया गया क्योंकि उन्हें बचाया नहीं जा सका और हैदराबाद से Setaria italica (9), Eleusine coracana (2) और मध्य प्रदेश से Cajanus cajan (1) को भी भारी कवक संदूषण के कारण खारिज कर दिया गया। कुल 292 स्वदेशी नमूने नेमाटोड से संक्रमित थे। इसके अलावा, क्रायो–संरक्षण से पहले/बाद में बीज स्वास्थ्य परीक्षण के लिए टीसीसीयू से 83 नमूने प्राप्त हुए, जिनमें से 34 नमूने विभिन्न कवक से संक्रमित पाए गए और सभी को बचा लिया गया।

रिपोर्टाधीन अवधि के दौरान gnjkckn में कुल 55,489 नमूनों (16,262 आयातय 39,227 निर्यात) को संगरोध निकासी के लिए संसाधित किया गया था। 43 पादप स्वच्छता प्रमाणपत्र जारी किए गए। कीटों/रोगजनकों से संक्रमितध्संक्रमित आयातित फसल जननद्रव्य के नमूने (8,694) को बचाया गया और जारी किया गया। आईसीआरआईएसएटी (41) और विश्व सब्जी केंद्र (204), निजी उद्योग (3,174), सार्वजनिक संगठनों (40) और एनबीपीजीआर ग्रीनहाउस (104) में उगाई जाने वाली विभिन्न फसलों के 3,563 प्राप्तियों पर पोस्ट–एंट्री संगरोध

निरीक्षण किया गया था। दक्षिण भारत में 40 संगठनों तक संगरोध सेवाओं का विस्तार किया गया।

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2021 के दौरान, विभिन्न कृषि–बागवानी फसलों की कुल 32,337 प्राप्तियों की विशेषता/मूल्यांकन/पुनर्जीवित/गुणन किया गया, जिसमें गेहूं (2374), मक्का (227), जौ (700), बकव्हीट (250), ब्रासिका (2159), तिल (6500), अलसी (2657), सोयाबीन (8029), चना (5084), मूंग (410), सेम (827), मटर (2443), राइसबीन (252) .), बाकला (216), लोबिया (425), बैंगन (110) और ककड़ी (22)। विशेषता विशिष्ट मूल्यांकन के संबंध में, विभिन्न फसलों की कुल 1065 प्रविष्टियां अर्थात मक्का, ब्रासिका, मिर्च, मटर, भिंडी और ककड़ी का फसल विशिष्ट जैविक प्रतिबलों के लिए मूल्यांकन और अजैविक दबावों के अंतर्गत गेहूँ, जौ, अलसी और मसूर की कुल 7286 प्राप्तियों का मूल्यांकन किया गया। इसके अलावा, विभिन्न क्षेत्रों की फसलों के कुल 3,231 जननद्रव्य प्राप्तियों का विभिन्न गुणवत्ता लक्षणों के लिए विश्लेषण किया गया। इसके अलावा, कृषि–जैव विविधता–पीजीआर घटक–II पर सीआरपी के तहत, गुणवत्ता लक्षणों, अजैविक और जैविक तनावों के लिए एआईसीआरपी केंद्रोंध्हॉटस्पॉट में गेहूं (662) और भिंडी (60) सहित कुल 722 प्राप्तियों का मूल्यांकन किया गया। एनबीपीजीआर, ईसापुर फार्म, नई दिल्ली में क्रमशः 28 और 29 मार्च, 2022 को 'चना' और 'गेहूं और जौ' पर जननद्रव्य प्रक्षेत्रदिवस आयोजित किए गए। फसल सुधार कार्यक्रमों में उपयोग के लिए 79 मांगकर्ताओं को विभिन्न फसलों की कुल 6971 प्राप्तियों की आपूर्ति की गई।

vdkyk क्षेत्रीय स्टेशन ने 11142 प्राप्तियों (रबी 2020–21 में 2837 और खरीफ 2021 में 8305) की विशेषता और मूल्यांकन किया। क्षेत्रीय स्टेशन ने भारत में उपयोगकर्ता एजेंसियों को अनुसंधान उद्देश्य के लिए विभिन्न फसलों के 6958 प्राप्तियों की आपूर्ति भी की। समीक्षाधीन अवधि के दौरान विभिन्न फसलों के 8164 जननद्रव्य प्राप्तियों का गुणन और पुनर्जनन। क्षेत्रीय स्टेशन Hkkokyh में विभिन्न क्षेत्रों, बागवानी, डब्ल्यूईयूपी फसलों की कुल 1109 प्राप्तियों को गुणित किया गया और एमटीएस बीज प्रतिस्थापन के लिए कायाकल्प किया गया। क्षेत्रीय स्टेशन भोवाली में एमटीए के अंतर्गत देश भर के शोधकर्ताओं के साथ विभिन्न फसल जननद्रव्यों की 601 प्रविष्टियां साझा की गईं। इसके अलावा कृषक समुदाय को 8818 जीवित पौधेध्जड़ वालेध्ग्राफ्टेड पौधे भी प्रदान किए गए। dVd में विभिन्न फसलों और जंगली रिश्तेदारों के 1660 परिग्रहणों के एक सेट को गुणा/पुनर्जीवित किया गया और 347 परिग्रहणों को विभिन्न मॉर्फो–एग्रोनॉमिक लक्षणों के लिए चित्रित किया गया। डब्ल्यूआरसीपी (27), जंगली चावल (77) वाले 104 परिग्रहणों के एक सेट की आईसीएआर–संस्थानों को आपूर्ति की गई और एनबीपीजीआर, नई दिल्ली से विदेशी चावल जर्मप्लाज्म (112) प्राप्त हुए। gnjkckn में, विभिन्न कृषि–बागवानी फसलों की 1,282 प्रविष्टियां लक्षण वर्णन, मूल्यांकन, स्क्रीनिंग, कायाकल्प और गुणन के लिए तैयार की गईं। ICRISAT अरहर मिनी–कोर जर्मप्लाज्म (34), लोबिया (9) और धान (21) से मिलकर चौंसठ प्राप्तियों को गुणा किया गया और लंबी अवधि के भंडारण के लिए नेशनल जीन बैंक को भेजा गया। स्टेशन पर एमटीएम में मूल्यांकित और बहुगुणित देशी जननद्रव्य की 464 प्रविष्टियां जोड़ी गईं। 35 एसएयू/आईसीएआर संस्थानों को विभिन्न कृषि–बागवानी फसलों के कुल 1,344 जननद्रव्य प्राप्तियां प्रदान की गईं।

tk/kiqj स्टेशन पर रबी 2020–21 के दौरान 944 और खरीफ 2021 के दौरान 439 प्राप्तियों सहित विभिन्न फसल समूहों के कुल 1383 प्राप्तियों का लक्षण वर्णन और मूल्यांकन किया गया। विभिन्न कृषि–बागवानी फसल प्रजातियों के कुल 1959 जननद्रव्य प्राप्तियों को एमटीएस और एफजीबी से भारत के 19 मांगकर्ताओं को आपूर्ति की गई। समीक्षाधीन अवधि के दौरान मूंग की 50 जननद्रव्य प्राप्तियों और विभिन्न बागवानी फसलों की 200 कलमों का गुणन और पुनर्जनन किया गया । jkph में, मसूर की कुल 179 प्रविष्टियां, नाइजर की 14 जीनोटाइप, बाकला की 60 जीनोटाइप, कटहल की 140 प्रविष्टियां और इमली की 38 प्रविष्टियां उपज विशेषताओं और रूपात्मक लक्षणों के लिए मूल्यांकित/लक्षणित की गईं। f'kykx में, चावल की 24 प्राप्तियों का प्रारंभिक मूल्यांकन, राजमुंग की 126 प्राप्तियों की बेहतर जीनोटाइप पहचान, सोफ्लंग की 26 प्राप्तियों का संभावित फसल मूल्यांकन, कुट्टू के 645 प्राप्तियों और श्रेष्ठ जननद्रव्य की पहचान, जॉब्स टेअर के 126 प्राप्तियों के बेहतर जननद्रव्य का मूल्यांकन और पहचान किया गया। f'kykx स्टेशन ने एमटीए मांगपत्रों के आधार पर तीन अनुसंधान संस्थानों को 219 जननद्रव्य प्राप्तियों (बकव्हीट 200, सरसों–16 और चावल–03) की आपूर्ति की।

f'keyk स्टेशन ने विभिन्न फसलों के 1043 जननद्रव्य प्राप्तियों की विशेषता और मूल्यांकन किया, जो महत्वपूर्ण कृषि–रूपात्मक लक्षणों के लिए थे और अनाज चौलाई, बकव्हीट, अजुकी बीन, फ्रेंच बीन और चना में आशाजनक

परिग्रहण की पहचान की गई थी। अल्पप्रयुक्त फसलों पर एआईसीआरपी के तहत क्विनोआ की एक किस्म ''हिम शक्ति और बकव्हीट, की ''हिम फाफरा'' विकसित की गईं। Jhuxj क्षेत्रीय स्टेशन पर कृषि–रूपात्मक लक्षणों के लिए 135 जननद्रव्य प्राप्तियों का लक्षण वर्णन किया गया। इसके अलावा, संभावित फसलों पर एआईसीआरएन के तहत फैबाबीन की 41 प्रविष्टियों का मूल्यांकन किया गया। f='kwj में, कुल 861 संग्रह में फॉक्सटेल मिलेट के 21, मूंग के 400, कुल्थी के 300, ककड़ी के 44, खरबूजे के 19, तारो के 40, करी पत्ते के 18 और कटहल के 45 शामिल थे। एनजीबी में एलटीएस के लिए 270 संग्रहों के जननद्रव्य और 353 गुणित जर्मप्लाज्म जिसमें विभिन्न फसलें और उनकी फसलें जंगली रिश्तेदार/औषधीय पौधे शामिल हैं, को एलटीएस के लिए भेजा गया। एमटीए के तहत 47 प्रयोक्ता एजेंसियों को विभिन्न प्रजातियों/टैक्सा में कुल 6221 प्राप्तियों की आपूर्ति की गई।

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राष्ट्रीय जीन बैंक में दीर्घकालीन संरक्षण के लिए जननद्रव्य की कुल 14649 प्रविष्टियां प्राप्त हुईं, जिनमें पुनर्जीवित जननद्रव्य, अधिसूचित की जाने वाली किस्में, जारी की गई किस्में और विभिन्न फसलों के विशिष्ट पंजीकृत जननद्रव्य शामिल हैं। विभिन्न कृषि–बागवानी फसलों के 14369 प्राप्तियों को आधार संग्रह में शामिल करते हुए जीनबैंक मानकों का पालन करते हुए इन्हें संसाधित किया गया, जिससे कुल जर्मप्लाज्म होल्डिंग बढ़कर 458873 हो गई। संरक्षित प्राप्तियों में से 10, 234 नई थीं और 4,135 प्रविष्टियां पुनर्जनन के बाद प्राप्त हुई थीं। लक्षण वर्णन/मूल्यांकन/पुनर्जन्म/अनुसंधान के लिए संग्रहीत जननद्रव्य (5060 परिग्रहण) में अंकुरण और बीज मात्रा की निगरानी और वितरण (14,147) अन्य प्राथमिकता वाले कार्य थे। आपूर्ति किए गए जर्मप्लाज्म में वे शामिल हैं जिन्हें कंसोर्टियम रिसर्च प्रोजेक्ट ऑन एग्रोबायोडाइवर्सिटी (सीआरपी–एबी) के तहत गुणन और लक्षण वर्णन के लिए भेजा गया है।

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इन विट्रो जीनबैंक (IVAG) में विभिन्न पौधों की प्रजातियों के 1,936 परिग्रहणों के इन विट्रो कल्चर को 8–25 डिग्री सेल्सियस के भंडारण तापमान पर संरक्षित किया गया, जिसकी उपसंस्कृति अवधि 1–24 महीने तक थी। क्रायोजेनबैंक में बीज, अक्ष, पराग और 2,194 जीनोमिक संसाधनों के रूप में कृषि–बागवानी प्रजातियों के कुल 12,137 परिग्रहणों का संरक्षण किया गया। आईवीएजी में कुल 21 नई प्रविष्टियां जोड़ी गईं और इन विट्रो बेस जीनबैंक (आईवीबीजी) में 19 प्रविष्टियां जोड़ी गईं। बूनियम पर्सिकम, फ्रिटिलारिया सिरोहोसा, पाइपर लोंगम, सोरोपस एंड्रोजेनस, स्मालंथस सोनचिफोलियस, साइजीगियम क्यूमिनी, जैन्थोसोमा सैगिटिफोलियम, जिंजिबर नीसानम और जेड व्हाइटियनम में इन विट्रो स्थापना और गुणन प्रोटोकॉल विकसित किए गए। विट्रीफिकेशन, ड्रॉपलेट–विट्रीफिकेशन, एनकैप्सुलेशन–डिहाइड्रेशन और वी– और डी–क्रायोप्लेट तकनीकों का उपयोग करके क्रायोप्रिजर्वेशन प्रयोगों में अलग–अलग डिग्री की सफलता हासिल की गई। फलों, औद्योगिक फसलों, फलियां, बाजरा, चारा, सब्जियों और जंगली प्रजातियों से संबंधित कुल 231 प्रविष्टियों को बीजों, भ्रूण अक्ष और पराग के रूप में क्रायोस्टोर किया गया। 12 प्रजातियों में हिमीकरण और शुष्कीकरण अध्ययन किए गए और तीन प्रजातियों में बीज निष्क्रियता को तोड़ने के लिए प्रोटोकॉल को अनुकूलित किया गया था। वैक्सीनियम स्पीशीज में क्रायोसंरक्षित पौधों की आनुवंशिक अखंडता के रखरखाव की पुष्टि (49 ISSR का उपयोग करके) की गई और कोलोकेसिया एस्कुलेंटा (38 ISSR मार्करों का उपयोग करके) और उच्च समानता का पता चला। टीसीसीयू की गतिविधियां एसडीजी 2, लक्ष्य 2.5 (खाद्य उत्पादन में आनुवंशिक विविधता बनाए रखना) का अनुपालन करती हैं।

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क्षेत्रीय स्टेशन vdksyk के मध्यम अवधि के भंडारण में नियंत्रित स्थिति में तिलहन (10452), दालें (4687), सब्जियां (2034), पोटेंशियल फसलें (1399), बाजरा (1536) और फसल पौधों के जंगली रिश्तेदार (730) सहित विभिन्न फसलों/प्रजातियों के कुल 20,838 प्राप्तियों का रखरखाव किया जा रहा है। क्षेत्रीय स्टेशन Hkkokyh में एमटीएस में कुल 11,786 एक्सेशन और फील्ड जीन बैंकों में 1301 एक्सेशन का भी रखरखाव किया जा रहा है। dVd में, M&AP] बागवानी फसलों, कंद फसलों और CWR सहित कुल 629 प्राप्तियों को FGB में रखा जा रहा है और कुल 1470 हर्बेरियम नमूनों को संरक्षित किया जा रहा है।

बारहमासी फसलों की कुल 453 जननद्रव्य प्राप्तियों को क्षेत्रीय स्टेशन जोधपुर के फील्ड जीन बैंक में जीवित पौधों के रूप में रखा जा रहा है। विभिन्न फसलो/प्रजातियों के जननद्रव्य की कुल 43,120 प्राप्तियों को मध्यम अवधि की भंडारण इकाई में नियंत्रित परिस्थितियों में स्टेशन पर संरक्षित किया जा रहा है। jkaph के फील्ड

जीन बैंक में कुल 617 औद्यानिक पादप परिग्रहणों और 300 औषधीय पादप परिग्रहणों का संरक्षण किया जा रहा है। आरएस f'kykax ने विभिन्न कृषि–बागवानी फसल जननद्रव्य की 1717 प्राप्तियों का अनुरक्षण और पुनर्जनन किया। f='kj में विभिन्न फसलों/बारहमासी बागवानी पौधों और उनके जंगली रिश्तेदारों के 11,760 परिग्रहणों का जननद्रव्य है, जिनमें से 9832 एमटीएस में और 1928 एफजीबी में हैं।

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19 कृषि–बागवानी फसलों के एक सौ छह (106) नमूनों के लिए डीएनए फिंगरप्रिंटिंग सेवा प्रदान की गई। ब्राउनटॉप मिलेट, तिल आदि जैसी फसलों में नए जीनोमिक संसाधनों का विकास किया गया। कुल 57 छोटे लिटल मिलेट प्राप्तियों को शुद्ध किया गया और कृषि–रूपात्मक लक्षणों के लिए उनकी विशेषता भी बताई गई। ऐमारैंथ में जीनोमिक अध्ययन में तेजी लाने के लिए, एक एसएनपी जीनोटाइपिंग चिप जिसमें लगभग 671 एसएनपी मार्कर शामिल थे, को विकसित किया गया और अनाज ऐमारैंथ के 192 परिग्रहणों में परीक्षण किया गया। इसके अलावा, ऐमारैंथ का एक जीनोमिक संसाधन डेटाबेस भी विकसित किया गया है जिसमें सार्वजनिक रूप से उपलब्ध संसाधनों से एनोटेट किए गए एसएनपी, एसएसआर, ट्रांसक्रिप्शन कारक, ट्रांसपोर्टर्स, माइक्रोआरएनए और जीन पर जानकारी शामिल है। पाइपर नाइग्रम, सेसमम इंडिकम (सीवी. स्वेथा) और एस. इंडिकम सबस्प मालाबारिकम नामक तीन प्रजातियों के क्लोरोप्लास्ट जीनोम को इकट्ठा किया गया। गेहूं और चावल में पत्ती और गैर–पर्ण प्रकाश संश्लेषक ऊतकों के ट्रांसक्रिप्टोमिक अध्ययनों ने पीएसीएमएडी क्लैड में मजबूत सी4 प्रकाश संश्लेषण मार्ग से पहले, पोएसी परिवार के बीओपी क्लैड में कमजोर सी4 मार्ग के विकास का समर्थन करने वाले एक मॉडल का विकास किया। गेहूं जीनोटाइप झत्स्3–4 के ट्रांसक्रिपटामिक विश्लेषण द्वारा अम्लता तनाव सहिष्णुता के प्रमुख जीनों और उससे जुड़े रास्ते की पहचान की गई। एलियम परिग्रहणों के साइटोलॉजिकल और डीएनए बारकोडिंग अध्ययनों ने आकृति विज्ञान की दृष्टि से भिन्न अज्ञात एलियम टैक्सोन के साक्ष्य प्रदान किए हैं, जो ए. प्रेजेवलस्किनम से निकटता से संबंधित है। कुसुम के जंगली रिश्तेदारों में एसएसआर मार्करों की क्रॉस–प्रजाति हस्तांतरणीयता का विश्लेषण किया गया। गेहूं के जीनोटाइप में स्टार्च ग्रेन्यूल्स की स्कैनिंग इलेक्ट्रॉन माइक्रोस्कोपी (एसईएम) छवियों को विकसित किया गया जो हीट स्ट्रेस के लिए संवेदनशीलता के चर स्तर पर विकसित हुए थे जो कुछ जीनोटाइप में गर्मी सहिष्णुता के उच्च स्तर के पीछे तंत्र पर कुछ प्रकाश डाल सकते थे। बीज की सतह की विशेषताओं की SEM छवियों को तिल के जंगली रिश्तेदारों को अलग करने में उपयोगी पाया गया।

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एनबीपीजीआर में कृषि ज्ञान प्रबंधन इकाई (एकेएमयू) आईसीएआर में पीजीआर सूचना विज्ञान गतिविधियों का केंद्र है। यूनिट का उद्देश्य पीजीआर डेटाबेस और वेब–आधारित अनुप्रयोगों के विकास और रखरखाव के माध्यम से पीजीआर उपयोग को बढ़ाने के लिए पीजीआर सूचना तक आसानी से पहुंच की सुविधा प्रदान करना है। PGR पोर्टल, NBPGR का प्रमुख वेब–आधारित सूचना संसाधन, कई देशों से एक्सेस किया गया। नए एप्लिकेशन विकसित किए गए और कुछ सार्वजनिक उपयोग के लिए लॉन्च किए गए। ट्विटर के माध्यम से पीजीआर गतिविधियों पर सूचना प्रसारित करने के एकेएमयू के प्रयास ने एनबीपीजीआर द्वारा निभाई गई भूमिका को लोकप्रिय बनाने वाले कई उपयोगकर्ताओं को आकर्षित किया है।

बेस सेंटर dVd ने आदिवासी उप–योजना के तहत मयूरभंज के ठाकुरमुंडा ब्लॉक और क्योंझर, ओडिशा के तेलकोई ब्लॉक में पीजीआर जागरूकता कार्यक्रम और जैव विविधता मेले का आयोजन किया जिससे 300 आदिवासी किसान लाभान्वित हुए। हरियाणा के प्रगतिशील किसानों के लिए एक्सपोजर विजिट और प्रदर्शन कार्यक्रम और बीज वितरण कार्यक्रम आयोजित किया। केंद्र में बीज वितरण कार्यक्रम ''विशेष राष्ट्रीय स्वच्छता अभियान (कचरे से धन)'' कटक में अस्पताल, बच्चों के पार्क आदि में कृषक समुदाय और नागरिक समाज के सदस्यों के साथ आयोजित किया गया। एमजीएमजी कार्यक्रम के तहत ग्रामीणों के बीच नियमित सलाहकार सेवाएं प्रदान की गईं और चावल की किस्मों का वितरण किया गया। झारखंड के खूंटी जिले के रनिया ब्लॉक में भाकृअनुप–एनबीपीजीआर क्षेत्रीय स्टेशन, jkaph द्वारा एक दिवसीय पादप आनुवंशिक संसाधन संरक्षण जागरूकता कार्यशाला सह जैव विविधता मेले का आयोजन किया गया। f'kykax स्टेशन ने मियांगखो गांव, दीमा हसाओ असम में जनजातीय उप–योजना के तहत पीजीआर जागरूकता पर एक प्रशिक्षण जागरूकता कार्यक्रम आयोजित किया, जिससे डिमासा आदिवासी समुदाय के 100 किसानों को लाभ हुआ और भाग लेने वाले किसानों को नैपसैक स्प्रेयर वितरित किए गए। पीपीवी और एफआर प्राधिकरण के साथ किसानों की

किस्मों के पंजीकरण की सुविधा के लिए किसानों के बीच जागरूकता पैदा करने और पारंपरिक फसलों की स्थानीय विविधता के पीजीआर संरक्षण पर क्षमता विकास कार्यक्रम शुरू करने के लिए f'keyk में एससी–एसपी के तहत एक पीजीआर जागरूकता कार्यक्रम आयोजित किया गया था। Jhuxj स्टेशन ने कश्मीर में उरी (बारामूला जिला) और लद्दाख में गरकोन (कारगिल जिला) जैसे सुदूर आदिवासी क्षेत्रों में टीएसपी के तहत तीन जागरूकता कार्यक्रमों का आयोजन किया। इन कार्यक्रमों में 132 महिलाओं सहित कुल 410 किसानों ने भाग लिया और किसानों के बीच 200 किलोग्राम से अधिक मटर और स्थानीय राजमाश के बीज वितरित किए गए। f='kj में, किसानों के साथ दो जननद्रव्य विनिमय दिवस और दालों और भिंडी पर दो प्रक्षेत्रदिवस आयोजित किए गए। 2021 में संस्थान मुख्यालय और क्षेत्रीय स्टेशनों में 13 प्रशिक्षण/कार्यशाला/जागरूकता कार्यक्रम आयोजित करने में शामिल था। विभिन्न वैज्ञानिक कर्मचारियों ने 33 प्रशिक्षण कार्यक्रमों में भाग लिया। तकनीकी और प्रशासनिक कर्मचारियों ने क्रमशः 7 और 6 प्रशिक्षणों में भाग लिया। ब्यूरो के सभी वैज्ञानिकों और 04 तकनीकी कर्मचारियों ने विभिन्न सेमिनारों/सम्मेलनों/संगोष्ठियों/कार्यशालाओं/बैठकों में भाग लिया।

EXECUTIVE SUMMARY

The significant achievements during 2021 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 2021, **a total of 38 explorations** were undertaken across the country and **2,600 accessions of various agri-horticultural crops, wild relatives** of crops and other economic species were collected from 76 districts located in 20 states (Assam, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Sikkim, Uttarakhand, Uttar Pradesh, West Bengal, Laddakh and Lakshadweep). Of these, 942 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 18 explorations conducted in 14 states of India.

A total of **702 herbarium specimens** (including 16 unrepresented taxa) were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Morphological, cytological and molecular evidences were drawn to support the identification of a new wild *Allium* species (*Allium negianum*) from India and a distinct taxonomic status was confirmed. Geo-referencing and mapping of 16,246 indigenous accessions of chickpea (*Cicer aeritinum*), 1,556 accessions of moth bean (*Vigna aconitifolia*) and 2,327accessions of rice bean (*Vigna umbellata*) were done.

Akola regional station undertook four exploration and collection programmes during the year and a total of 317 accessions of different crop species and wild relatives were collected from the districts of Maharashtra and Madhya Pradesh states. **RS Bhowali** made 53 different collections in one national exploration plan. At Base Centre **Cuttack**, three exploration missions were undertaken and 311 acc comprising wild rice, wild crop relatives, pulses, millets and valuable M&AP were collected from Odisha and Chhatisgarh. Occurrence of three taxonomic varieties of wild okra viz. *Abelmoschus angulosus* var. *grandiflorus*, *A. tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* were reported first time from Odisha and form new distributional records for Eastern India. **RS Jodhpur** conducted an exploration in collaboration with ICAR-DMAPR Anand, AICRP on MAP and Betelvine center Agriculture University Jodhpur for collection of M&P from Sikar and Nagaur Districts (Rajasthan); Bhiwani District (Haryana)and collected 38 germ plasm accns. RS **Ranchi** conducted two exploration programme in Jharkhand to collect 179 accessions of cereals, pulse, vegetable, oilseed and crop wild relatives. **Shillong** station undertook two explorations at Dima Hasao, Assam for multi crops and Garo hills, West Khasi hills and East Jaintia hills for Citrus germplasm. Shimla regional station conducted two explorations for various agri-horticultural crops from Salooni block of Chamba Himachal Pradesh and Bhaderwah block of Doda in Jammu & Kashmir and a total of 192 accessions were collected. **Srinagar** regional station undertook two exploration and germplasm collection programmes and a total of 150 accessions of agri-horticultural crops and crop wild relatives (CWR) were collected from various areas of Kashmir. At **Thrissur** station, 394 samples of germplasm were collected in four exploration missions, covering districts of Tamil Nadu, Karnataka and Valmiki Tiger Reserve, Bihar. One new taxon each of *Momordica* and *Trichosanthes* was described.

Germplasm exchange

During the period under report **50,596 accessions (1,67,042 samples) were imported** including 34,031 accessions (40,934 samples) of germplasm and 16565 entries (1,26,108) samples of CGIAR nurseries for trials. A total of **700 samples of wheat (350 to Bolivia and 350 to Bangladesh) were exported** under ICAR-CIMMYT Project. A total of **13, 448 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, **40,615 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 germplasm quarantine

A total of **1,37,671 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 (7,730)** comprised insects (6,550), nematodes (429), fungi (736), viruses (15) and weeds (53) including several exotic pests. Of the 7,730 infested/ infected/ contaminated samples, **7,623 were salvaged** through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test while 107 infected samples could not be salvaged, hence rejected. A total of 137 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 **51 post-entry quarantine inspections** were carried out at various indenter's sites during this period. A total of **1871 samples of various crops were processed for export** of which 37 infested samples were salvaged, 16 samples contaminated with 04 types of weed species were salvaged and 11 Phytosanitary Certificates were issued. Quarantine processing of 37 samples of imported transgenic planting material resulted in interception of fungal pathogens in both soybean and cotton. 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 12,689 samples** were received from Division of Germplasm Conservation As a result of SHT, 547 samples were found infected with different pathogens including fungi (520 samples) and bacteria (2 samples) and viruses (25 samples). A total of 31 infected samples including 10 *Triticum aestivum* samples infected with *Tilletia carries* (6) and *T. indica* (4); one *Hordeum vulgare* sample infected with *T. carries*; six *Oryza sativa* samples infected with *T. barclayana*; one *Echinochloa esculenta* sample infected with *Ustilago panici-frumentacei* and one *Glycine max* sample infected with *Peronospora manshurica* were rejected as they could not be salvaged and *Setaria italica* (9), *Eleusine coracana* (2) from Hyderabad and *Cajanus cajan* (1) from Madhya Pradesh were also rejected due to heavy fungal contamination. A total of 292 indigenous samples were infected with nematodes. In addition, **83 samples were received from TCCU** for seed health testing before/ after cryo-preservation, of which 34 samples were found infected with different fungi and all were salvaged.

At **Hyderabad**, during the period under report a total of **55,489** samples (**16,262** imports; **39,227** exports) were processed for quarantine clearance. **43** Phytosanitary certificates were issued. Import crop germplasm samples (**8,694**), infested/ infected with pests/pathogens, were salvaged and released. **Post-entry quarantine inspection was conducted on 3,563 accessions of different crops grown at ICRISAT (41) and World Vegetable Center (204),**

private industry (3,174), public organizations (40) and NBPGR greenhouse (104). Quarantine services were extended to 40 organizations in South India.

Germplasm characterization and evaluation

During 2021, a total of **32,337 accessions of various agro-horticultural crops were characterised/evaluated/regenerated/multiplied** which comprised wheat (2,374 acc.), maize (227), barley (700), buckwheat (250 acc.), brassica (2,159 acc.), sesame (6,500), linseed (2,657), soybean (8,029 acc.), chickpea (5,084), mungbean (410), dolichos (827 acc.), pea (2,443 acc.), ricebean (252 acc.), fababean (216 acc.) cowpea (425 acc.), brinjal (110 acc.) and cucumber (22 acc.). Regarding trait specific **evaluation, a total of 1,065 accessions** of different crops *viz*. maize, brassica, chilli, pea, okra and cucumber were evaluated for crop specific biotic stresses and a total of 7,286 accessions belonging to wheat, barley, linseeds, and lentil were evaluated under abiotic stresses. In addition, a total of **3,231 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 **722 accessions comprising wheat (662 acc.) and okra (60 acc.) were evaluated** at AICRP centres/hotspots for quality traits, abiotic and biotic stresses. Germplasm Field Days on 'Chickpea' and 'Wheat and Barley' were organized at NBPGR, Issapur farm, New Delhi on 28 and 29 March, 2022 respectively. A total of **6971 accessions of various crops were supplied** to 79 indenters for use in crop improvement programmes.

Akola regional station characterized and evaluated 11,142 accessions (2837 in *Rabi* 2020-21 and 8,305 in *Kharif* 2021). The regional station also supplied 6,958 accessions of various crops for research purpose to user agencies within India. Multiplied and regenerated 8,164 germplasm accessions of different crops during the reporting period. At **RS Bhowali** total 1,109 accessions of various field, horticultural, WEUP crops were characterized, multiplied and rejuvenated for MTS seed replacement. At **RS Bhowali** 601 accessions of various crop germplasms were shared with researchers across the country against MTA. In addition 8,818 live plants/rooted plants/grafted plant were also supplied to the farming community. At **Cuttack a** set of 1,660 acc of different crops and wild relatives was multiplied/ regenerated and 347 accessions were characterized for different morpho-agronomic traits. A set of 104 acc comprising WRCP (27), wild rice (77) were supplied to ICAR-institutes and exotic rice germplasm (112) were received from NBPGR, New Delhi. At **Hyderabad**, **1,282** accessions of different agri-horticultural crops were raised for characterisation, evaluation, screening, rejuvenation and multiplication. **Sixty-four** accessions consisting of ICRISAT pigeon pea Mini-Core germplasm (34), cowpea (9) and paddy (21) were multiplied and sent to NGB for long term storage. **464** accessions of evaluated and multiplied indigenous germplasm were added to the MTS at the station. A total of **1,344** germplasm accessions of different agri-horticultural crops was provided to 35 SAUs/ ICAR institutes.

A total 1,383 germplasm accessions of various crop groups comprising 944 accessions during *Rabi* 2020-21 and 439 accessions during *Kharif* 2021 were characterized and evaluated at **Jodhpur** station. A total of 1959 germplasm accessions of various agri-horticultural crop species were supplied from MTS and FGB to 19 indenters. Multiplied and regenerated 50 germplasm accessions of mung bean and 200 cuttings of various horticultural crops during the period under reporting. At **Ranchi, a** total of 179 accessions of Lentil, 14 genotypes of Niger, 60 genotypes of Fababean, 140 accessions of Jackfruit and 38 accessions of Tamarind were evaluated/ characterized for yield attributes and morphological traits. At **Shillong,** preliminary evaluation of 24 accessions of rice, 126 accessions of rice bean superior genotypes identification, potential crop evaluation of 26 accessions of sohphlang, 645 accessions of buckwheat for identification of superior germplasm for 126 accessions of Job"s tears evaluation and identification of superior germplasm was done. Shillong station supplied 219 germplasm accessions (Buckwheat 200, Mustard-16 and Rice-03) to three research institutes based on MTA indents.

Shimla station characterized and evaluated 1043 germplasm accessions of various field crops against important agro-morphological trait sand promising accessions were identified in grain amaranth, buckwheat, adzuki bean, french bean and chickpea. Two varieties, one each, of Quinoa, "Him Shakti and Buckwheat, "Him Phaphra" were developed under AICRP on Potential crops. At **Srinagar** regional station 135 germplasm accessions were characterized for agro-morphological traits. Besides, 41 entries of fababean were evaluated under AICRN on Potential Crops. At **Thrissur**, a total of 861 collections comprising 21 of foxtail millet, 400 of greengram, 300 of horsegram, 44 of cucumber, 19 of melon, 40 of taro, 18 of curry leaf and 45 of jackfruit were characterized. Germplasm of 270 collections and 353 of multiplied germplasm comprising various crops and their crop wild relatives/ medicinal plants were sent for LTS in NGB. A total of 6221 accessions in various species/ taxa were supplied to 47 Indenters under MTA.

Ex-situ conservation of germplasm

A total of 14649 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 14369 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 458873. Of the conserved accessions, 10, 234 were new and 4,135 accessions were received after regeneration. Monitoring of viability and seed quantity in conserved germplasm (5060accessions) and distribution (14,147) for characterization/ evaluation/regeneration/research were the other priority activities.

In-vitro and cryo conservation of germplasm

In vitro cultures of 1,936 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 12,137 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 21 new accessions were added to the IVAG and 19 accessions were added to *In Vitro* Base Genebank (IVBG). *In vitro* establishment and multiplication protocols were developed in *Bunium persicum*, *Fritillaria cirrhosa*, *Piper longum*, *Sauropus androgynous*, *Smallanthus sonchifolius*, *Syzygium cumini*, *Xanthosoma sagittifolium*, *Zingiber neesanum* and *Z. whitianum*. Varying degrees of success was achieved in cryopresevation experiments using vitrification, droplet-vitrification, encapsulation-dehydration and V- and D-cryoplate techniques. A total of 231 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 12 species and protocols for breaking seed dormancy were optimized in three species. Maintenance of genetic integrity of cryopreserved plants was confirmed in *Vaccinium* spp. (using 49 ISSR) and *Colocasia esculenta* (using 38 ISSR markers) and revealed high similarity.

Germplasm in MTS & FGB

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**. At **RS Bhowali** a total of 11,786 accessions in MTS and 1301 accessions in field gene banks are also being maintained. At **Cuttack**, a total of 629 accessions comprising M&AP, horticultural crops, tuber crops and CWR are being maintained in the FGB and a total 1470 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 43,120 accessions of various crops/species germplasm are being conserved at the station under controlled conditions in the medium term storage unit. A total of 617 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank of **Ranchi**. **RS Shillong** maintained and regenerated 1717 accessions of various agri-horticultural crop germplasm. **Thrissur** has a germplasm holding of 11,760 accessions of various crops/ perennial horticultural plants and their wild relatives of which 9832 are in the MTS and 1928 in the FGB.

DNA fingerprinting, genomic resources generation and GM detection

DNA fingerprinting service was provided for one hundred and six (106) samples of 19 agri-horticultural crops. Novel genomic resources were developed in crops such as browntop millet, sesamum, etc. Genetic diversity studies were undertaken in crops such as sesamum, browntop millet, little millet, finger millet using SSR markers. A total of 57 little millet accessions were purified and also characterized for agro-morphological traits. In order to accelerate genomic studies in **Amaranth, a SNP genotyping chip** containing approximately 67k SNP markers was developed and tested in 192 accessions of grain amaranth. Moreover, a **Genomic Resources Database of Amaranth** has also been developed that contains information on SNPs, SSRs, transcription factors, transporters, microRNA and genes annotated from the publicly available resources. The **chloroplast genomes of three species** namely *Piper nigrum, Sesamum indicum (*cv. Swetha) and *S. indicum* subsp. *malabaricum* have been assembled. The transcriptomic studies of leaf and non-foliar photosynthetic tissues in wheat and rice have led to a model supporting **evolution of the weak C_4 pathway in the BOP clade of Poaceae family**, prior to the strong C_4 photosynthesis pathway in the PACMAD clade. Transcriptomic analysis of wheat genotype KRL3-4 identified **key genes and pathways associated with sodicity stress tolerance**. Cytological and DNA barcoding studies of *Allium* accessions have provided evidence for a **morphologically distinct unknown *Allium* taxon**, closely related to *A. przewalskianum*. Cross-species transferability of SSR markers was analysed in wild relatives of safflower. Scanning electron microscopy (SEM) images of the starch granules in wheat genotypes having variable levels of susceptibility to heat stress were developed that could shed some light on the **mechanism behind high levels of heat tolerance** in some genotypes. SEM images of the seed surface characteristic features were found useful in distinguishing crop wild relatives of sesamum.

Other Activities

Agricultural Knowledge Management Unit (AKMU) at NBPGR is the centre 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 from many countries. New applications were developed and some were launched for public use. AKMU's endeavour to disseminate information on PGR activities via Twitter has attracted many users popularizing the role played by NBPGR.

Base Centre **Cuttack** organized PGR awareness programs and biodiversity fair in Thakurmunda block of Mayurbhanj and Telkoi block of Keonjhar, Odisha under Tribal Sub-plan and 300 tribal farmers were benefited and conducted exposure visit and demonstration programme for progressive farmers of Haryana and seed distribution programme at the centre. "Special National Swachhta Campaigns (waste to wealth)" was organized at **Cuttack** in hospital, childrens' park etc with farming community and civil society members. Regular advisory services were provided and distributed rice varieties among the villagers under MGMG programme. A one day Plant Genetic Resources Conservation Awareness Workshop cum Biodiversity Fair was organized by ICAR-NBPGR Regional Station, **Ranchi** on 30.09.2020 in Rania block of Khunti district of Jharkhand. **Shillong** station conducted one training awareness programme under Tribal Sub-Plan on PGR awareness in Miyungkhro village, Dima Hasao Assam benefiting 100 farmers belonging to dimasa tribal community and knapsack sprayer were distributed to the participating farmers. At **Shimla** one PGR awareness programme was organized under SC-SP to create awareness among farmers to facilitate the registration of Farmers' Varieties with the PPV& FR Authority and to undertake capacity development programme on PGR conservation of local diversity of traditional crops. **Srinagar** station organized three awareness programmes under TSP in remote tribal areas like Uri (Baramulla distt.) in Kashmir and Garkon (Kargil distt.) in Ladakh. A total of 410 farmers including 132 women participated in these programmes and more than 200 kg seeds of field pea and local rajmash landraces were distributed among the farmers. At **Thrissur**, two germplasm exchange day with farmers and two field days on pulses and okra amphidiploids were conducted. In 2021 the institute was involved in organizing 13 trainings / workshops / awareness programs in the headquarters and regional stations. Various scientific staff attended 33 training programs. The technical and administrative staff attended seven and six trainings, respectively. All scientists of the Bureau and 04 technical staff participated in various Seminars/ Conferences/ Symposia/Workshops/meetings.

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 ha. 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.

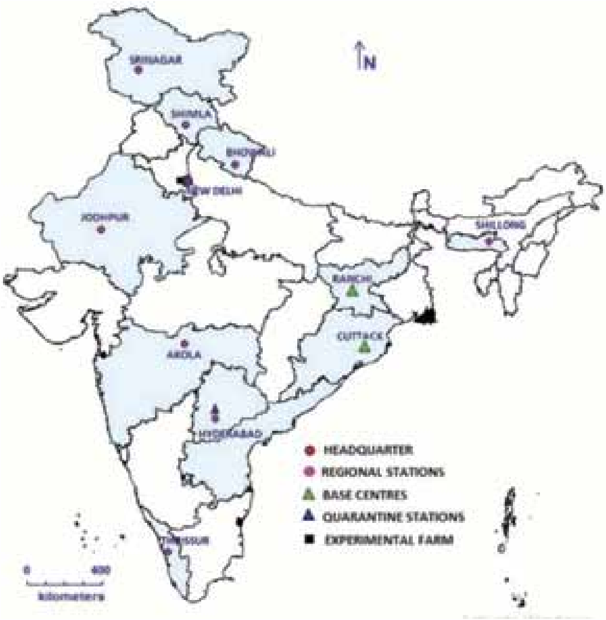


Fig. 1 NBPGR network of regional stations and base centres

National genebank

The National Genebank, ICAR-NBPGR, New Delhi was established to conserve national heritage of germplasm collections in the form of seeds,

INDIAN COUNCIL OF AGRICULTURAL RESEARCH DIVISION OF CROP SCIENCES

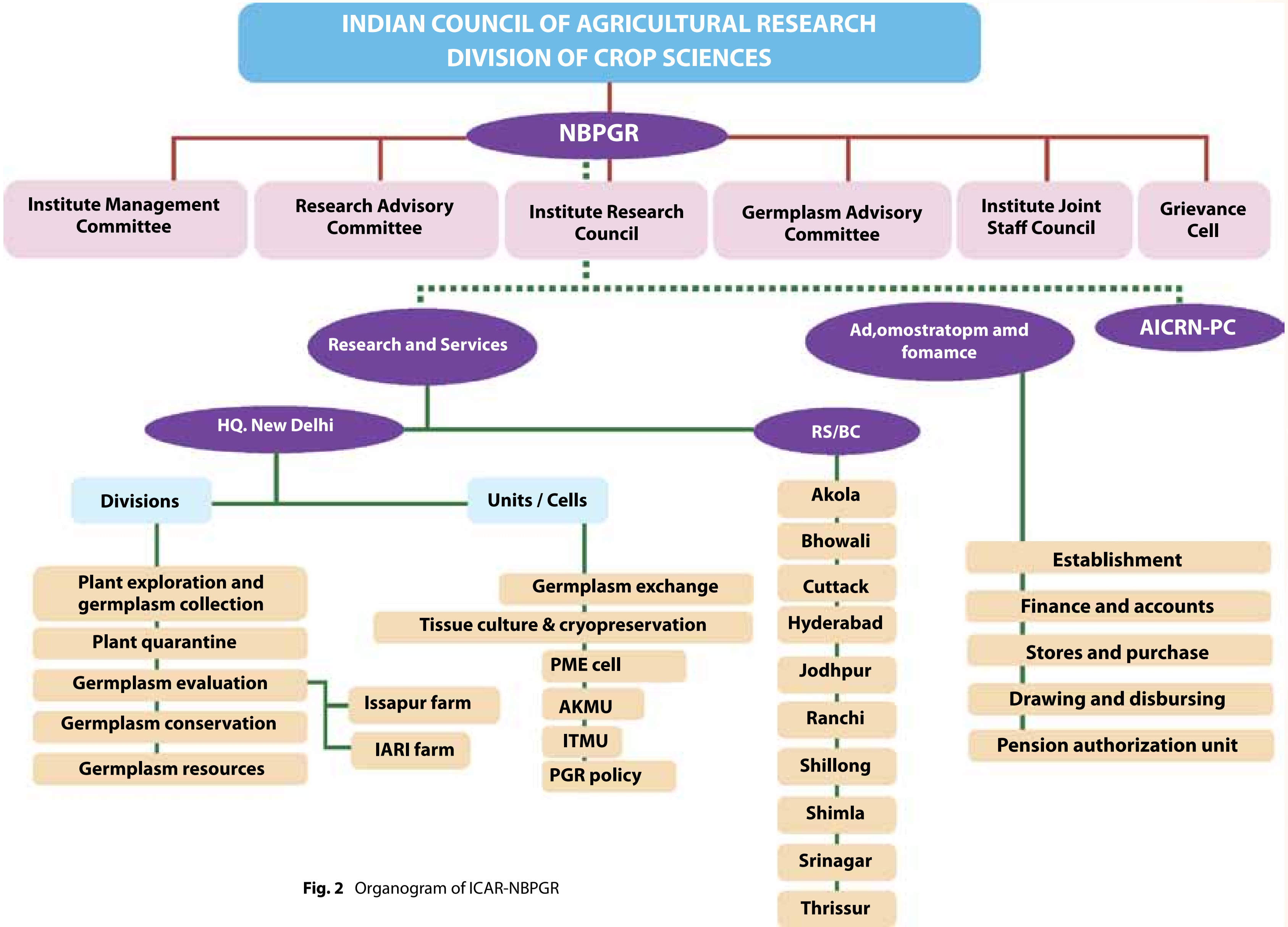


Fig. 2 Organogram of ICAR-NBPGR

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 have been commissioned for upgradation of the NGB.

Indian national plant genetic resources system (INPGRS)

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

All India coordinated research network on potential crops

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

i. To explore and domesticate new plant sources of food, fodder, fuel, fibre, energy and industrial uses

ii. To collect/ introduce and characterize available germplasm and its wild relatives

iii. To identify superior genotypes of these new plants and to develop improved varieties for different agro-climatic regions.

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

International collaboration

NBPGR implements work plans developed under MoU between ICAR and Bioversity International. Regional training courses on conservation and utilization of genetic resources of local crops of agricultural importance in South Asia and adjoining regions sponsored by FAO and Bioversity International are organized by ICAR-NBPGR.

Besides working closely with Bioversity International, ICAR-NBPGR also collaborates actively with the International Agricultural Research Centers like ICRISAT, IRRI, ICARDA and CIMMYT. It has exchanged plant germplasm with more than 80 countries and implements work plans developed under bilateral, regional and international agreements.

Training programmes and information services

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

Library and documentation services

NBPGR has a dedicated library on plant genetic resource management and is being used by all staff and students regularly. The library maintained its designated services and activities of acquisition of books and journals, exchange of literature, development of library collection database, circulation, reference services and documentation. NBPGR library is one of the members of ICAR-CeRA Consortium that facilitates online access to the journals and databases from 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 three Ph.D. students were awarded degree in 59th Convocation of P G School IARI. Currently, a total of 35 students including seven M.Sc. and twenty eight 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

Summary: A total of 38 explorations were undertaken across the country and 2,600 accessions of various agri-horticultural crops, wild relatives of crops and other economic species were collected from 76 districts located in 20 states (Assam, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Sikkim, Uttarakhand, Uttar Pradesh, West Bengal, Laddakh andLakshadweep). Of these, 942 accessions were collected by the ICAR-NBPGR Headquarters, New Delhi through 18 explorations conducted in 14 states of India. A total of 702 herbarium specimens (including 16 unrepresented taxa) were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi. Morphological, cytological and molecular evidences were drawn to support the identification of a new wild *Allium* species (*Allium negianum*) from India and a distinct taxonomic status was confirmed. Geo-referencing and mapping of 16,246 indigenous accessions of chickpea (*Cicer aerietinum*), 1,556 accessions of moth bean (*Vigna aconitifolia*) and 2,327 accessions of rice bean (*Vigna umbellata*) were done.

1.1 Plant exploration and germplasm collection

During the year 2021, a total of 38 explorations involving 16 collaborators (ICAR-2, SAUs-14) were undertaken and 2600 accessions of different agri-horticultural crops comprising 1596 accessions of cultivated (61%) and 1004 accessions of wild species (39%) were collected from 76 districts covering 20 states and UTs of India (Tab. 1.1). The states and UTs include, Assam, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Sikkim, Uttarakhand, Uttar Pradesh, West Bengal, Laddakh and Lakshadweep. These collections captured diversity in 405 taxa belonging to cultivated and crop wild relatives in 11 crop-groups (Table 1.2). Focus was to collect germplasm from various diversity-rich, remote/tribal inhabited, disturbed and under-explored areas mainly in Arunachal Pradesh, Assam, Jammu & Kashmir, Chattishgarh, Odishaand Uttarakhand. A total of 1772 collected accessions were sent to Germplasm Handling Unit (GHU) for conservation, while the remaining accessions were conserved in NGB and those having less seeds were sent for multiplication. Status of germplasm collected in explorations conducted by ICAR-NBPGR and its regional stations/base centres is given below (Table 1.2). Significant progress was made as majority of explorations planned in NEP-2021-22 have been conducted despite the restricted movement in the wake of Covid-19 pandemic.

1.2 Explorations undertaken and germplasm collected by the Headquarters

During the reporting period, 18 explorations were undertaken by the Division at NBPGR headquarters in parts of Assam, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Odisha, Punjab, Rajasthan,Madhya Pradesh, Meghalaya, Sikkim, Uttarakhand and Uttar Pradesh. A total of 942 accessions (cultivated: 587 and wild species: 355) of different agri-horticultural crops were collected (Table 1.3).

Table 1.2: Explorations undertaken and germplasm collected in the year 2021

Headquarter/Station/ Centre	Explorations undertaken	Germplasm collected		
		Cultivated	Wild	Total
Akola	4	259	58	317
Bhowali	2	89	29	118
Cuttack	3	125	186	311
Jodhpur	1	6	32	38
New Delhi (HQ)	18	587	355	942
Ranchi	2	155	24	179
Shillong	1	31	1	32
Shimla	2	104	88	192
Srinagar	2	19	131	150
Thrissur	3	221	100	321
Total	**38**	**1596**	**1004**	**2600**

Table 1.2: Details of germplasm collected in different crop groups during the year 2021

Crop-group (accs.)	Crop/wild species (accessions)
Cereals (440)	*Coix aquatica* (2), *C. lacryma-jobi* (7), *Elymus caninus* (23), *E. dahuricus* (4), *E. dentatus* (11), *E. longearistatus* (2), *E. nutans* (4), *E. repens* (1), *E. semicostatus* (27), *E. shugnanicus* (1), *Hordeum murinum* ssp. *leporinum* (15), *Hordeum vulgare* (21), *H. vulgare* var. *himalense* (2), *Leymus secalinus* (1), *Oryza nivara* (16), *O. officinalis* (4), *O.rufipogon* (26), *O. sativa* (174), *O. sativa* var. *spontanea* (19), *Triticum aestivum* (17), *T. sphaerococcum* (1), *Zea mays* (62)
Pseudo-cereals (95)	*Amaranthus caudatus* (3), *A. cruentus* (4), *A. dubius* (6), *A. graecizans* ssp. *thellungianus* (3), *A. hybridus* (1), *A. hypochondriacus* (8), *A. polygonoides* (1), *A. spinosus* (8), *A. tricolor* (27), *A. viridis* (5), *Chenopodium album* (13), *Fagopyrum esculentum* (8), *F. tataricum* (8)
Millets & minor millets (171)	*Avena sativa* (1), *Echinochloa colona* (1), *E. crus-galli* (4), *E. frumentacea* (7), *Eleusine coracana* (55), *E. indica* (3), *Panicum miliaceum* (2), *P. sumatrense* (24), *Paspalum dilatatum* (1), *P. distichum* (1), *P. scrobiculatum* (16), *Pennisetum typhoides* (6), *Setaria italica* (21), *S. pumila* (2), *S. verticillata* (1), *Sorghum bicolor* (26)
Pulses (451)	*Cajanus cajan* (30), *C. cajanifolius* (6), *C. platycarpus* (1), *C. scarabaeoides* (39), *Cicer arietinum* (14), *Lathyrus oleraceus* (2), *L. sativus* (13), *Lens culinaris* (11), *Macrotyloma uniflorum* (36), *Phaseolus coccineus* (1), *P. lunatus* (1), *P. vulgaris* (24), *Rhynchosia cana* (1), *R. minima* (1), *R. rufescens* (1), *Vigna aconitifolia* (5),*V. angularis* (14), *V. angularis* var. *nipponensis* (2), *V. dalzelliana* (3), *V. hainiana* (4), *V. mungo* (65), *V. mungo* var. *silvestris* (8), *V. radiata* (69), *V. radiata* var. *sublobata* (9), *V. stipulacea* (4), *V. trilobata* (5), *V. unguiculata*(68), *V. unguiculata* var. *cylindrica* (9), *V. vexillata* (6)
Oilseeds (217)	*Arachis hypogaea* (6), *Brassica rapa* (6), *B. rapa*var. *yellow sarson* (10), *B. juncea (9), B. napus* (1), *B. nigra* (5), *B. rapa* var. *brown sarson* (8), *B. rapa* var. *toria* (7), *Glycine max* (15), *Guizotiaabyssinica* (8), *Helianthus tuberosus* (1), *Linummysorense* (7), *L. usitatissimum*(13), *Perilla frutescens* (7), *Ricinus communis* (1), *Sesamum alatum* (1), *S. indicum* (58), *S. laciniatum* (2), *S. indicum* var. *malabaricum* (54)
Fiber and allied species (87)	*Corchorus aestuans* (9), *C. capsularis* (13), *C. olitorius* (23), *C. tridens* (1), *C. trilocularis* (5), *Crotalaria juncea* (1), *C. pallida* (2), *C. burhia* (1), *Hibiscus calyphyllus* (1), *H. cannabinus* (4), *H. panduriformis* (3), *H. sabdariffa* (8), *Malachra capitata* (2), *Sesbania bispinosa* (1), *S. cannabina* (3), *S. grandiflora* (3), *S. sesban* (5), *Thespesia lampas* (2)

Crop-group (accs.)	Crop/wild species (accessions)
Fruits and Floriculture (292)	*Aegle marmelos* (3), *Annona reticulata* (2), *Barleria cristata* (1), *Buchanania lanzan* (20), *Carica papaya* (1), *Cassia hirsute* (2), *Citrus aurantifolia* (3), *C. aurantium* (4), *C. grandis* (9), *C. indica* (1), *C.jambhiri* (14), *C. limon* (4), *C. macroptera* (4), *C. medica* (6), *C. megaloxycarpa* (1), *C. pseudolimon* (1), *C. reshni* (2), *C. reticulata* (11), *C. sinensis* (5), *Clerodendron floribundum* (1), *Cotoneaster affinis* var. *bacillaris* (2), *C. integerrimus* var. *nummularius* (1), *C. microphyllus* (1), *Cydonia oblonga* (1), *Dillenia indica* (1), *Diospyros lotus* (1), *D. melanoxylon* (1), *D. montana* (2), *Elaeagnus latifolia* (1), *E. umbellate* (1), *Eriobotrya japonica* (53), *Euryale ferox* (1), *Feronia limonia* (2), *Hippo phae salicifolia* (1), *Holboellia latifolia* (1), *Jasminum grandiflorum* (1), *Juglans regia* (11), *Malus baccata* (1), *Musa balbisiana* (6), *Olea europaea* (1), *Parthenocissus quinquefolia* (1), *P. tricuspidate* (1), *Physalis pruinose* (1), *Phytolacca acinose* (1), *Pithecellobium dulce* (2), *Prunus armeniaca* (3), *P. cerasifera* (1), *P. cerasoides* (31), *P. cornuta* (6), *P. mira* (2), *P. persica* (3), *P. salicina* (1), *Pyracantha crenulate* (1), *Pyrus pashia* (3), *P. pyrifolia* (3), *Ribes orientale* (2), *Rosa alpestre* (1), *R. macrophylla* (1), *R. moschata* (3), *R. sericea* (3), *R. webbiana* (2), *Rubus biflorus* (1), *R. ellipticus* (1), *R. fasciculatus* (1), *R. idaeus* (4), *R. niveus* (2), *R. paniculatus* (1), *R. ulmifolius* (2), *Sorbus aucuparia* (1), *S. cuspidate* (5), *S. foliolosus* (1), *Stauntonia latifolia* (1), *Vitis jacquemontii* (1), *V. vinifera* (3), *Ziziphus jujuba* ssp. *Jujuba* (4), *Z. mauritiana* (7)
Vegetables (563)	*Abelmoschus angulosus* (2), *A. caillei* (5), *A. esculentus* (13), *A. ficulneus* (7), *A. manihot* ssp. *tetraphyllus* var. *tetraphyllus* (1), *A. moschatus* (1), *A. tetraphyllus* (23), *A. tetraphyllus* var. *pungens* (1), *A. tuberculatus* (12), *Allium aggregatum* (1), *A. carolinianum* (2), *A. cepa* var. *aggregatum* (1), *A. chinense* (1), *A. consanguineum* (1), *A. humile* (2), *A. porrum* (1), *A. przewalskianum* (2), *A. stracheyi* (3), *A. tuberosum* (2), *A. wallichii* (1), *Amorphophallus paeonifolius* (4), *Basella alba* (1), *Benincasa hispida* (10), *Brassica junceavar. rugosa* (4), *Canavalia gladiate* (3), *Capsicum annuum* (28), *C. chinense* (2), *C. frutescens* (6), *Celosia argentea* (1), *Citrullus lanatus* (1), *Coccinia grandis* (5), *Colocasia esculenta* (3), *Cucumis dipsaceus* (1), *C. maderaspatanus* (3), *C. melo* (11), *C. melo* var. *agrestis* (26), *C. melo* var. *conomon* (1), *C. melo* var. *momordica* (1), *C. sativus* (18), *C. sativus* var. *hardwickii* (25), *Cucurbita maxima* (14), *C. moschata* (12), *C. pepo* (8), *Cyamopsis tetragonoloba* (1), *Cyclanthera pedata* (3), *Cyphomandra betacea* (1), *Dioscoreaalata* (5), *D. bulbifera* (2), *D. glabra* (3), *D. pubera* (1), *Lablab purpureus* (19), *Lagenaria siceraria* (28), *Luffa acutangula* (25), *L. acutangula* var. *amara* (7), *L. cylindrica* (46), *L. graveolents* (1), *L. hermaphrodita* (2), *Lycopersicon esculentum* (8), *L. pimpinellifolium* (1), *Malva verticillata* (2), *Momordica balsamina* (3), *M. charantia* (4), *M. charantia* var. *muricata* (12), *M. cymbalaria*(4), *M. dioica*(6), *Moringa oleifera* (21), *Phytolacca americana* (2), *Pisum arvense*(4), *P. sativum* (7), *Psophocarpus tetragonolobus* (1), *Raphanus sativus* (4), *Solanum americanum* (1), *S. aethiopicum* (4), *S. incanum* (3), *S. indicum* (1), *S. khasianum* (1), *S. macrocarpon* (1), *S. melongena* (9), *S. pseudocapsicum* (1), *S. sisymbrifolium* (2), *S. spirale* (1), *S. viarum* (9), *S. villosum* (2), *S. virginianum* (9), *Trichosanthes anguina* (3), *T. bracteate* (2), *T. cucumerina* (9), *T. dicoelosperma* (2), *T. dunniana*(1), *T. khasiana* (1), *T. tricuspidate* (1), *Vicia faba* (4)
Medicinal and aromatic plants, spices and condiments (241)	*Abrus precatorius* (1), *Abutilon theophrasti* (1), *Acacia catechu*(1), *Aconitum heterophyllum* (1), *Adenanthera pavonine* (1), *Allium sativum* (2), *Alpinia nigra* (1), *Amomum maximum* (1), *Andrographis paniculate* (3), *Anethum graveolents* (1), *Anisochilus carnosus* (1), *Argemone mexicana* (1), *Argyreia nervosa* (1), *Aristolochia bracteata* (1), *Bauhinia purpurea* (1), *Berginiaciliata* (1), *Bixa orellana* (3), *Cardiospermum halicacabum* (1), *Carum carvi* (2), *Cassia tora* (1), *Catharanthus roseus* (1), *Catunaregam spinosa* (1), *Citrullus colocynthis* (1), *Cleome viscosa* (2), *Clitoria ternatea* (5), *Coptisteeta* (1), *Coriandrum sativum* (21), *Corylus jacquemontii* (2), *Costusspeciosus* (1), *Curcuma amada* (2), *C. longa* (4), *Datura metel* (3), *D. stramonium* (3), *Diplocyclos palmatus* (2), *Ferula jaeschkeana* (8), *Hedychium spicatum* (1), *Hyoscyamus niger* (1), *Leonotis nepetifolia* (3), *Mucuna nigricans* (1), *M. pruriens* (9), *Murraya koenigii* (13), *Nelumbo nucifera* (2), *Nicotiana tabacum* (2), *Nigella sativa*(1), *Ocimum americanum* (11), *O. basilicum* (10), *O. citriodorum* (4), *O. gratissimum* (4), *O. tenuiflorum* (20), *Origanum vulgare* (1), *Oroxylum indicum* (2), *Pedalium murex* (3), *Picrorhiza kurroa* (1), *Piper betle* (1), *P. longum* (2), *Podophyllum hexandrum* (3), *Polygonatum verticillatum* (4), *Rauvolfia tetraphylla* (2), *Rheum austral* (1), *Saussurea costus* (1), *Schisandra grandiflora* (1), *Senna alexandrina* (1), *S. occidentalis* (1), *Solanum anguivi* (3), *S. nigrum* (2), *S. torvum*(5), *S. trilobatum* (4), *S. violaceum* (3), *S. xanthocarpum* (2), *Spilanthus acmella* (2), *Strychnosnux-vomica* (1), *Tamilnadiauliginosa* (1), *Teramnus labialis* (1), *Tinospora cordifolia* (1), *Trachyspermumammi* (2), *Trigonella corniculate* (2), *T. foenum-graecum*(7), *Valerianajatamansi* (1), *Vernonia amygdalina* (1), *Viburnum grandiflorum* (1), *Withania somnifera* (1), *Xanthium indicum* (1), *Zanthoxylum rhetsa* (4), *Zingiber capitatum* (1), *Z. chrysanthum* (2), *Z. zerumbet* (2)

Crop-group (accs.)	Crop/wild species (accessions)
Forages (35)	*Aeschynomene americana* (1), *Alysicarpus rugosus* (1), *Apluda mutica* (2), *Aristida adscensionis* (1), *Bauhinia acuminata* (1), *Chloris gayana* (1), *Chrysopogon aciculatus* (1), *C. fulvus* (1), *Dichanthium annulatum (5), D. aristatum (4), D. caricosum (1), Digitaria longiflora (1), Eragrostis amabilis* (1), *E. patula* (1), *Paspalidium flavidum* (1), *Pennisetum pedicellatum* (7), *Pueraria phaseoloides* (1), *Sacciolepis indica* (1), *Sporobolous airoides* (1), *Themeda triandra* (1), *Zea mexicana* (1)
Other economic species (8)	*Dalbergia sissoo* (1), *Saccharum munja* (1), *S. spontaneum* (2) *Indigofera caerulea* (1), *I.tinctoria* (1), *Lawsonia inermis* (2)

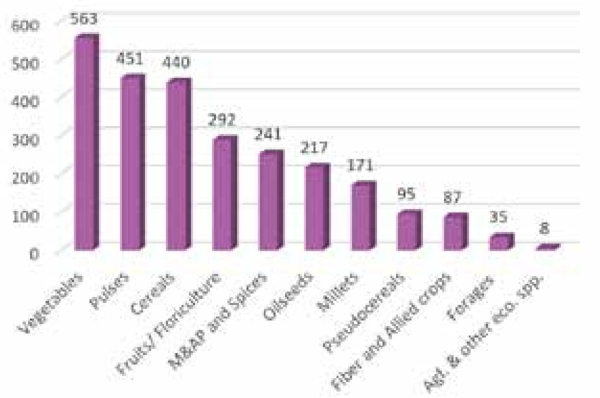


Fig. 1.1a Germplasm collected during 2021 across different crop groups

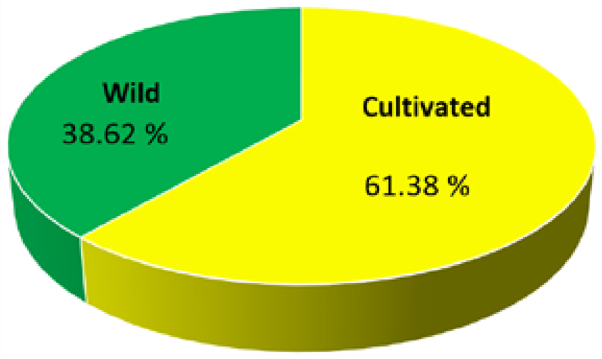


Fig 1.1b Share of cultivated and wild accessions among germplasm collected

Details of germplasm, unique accessions collected and diversity recorded in these 18 explorations are presented below:

1.2.1. Collection of *Cajanus cajanifolius* and wild economic species from parts of Odisha & Chhattisgarh:

A total of 43 accession scomprising of *Cajanus cajanifolius* (6), *Cucumis sativus* var. *hardwickii* (4), *Cajanus cajan* (3), *Cajanus scarabaeoides* (3), *Solanum anguivi* (2), *Solanum viarum* (2), *Momordica muricata* var. *muricata* (2), medicinal & aromatic Plants (12) and others (9) were collected from diverse forest ranges of Odisha and Chhattisgarh

Table 1.3 Explorations undertaken by the ICAR-NBPGR, Headquarters (2021)

S No.	Crops collected	State, districts and period	No. of Accsessions			Collaborating Institute/SAU
			Cult.	Wild	Total	
1	Wild economic species incl. *Cajanus* spp.	**Odisha** (Khordha, Ganjam, Gajapati, Rayagada, Koraput), and **Chhattisgarh** (Bastar, Dantewada), Feb. 9-16, 2021	8	35	43	
2	Multi-crop germplasm from Bihar	**Bihar** (Kaimur and Rohtas), March, 30-April 7, 2021	54	02	56	KVK, Kaimur
3	Multi-cropgermplasm	**Arunachal Pradesh** (Lower Dibang Valley and adjoining areas), March, 31-April 8, 2021	13	12	25	CHF, CAU, Pasighat
4	Tropical underutilized fruits	**Chhattisgarh** (Bastar, Bijapur, Dantewada, Kanker, Kondagaon), April 2-8, 2021	-	26	26	-
5	Loquat	**Uttar Pradesh** (Meerut, Shamli, Muzffarnagar) and **Uttarakhand** (Haridwar), April 07-11, 2021	27	02	29	-

S No.	Crops collected	State, districts and period	No. of Accsessions			Collaborating Institute/SAU
			Cult.	Wild	Total	
6	Loquat	**Haryana**, **Punjab** and **HP** (Yamunanagar, Kangra, Ludhiana, Gurdaspur, Pathankot), April 7-12, 2021	27		27	-
7	Multi-crop germplasm	**Uttarakhand** (Pithoragarh), Sept. 29-Oct. 10, 2021	20	15	35	-
8	Multi-crop germplasm	**Gujarat** (Chhota Udaipur) and **Madhya Pradesh** (Alirajpur, Barwani), Oct. 05-12, 2021	58	09	67	KVK, Alirajpur and KVK, Barwani
9	Multi-crop germplasm	**Arunachal Pradesh** (Dibang valley), Oct. 14-27, 2021	58	11	69	-
10	Multi-crop including CWR	**Assam** (Dima Hasao) and **Meghalaya:** West Jaintia Hills, Oct. 17-26, 2021	74	11	85	KVK, Dima Hasao
11	Fodder and forage legumes	**Chhattisgarh** (Kanker, Kondagoan and Bastar), Oct.19-29, 2021	17	60	77	IGFRI, Jhansi & IGKV, Raipur KVK Kanker, KVK Kondagaon, KVK Jadhalpur
12	Multi-crop	**Chhattisgarh** (Kabirdhamand **MP** (Mandla), Oct. 20-29, 2021	44	11	55	IGKV, Raipur
13	Multi-crop including CWR and other economic spp	**Bihar** (Valmiki Tiger reserve, West Champaran), Nov. 01-08, 2021	39	45	84	KVK, Champaran
14	Rice (cultivated & wild)	**Bihar** (Bhojpur and Buxar), Nov.08-11, 2021	32	22	54	KVK, Buxar
15	Crop wild relatives of vegetables	**Gujarat** (Navsari), Nov. 16-25, 2021	05	55	60	NAU, Navsari, KVK Navsari
16	Multi-crop germplasm	**Bihar** (Madhepura, Saharsa and Supaul), Nov. 18-27, 2021	83	09	92	BAU, Bhagalpur KVK- Madhepura, KVK-Saharsa, and KVK Supaul
Explorations undertaken in externally funded projects 18						
17	Crop wild relatives of Sesame	**Haryana and Rajasthan** (Jhajjar, Bhiwani, Mahendragarh, Rewari, Alwar), Oct. 05-07, 2021	-	30	30	-
18	*Citrus* spp.	**Sikkim** (South, East and West Sikkim), Nov.20-27, 2021	28	-	28	CAU, Sikkim
	TOTAL		**587**	**355**	**942**	

(Fig 1.2). During survey in probable sites of *Cajanus cajanifoilus*, Khallikot, Taptapani hills, Rayadada-Kashipur Hill Range and JeeramGhatiin the district of Odhisa were surveyed. In Khallikot Forest Range (Khurda), few scattered populations (15 plants) were observed between Baperbera Beat to Dhuanali and Ashok Nala to Ayatpur Beat. However little bit high plant population (around 100 plants) was observed between Ashok Nala and Ayatpur Forest Beat .In Taptapani Hills (Ganjam), scattered plant population (about 100 plants) of both *C. cajanifolius* and *C. scarabaeoides* was observed in forest land and adjoining cultivated fields. In Rayagada-Kashipur Hill Range (Rayagada), hilly areas near Rupa Jharan, Kashipur, Rautaghati, Jalakura, Pansapadar, Oda manjhi, Dalma villages were surveyed where good population (200-250 plants) was observed. Plant population was also found in Kanger Ghati forest ranges and Jeeram Ghati (Jagdalpur). In Bailadilla Hills (Dantewada district), a range of about 22 km long forest area was surveyed and four samples were collected. The population were having both old and young plants (height 100-300 cm) in large number. In *C. cajnifolius* observations were recorded on number of branches/plant (5-20), fertile braches (5-13), stem girth (5-10cm), stem shape (quadrangular with pale green colour), flower colour (yellow and tinge with reddish petals), flowers/ cluster (5-14), pods/ cluster (2-5), pod length (2-4cm), pod color (dark green at young stage, whitish brown or light brown at maturity), grains/pod (2-4), hilum dull white, grain flat, oblong & black in colour, 100 seed weight (4-5g), grain length and width (4-5 X 2-3 mm). It has been observed that in open sites, maturity was early and plants were dwarf in size, while on shady sites, plants were having good growth and comparatively tall but maturity was late.

1.2.2. Multi-crop germplasm from remote areas of Bihar

Fifty-six accessions comprising of *Brassica rapa* var. *brown sarson* (9), *Lathyrus sativus* (6), *Cicer arietinum* (6), *Brassica rapa* var. *yellow sarson* (5), *Cajanus cajan* (5), *Linum usitatissimum* (4), *Coriandrum sativum* (3), *Hordeum vulgare* (3) *Pisum sativum* var. *arvense* (3), *Lens culinaris* (3) and *Brassica rapa* var. *toria* (2) were collected in an exploration to parts of Kaimur and Rohtas districts of Bihar (Fig 1.3). Variability was observed in *Brassica rapa* var. *brown sarson*, chickpea, grass pea and field pea for maturity (early and late), plant

Fig. 1.2 (A) The plant population of *C. cajanifolius* in prolific flowering and fruiting stage, (B) Left to Right-pods with seeds of *Cajanus cajan, C. cajanifolius, C. scarabaeoides* and *Rhynchosiacana* and (C) First row left to right-seeds of *C. cajanifolius, C. scarabaeoides* and second row-landraces of *Cajanus cajan*

height, seed shape, size and colour. In pigeon pea, variability was observed for seed size (small and bold), shape (round/lens shape) and colour (black, light brown to chestnut brown and silvery white).

1.2.3. Germplasm of economic species explored and collected from parts of Arunachal Pradesh

A total of 25 samples belonging to vegetables (9), M&AP (7), minor fruits (3), oilseeds (3) and others (3) including endemic species *Coptisteeta* were collected from Lower Dibang Valley, Lohit and East Siang districts of Arunachal Pradesh. Important collection made was *Coptisteeta*, locally known as '*mishmi teeta*', a valuable endemic plant of the region, its rhizome (yellow colour) is used for treatment of various ailments such as dysentery, fevers, jaundice etc. Indiscriminate collection and habitat destruction have resulted inthe species being under endangered status of IUCN (Fig 1.4).

1.2.4. Collection of tropical under utilized fruits from parts of Chhattisgarh

An exploration for collection of tropical underutilized fruits was undertaken in parts of Chhattisgarh (Bastar, Kanker, Dantewada, Kondagaon and Bijapur districts) and a total of 26 accessions comprising *Buchanania lanzan (20), Annona reticulata (2), Pithecelobium dulce*(2), *Aegle marmelos* (2) were collected. Chironji (*Buchanaialanzan*) locally known as Char, Ekta (popularly known for its costly, high-priced kernel because of rich sources of nutrients and minerals) was observed with good population in entire surveyed areas. The demand of Bastar (Chhattishgarh) chironji is very high in the national and international market. In Bastar and Jagdalpur forests, majority of the chironji population was late maturing type, which was also confirmed by the local inhabitants, whereas in Kanker, Dantewada, Kondagaon and Bijapur areas the population was early maturing type (starts maturing in first week of April). Majority of chironji population was found in mahuwa (*Madhuca indica*) and saal (*Shorearobusta*) dominated forests. In Dantewada forests, natural regeneration was good/trees of different age group (saplings) were seen in abundance due to protection of area by the forest department to enhance biodiversity of state. In chironji, variability was observed for morphological traits *viz.* growth

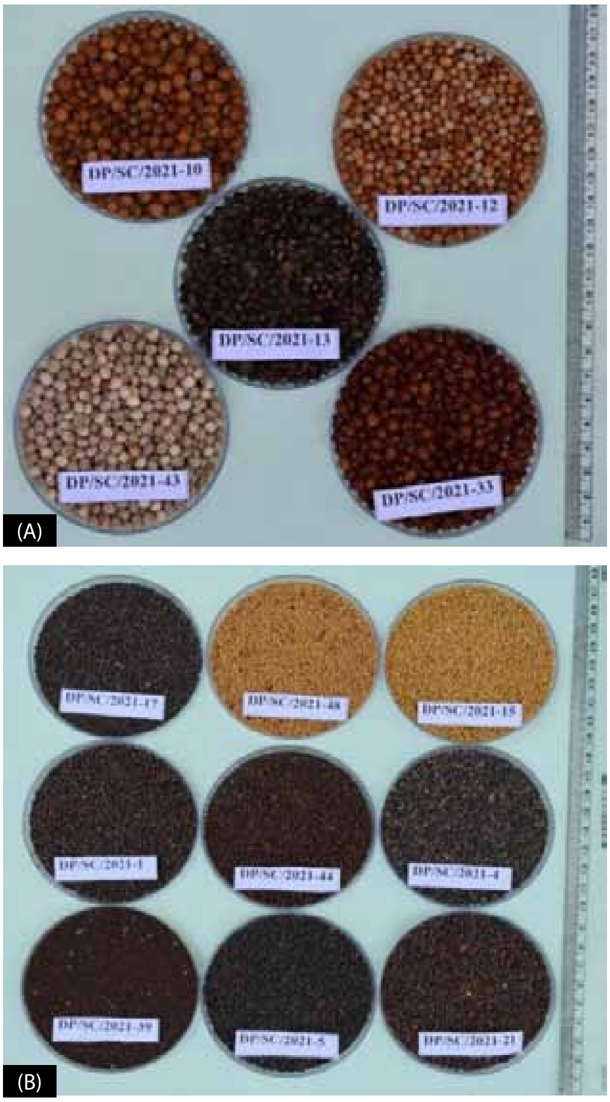


Fig. 1.3 (A) Variability in pigeon pea and (B) Brassica species

Fig. 1.4 (A) Mishmi teeta (Coptis teeta): *aendangered* species in Mishmi hills, Arunachal Pradesh

habit (spreading and upright), plant height (4-20m), foliage (dense, sparse and leaf less), leaf shape (oblong, ovate and elliptic), leaf colour (light green to dark green), stem colour (dark grey to black), early maturity (first week of April), late maturity (4th week of April), fruit size (medium and bold), fruit bearing (sparse and profuse). Though the area is having good population but no/or less destruction was observed by the tribals. Good population of *Pithecelobium dulce* locally known as 'Angreji jalebi' was also observed with profuse bearing on waste localities, road side, home gardens and near houses in Jagdalpur and Bastar and collected two types (fruits having red and white arils with medium and large seeds). Ethnobotanical information gathered on *Borassus flabellifer* locally known as 'Salphi' for fruit and sap; Mahuwa (*Madhuca indica*) flowers for extracting of an alcoholic drink, consumed in abundance; 'Tikhur'*Curcuma angustifolia*, a summer drink is prepared from its roots, sold in local market in the form of starch (powder); Tendu (*Diospyros melanoxylon*), an important wild edible fruit is sold in local market; tubers of Keu (*Costus speciousus*) are baked in hot ash to prepare chutney; some leafy vegetables like 'Chench' (*Corchorus capsularis*), Koliyari (*Bauhinia variegata*), *Hibiscus subdariffa, Amaranthus viridis, Cordia myxa etc.* are consumed and sold in local markets. *Thysanolena latifolia* occurs in wild habitat and also grown by the tribals for making brooms (phool jhadu) and sold in local markets.

Fig. 1.5 Variability in fruits (A) *Pithecelobium dulce,* (B) *Annona reticulata,* and (C) Local vendor selling in market

1.2.5. Loquat-a dwindling fruit tree, surveyed inparts of Uttar Pradesh and Uttarakhand

A survey was conducted in dwindling orchards of Meerut, Mujaffarnagar, Saharanpur and Bijnor districts of Uttar Pradesh and Haridwar district of Uttarakahand for recording information on availability of loquat *(Eriobotrya japonica)*-a locally important fruit crop germplasm. A total of 29 sites were surveyed where varieties like *Goal Surkha, Pahadi, Safeda, Talheta, Lamba Surkha, Chini, Gola Red, Orange Red, Saharanpur Special, Surkha, California, Tanaka, Japani, Golden Yellow, Golden Red, Dum Dum, Kathiya* and *Deshi* were being maintained by the farmers in the age-old orchards (Fig 1.6). Trees of *Morus macroura* (red and white fruit type)were tagged at four surveyed sites. During survey, orchards of loquat (*Eriobotrya japonica*) were surveyed mainly in Dhaulari (Meerut); Chandsina, Khatauli (Mujaffarnagar); Kairana, Kandla, Garhi Abdulla Khan and Mundeth areas (Shamli) and Mujaffarabad, Usand and Company Bagh area (Saharanpur district) of Uttar Pradesh. New plantation was also observed in Saharanpur, Shamli and Meerut (UP) and Haridwar (UK) districts, but drastic decline of orchards in Bijnor district was noticed due to replacement of loquat orchards by plantation of mango, peach, pear and plum. Over 12 varieties were being maintained at Company Bagh, Saharanpur with few old trees (40 years old). 70-80 years old trees were being maintained at Kandla (Shamli) and Bijnor, Saharanpur, Manglore (Haridwar) and at Garhi Abdulla Khan area in Shamli. The variability was observed for fruit colour (yellow, light yellow, orange, dark orange); fruit size & shape (round, pear shape, oblong, small. Medium & bold/bog); pulp colour (whitish/ light yellow, yellow, orange/red) and in taste (sweet, less sweet and light sour and sweet). The cultivar *Pahadi* had maximum fruit weight (53g), fruit length & width (5.38 & 4.37cm) followed by cultivar *Tanaka* (fruit weight-31g, fruit length and width-4.90 & 3.73cm and *Talheta* (fruit weight -32.55g, fruit length and width-4.80 & 3.60cm). The fruits per cluster ranged between 10-35 fruits. The loquat plants used as filler crop in orchards due to its fast-growing nature, starts fruiting within 3-4 years.

1.2.6. Collection of Loquat from Haryana, Punjab and Himachal Pradesh

Another Survey was conducted in dwindling orchards located in Yamunanagar district of Haryana; Ludhiana, Hoshiarpur, Gurdaspur districts of Punjab; Pathankot district of Jammu & Kashmir and Kangra district of Himachal Pradesh for recording information on availability of loquat *(Eriobotrya japonica)* -alocally important fruit crop germplasm. In Himachal Pradesh, it was found mostly in backyard or home gardens. Total 26 accessions representing different varieties were collected from orchards and homesteads of the

Fig. 1.6a Variability in fruits and seeds for size, shape, colour of Loquat

Fig. 1.6 Fruiting of different varieties (A) *California* (B) *Gola Surkha* (C) *Saharanpur* and (D) *Safeda* of Loquat

farmers.

1.2.7. Multi-crop germplasm collection fromhigher altitude areas of Uttarakhand

A total of 35 accessions comprising barley (hulled/hull-less), *Brassica* species, buckwheat, French bean, *Allium* species, M&APs, temperate fruits and wild economic species were collected from remote valleys in Pithoragrh district bordering to Nepal and China in Uttarakhand. The high-altitude areas visited were Malpa, Garbyang, Gunji and Kuti villages of Pithoragarh (Uttarakhand), which are in habited by a nomadic tribe *Bhotia,* which is rich in traditional culture. Notable collections with good variability made were wheat (Napali), barley (necked barley), buckwheat (tartary & sweet type), French bean, wild *Allium (A. carolinianum, A. przewalskianum),* wild fruits *(Cotoneaster microphyllus, Hippophaesalicifolia, Malus baccata, Prunus cornuta, Prunus mira, Ribes alpestre, Ribes orientale, Rosa sericea* and *Rosa macrophylla),* endangered species *(Polygonatum verticillatum)* from the explored areas (Fig 1.7). Cultivation of *Allium przewalskianum* in place of *A. stracheyi* was observed first time in the valley, possibly introduced from Tibet long back.

1.2.8. Multi-crop collection from tribal areas of Madhya Pradesh and Gujarat

Sixty-seven accessions (58 cultivated and 9 wild species) consisting *Setaria italica* (7), *Vigna radiata* (7), *Oryza sativa* (5), *Zea mays* (4), *Sorghum bicolor* (4), *Macrotyloma uniflorum* (4), *Cajanus cajan* (3), *Cicer arietinum* (3), *Vigna mungo* (3), *Vigna unguiculata* (3), *Panicum sumatrense* (2), *Arachis hypogaea* (2), *Momordica dioica* (2) and others (18) were collected from tribal dominated areas of districts Alirajpur, Barwani (Madhya Pradesh) and Chhota Udaipur (Gujarat). Notable collection

Fig. 1.7 (A) Variability in local French bean from the valley, (B) Collection of wild *Allium* species and(C &D)threshing and cleaning of local wheat landrace 'Napali' in Gunji village

Fig. 1.8 Collection of wild temperate fruits (A) *Malus baccata,* (B) *Rosa macrophylla,* (C) *Prunus cornuta* and (D) *Hippophae salicifolia*

includes landraces of foxtail (7), blackgram (7), chickpea (3), rice (5), maize (4) and vegetables (10). Among millets, foxtail (*lalsanvai, bhandi, golden grain sanvai*); black sanvai- *Panicum sumatrense*-; kodo millet -*Paspalum scrobiculatum*; red and white grain sorghum, *nalli jowar* maturing in 90 days; indigenous-rainfed wheat, different types of cowpea (*choula*), landraces of chickpea and pigeonpea, groundnut, mothbean and among rice -*kaalidhan, dangurdhan*, black and red grain rice, green and black grain *desi* moong; red and white grain maize used in making chapati etc. were collected (Fig 1.9). Black grain type little millet fetches higher price than white grains. Medicinal uses of wild kulthi in cold, dysentery and vomiting were noted. Large variability in shape, size and colour of cucumber landraces (round, elliptical, long, mottled skin, green and yellow skin) and different type of *Momordica* (*desi karela, jungli karela*, spine gourd) and other vegetables like white seeds macuna etc. were collected. Wild species of *Abelmoschus* (*A.*

tuberculatus and *A. manihot* ssp. *tetraphyllus*) and in *Vigna* (*V. aconitifolia* and *V. radiata* var. *sublobata*) were also collected.

1.2.9. Multi-crop germplasm collected from Dibang Valley in Arunachal Pradesh

Sixty-seven accessions belonging to various local landraces, underutilized crops and wild economic species viz. *Chenopodium album* (8), *Zea mays* (7), *Glycine max* (6), *Coixlacryma-jobi* (4), *Eleusine coracana* (4), *Vigna angularis* (4), *Vigna umbellata* (3), *Oryza sativa* (3), *Solanum aethiopicum* (3), *Spilanthesacmella* (2), *Zanthoxylum rhetsa* (2), *Setaria italica* (2), *Phaseolus vulgaris* (2), *Phytolacca americana* (2), *Trichosanthes dicoelosperma* (2) and

Fig. 1.9 (A) Variability in pulses (moong, urd, kulthi and chickpea) and (B) variability in millets

others (15) were collected from Dri river valley, Mathun river valley and Malniye areas of Dibang Valley district of Arunachal Pradesh (Fig 1.10). Variability was observed in fruit shape (with and without ridges and furrow) of *Solanum aethiopicum*; ear head types (closed, open and long fingers) and grain colour (black, brownish and light brown) in finger millet; plant height (tall and medium), leaf colour (purple and green), grain colour (ash-grey and creamy-white) in *Chenopodium album*; grain colour (dark maroon, light red and creamy yellow) in adzuki bean; grain size (small and medium), grain colour (black, mottled, greenish-yellow) and pod colour (green and purplish) in French bean; grain size (medium and bold), grain colour (maroon and creamy white) and plant type (highly branched and less branched) in soybean; grain colour (black and creamy) and grain size (bold and medium) in coix; smooth and spiny fruits in *Cyclenthera pedata*; grain husk colour (red and yellowish) in paddy; grain colour (creamy and yellow) in maize. Some of the notable collections made were: *Phytolacca americana*, the farmer told that it was brought by his relatives from some other area for vegetable. It is first time seen under cultivation in NEH (only in Dibang Valley district); *Solanum macrocarpon* is cultivated in limited pockets for vegetable purpose, has large leaves with dissected margin, rounded fruit, half of its covered with calyx, spines are present on almost all parts of the plant; *Holboelia latifolia*, an important minor fruit of NEH region, bears 2-3 bananas like purplish-brown fruits when ripe, found occasionally in wild state; fruits juicy, less sweet, eaten by children, chicken/birds. *Spilanthes acmella* is grown in Jhums, kitchen garden and juice of its flower heads is used as condiments and medicine; *Trichosanthes dicaelosperma,* a wild relative of snake gourd having small, round, orange red fruits was found occasionally in the surveyed area. Ethnobotanical information on some plants was also recorded from *Idu Mishmi* tribe residing in the entire Dibang Valley district, like *Glycine max*: its roasted grains are eaten, immature pods are boiled and eaten (locally called *Aduyi-sohi*); also used in preparation of local dish *Aduli-thee; Oryza sativa*: 'Kreba' most liked landrace, used in preparation of local beverage (Yuu); *Solanum spirale 'Jungliretka'*, its young fruits are eaten as vegetable and also used in preparation of chutney, fruits are bitter in taste, but considered good for blood pressure.

1.2.10. Multi-crop germplasm collection from hills of Assam and Meghalaya

In an exploration conducted in Dima Hasao (a hill district of Assam)and adjoining West Jaintia Hills (Meghalaya), a total of 85 accessions belonging to cereals, pseudo-cereals and millets (37),vegetables (28), oilseeds (10), and others (10) were collected (Fig 11). Rich variability was observed in upland and irrigated rice landraces (sticky and non-sticky, aromatic, scented), maize, cucurbits (fruit size and shape) and chillies (fruit size, shape, pulp colour, colour and in pungency etc). Good population of *Cajanus scarabaeoides* and *Vigna mungo* var. *sylvestris* was observed in open, hot and humid localities in lower/ mid hills of the area. Maize (sweet in taste) locally known as 'sugar maize' with very small cob and small dented& white grains was an interesting collection from Dima Hasao. It was observed that the genetic resources of rice, maize and millets are eroding drastically from the area due to introduction of new high yielding varieties, vegetables and plantation crops (areca nut, palm, litchi, banana and rubber plant).

Fig. 1.10 (A) Diversity in pulse & legumes, (B) Diversity in potential crops and (C) *Holboelia latifolia*-a minor potential wild fruit from Dibang valley district

1.2.11. Fodder grasses and forage legumes collection from parts of Chhattisgarh

Total diversity comprising of 77 accessions (38-fodder grasses and forage legume, 18-crop wild relatives, 7-vegetables, 7-wild medicinal plants, 5-pulses, 2-millets) were collected from parts of Kanker, Kondagaon and Bastar districts of Chhattisgarh. Diversity in wild relatives of legumes *viz. Vigna stipulacea*, *V. hainiana*, *Cajanus*

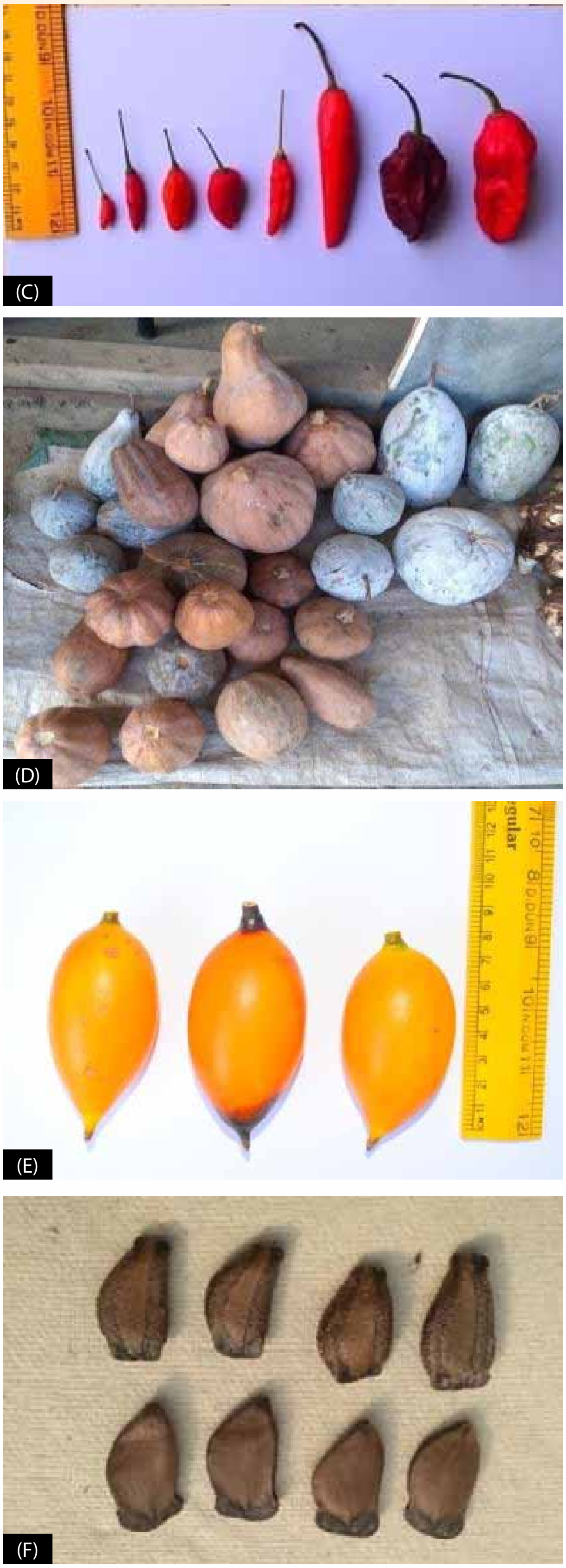


Fig. 1.11(A) Variability in maize cobs & grain for colour, shape & size, (B) Variability in rice landraces for grain colour, size & shape, (C) Fruit variability in chillies, (D) Fruit variability in pumpkin & ash gourd,(E) Fruits of *Trichosanthes dunniana* and (F) *T. khasiana* seeds

scarabaeoides was collected. Three species of *Oryza*viz. *O. nivara, O. spontanea* and *O. rufipogon* were found in ponds.

1.2.12. Collection of rainfed rice landraces from parts of Chhattisgarh and Madhya Pradesh

Fifty five germplasm accessions of rice including 17 named landraces (*Bhatta safri, Badochinga, Biduwasafri, Dev bhog, Dhaniya dhan, Desi chepti, Koko basmati, Sathiya dhan, Mahamaya dhan, Safari dhan, Kala dhan, Sindhi kapur* and *Tergisafri*) with variability in grain shape, size and

Fig. 1.12 (A) *Vigna stipulacea,* (B) *Vigna hainiana* and (C) *Pennisetum pedicellatum*

colour (black, brown, light yellow and golden); *Paspalum scrobiculatum* (7), *Sesamum indicum* (4), *Trichosanthes cucumerina* (4), *Panicum sumatrense* (2), *Solanum viarum* (2), *Oryza nivara* (2), *O.*

Fig. 1.13 (A) Variability in rice landraces; (B) Wild rice and (C) Jeera gehun

rufipogon (3), *Vigna mungo* (2), *Zea mays* (3) and others (9) were collected from parts of Kawardha (Kabirdham) district of Chhattisgarh and Mandla district of Madhya Pradesh (Fig 13). Variability was observed in kodo millet, little millet, maize and sesame for maturity (early and late), plant height, seed shape, size and colour. Seeds of wild rice (*Oryza rufipogon*) locally known as *Pachhar dhan*

Fig. 1.14 (A & B) Seeded wild banana (*Musa balbisiana*) (KP/PR/21-4) in VTR, (C) A putative natural hybrid between acid lime and sweet orange (KP/PR/21-49) cultivated at Gobardhana and (D) An abandoned lemon (KP/PR/21-54) in Gobardhana Range.

are eaten by local people during festivals and sold in local market.

1.2.13. Collection of multi-crop germplasm from Valmiki Tiger Reserve (VTR) in Bihar

A total of 84 samples collected including M&AP, spices and condiments (18), vegetables (14), cereals (13), grain legumes (09), fruits (09), oil seeds (08), millets (03), fibres (03), forages (02) and others (05) from buffer zone of Valmiki Tiger Reserve (VTR) in Bihar. Notable collections made were the seeded wild banana, putative natural hybrid between acid lime and sweet orange under cultivation at Gobardhana as well as primitive lemon growing naturally in Gobardhana range of VTR (Fig 1.14).

1.2.14. Collection of wild species and rice landraces from remote areas of Bihar

A total of 54 accessions comprising of *Oryza sativa* (13), *O. rufipogon* (12), *O. nivara* (3), *Linum usitatissimum* (4), *Brassica rapa* var. *yellow sarson* (3),*Cicer arietinum* (2), *Lathyrus sativus*(2), *Sesamum indicum* (2), *Sesbania sesban* (2) and others (11) were collected from parts of Buxar and Bhojpur districts of Bihar (Fig 15). Variability in named rice landraces was observed for seed size (small and bold types), shape and colour (black, light yellow, yellow, golden and red). The grains of wild rice (*Oryza rufipogon*) locally known as *Jharanga*, consumed by poor people or landless farmers, locally known as Musarin Bhojpur and Buxar districts of Bihar.

1.2.15. Exploration for collection of CWR of vegetables from South Gujarat

A total of 60 accessions comprising of wild species of okra, sponge gourd, jute, *Cucumis*, etc. were collected from parts of south Gujarat. In the surveyed areas, occurrence of wild *Abelmoschus, Luffa, Momordica* and less-known wild fruit species (*Ziziphus mauritiana*, *Z. oenoplia*) was frequently observed. *Abelmoschus manihot* var. *tetraphyllus* locally known as '*Rannbhendi*' was being used in jaggery industry as an organic clearant but no cultivation was known in the area. Landraces of paddy "Jeera phool", a scented rice variety is being grown on large scale by the tribal farmers in Vyara

Fig. 1.15 (A)Variability in rice landraces, (B) Wild rices and (C) Linseed

(Tapi) in Gujarat. Rich variability for plant height (3-5.5 meter)was observed in *Abelmoschus tuberculatus* (Fig 1.16A). In the entire southern Gujarat, potential legume lima bean (*Phaseolus lunatus*), called '*papdi'* and a tuberous vegetable, purple yam (*Dioscorea alata*) are widely used for edible purpose. Rich variability was noted for pod characters, seed colour in lima bean which is a popular staple vegetable as well as pulse in Navsari and Dang districts. Knowledge on use of *'Azilo'* (*Ocimum basilicum)* in preparing *damrichatni,* 'dungerbhaji' (safedmusli, *Chlorophytum borivilianum*), '*chill bhaji'* (*Chenopodium album*) for pot herb and other wild edible plants- leaves of *Bauhinia purpurea*, young bamboo shoots, fruits of 'tendu' (*Diospyros melenoxylon)* consumed by Dhodia tribe in Gandvi taluka, Navsari was documented. Locally growing plant called 'kalhar' (*Blumea lacera*), a common weed in *Rabi* season, distributed throughout India upto 800 msl. The whole plant is aromatic and is traditionally employed in *Ayurvedic, Unani* and *Homeopathic* systems of medicines. "Kalhar" leaf in the Dungri area of Valsad district is widely used in preparation of a tribal cuisine called "Umbadiyu" (Fig 16B).

1.2.16. Multi-crop germplasm collection from the parts of Bihar


(A)


(B)

Fig. 1.16 (A) Collection of wild *Abelmoschus tuberculatus* from South Gujarat; (B) *Blumea lacera* "Kalhar" a weed of commercial use in Valsad district, Gujarat

A total of 92 accessions of local crop diversity comprising of *Oryza sativa* (16), *Vigna radiata* (9), *Coriander sativum* (7), *Eleusine coracana* (6), *Brassica rapa* ssp. *toria* (5), *Sesamum indicum* var. *malabaricum* (5), *Linum usitatissimum* (4), *Luffa aegyptica* (4), *Malva verticellata* (3), *Pisum sativum* (3), *Lathyrus sativus* (2), *Sesbania sesban* (2), others (23) were collected from parts of Madhepura, Saharsa and Sapaul districts of Bihar. Ethno-botanical information on local leafy vegetables like *Malva verticillata, Basella alba, Chenopodium album* and *Corchorus sativus* was also documented. A unique rice landrace known as "Parwa Pankh", having glumes like the feathers of birdwas collected (Fig 1.17). Local people told that due to the presence of asymmetrical glumes, bird damage in this landrace is less than other landraces. Other collections include, fruits of *Abelmoschus moschatus* which are sold in the market and consumed by the local people; seeds of wild *sesamum* (*indicum* var. *malabaricum)* used extensively for oil extraction by the local people in Sapaul district; *Malva verticillata* '*Laphasaag*'; *Corchorus capsularis*' *Patuwa saag*', *Amaranthus viridis* '*cholai*', *Brassica juncea* var. *rugosa* '*Lai saag*' and *Basella alba* '*Poi saag*' are liked mostly by the people and consumed as leafy vegetables in these areas.

1.2.17. Crop wild *relatives* explored and collected from parts of Haryana

Thirty accessions belonging to *Sesamum indicum* var. *malabaricum* (24), *Cucumis callosus* (2) and *Corchorus olitorius* (2)were collected from parts of Bhiwani, Mahendragarh and Rewari districts of Haryana. In *S. indicum* var. *malabaricum*, variability was observed for plant height (3-4 to 8-10 ft) (Fig 19A). Besides, few plants among the sampled population were also found infected with phyllody and powdery mildew. Few plants with multilocular capsules, dwarf plant height (ca. 3 ft.) were also spotted in Badbar region, while only one plant having 1 cm long capsule length was found as notable collection for further studies. In Rohtak district adjacent to Meghot Binja, the presence of wild sesame (*S. indicum* var. *malabaricum*) around the cultivated sesame field was also observed, from where a natural hybrid (introgressed form) between *S. indicum* and *S. indicum* var. *malabaricum* was also collected (Fig 1.19B).

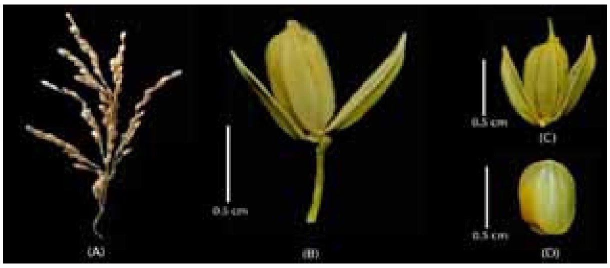


Fig. 1.17 (A) Spike of "*parwapank*" landrace collected from Supaul district, (B & C) Single caryopsis fruit and (D) Single grain

Fig. 1.18 (A) Sale of leaves of *Malva verticillata* (Lapha) in local market at Sapaul, Bihar, (B) Cultivation of *M. verticillata* in Kitchen garden and (C) *Abelmoschus moschatus* in market

1.2.18. Exploration for collection of Citrus from parts of Sikkim

A total of 28 accessions comprising of different species of citrus and other crops were collected from parts of East, West and South Sikkim. Good variability in fruit shape and size of *Citrus* were collected from surveyed areas.

1.3. Survey of a naturalized guava population site in Uttarakhand

A survey in Ramganga Valley, Pithoragarh, Uttarakhand was conducted to study the naturalized population of guava (*Psidium guajava*) with the following objectives: (i) to know the status of guava population distributed in different habitats;

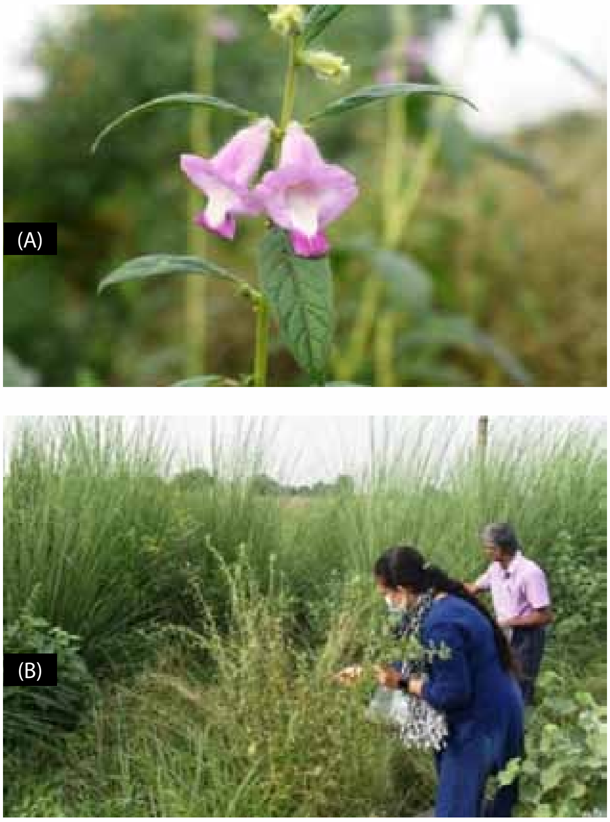


Fig.1.19 (A) *Sesamum indicum* var. *malabaricum* and (B) Collection of seeds from wild habitat

(ii) reasons of spreading guava population from cultivated land to forest/abandoned area; (iii) assessment of ecological parameters, and (v) to explore possibility of designating it asa conservation site in Uttrakhand. It was also aimed to record abundance, diversity and variability among the naturalized guava population in selected sites/ villages.

The salient findings of the survey are as follows:

1 The area comprises a narrow range of altitudinal gradients from 780 m to 1350 m (amsl) which experiences sub-montane climate. Guava population was distributed abundantly in Ramganga valley (Pipaltar, Barla, Muwani, Gol, Murthi villages) in comparision toSaryu (Sheraghat, Semalta, Hajeti, Gwadi villages) and Kali (Gaina, Gudoli, Bander Lima villages) river valleys. In these valleys, guava population was associated with three major habitats (i) natural forest site (ii) surrounding of villages and (iii) on cultivated land/fields.

2 It was observed that naturalized population is regenerated from previously planted (about 100-120 years old) guava plant or due to dispersal of fruits/seeds by the birds, monkey and shepherd/ graziers.

3 Ecological data were recorded using line transect/quadrat methods which revealed that 30% areas is under naturalized forest of the total sampling area (400m^2), while dominant species are covering>50% area.

4 In Pipaltar and Murthi villages, guava was regenerating naturally in forests land (through root suckers), abandoned and cultivated land.

1.4 National Herbarium of Cultivated Plants (NHCP)

Seven hundred and two herbarium specimens and 15seed samples/economic products were added to the National Herbarium of Cultivated Specimen (NHCP), making total collection of 25,139 herbarium specimens (representative of 4,373 species belonging to 1,545 genera and 267 families), 3,153 seed samples and 750 economic products. Fifteen new taxa, not represented earlier, were added as specimens and digital images to the NHCP. A total of 950 specimens/taxa belonging to crop genepool were authenticated and digitised including 16 unrepresented taxa in NHCP resulting

Fig. 1.20(A) Naturalized population of guava at Pipaltar, Pithoragarh, Uttarakhand and (B) Variability in guava fruits

into a total of 10,269 images. The webpage for herbarium digital resource has been made available for the users (http://www.nbpgr.ernet.in:8080/nhcp/). Identification services were provided and authentication certificates (40) issued to students and researchers for material taken up for experimental study. A total of Rs. 20,500/- were generated through issue of authentication certificates.

1.5 Systematics study on *Allium negianum*

A new species, *Allium negianum* (Amaryllidaceae) subgenus *Rhizirideum* collected from Uttarakhand Himalayan region of India was described (Fig 1.21). This is an endemic species, morphologically closer to *A. przewaliskianum* Regel but differentiated by its bulb having tunic colour, laxy flowers in an umbel, peduncle length, perianth

Table 1.4 New taxa added in the repository of NHCP during 2021

Family	New Species	State	W/C*
Rosaceae	*Rubus fasciculatus* P.J. Müll.	Uttarakhand	W
Liliaceae	*Aloe nobilis* Haw.	New Delhi	C
Tiliaceae	*Grewia multiflora* Juss.	Rajasthan	W
Malvaceae	*Bombax ceiba* L.	New Delhi	C
Nyctaginaceae	*Boerhaavia chinensis* (L.) Rottb.		W
Fabaceae	*Vigna subterranea* (L.) Verde		C
Orobanchaceae	*Orobanche aegyptiaca* Pers.	Haryana	W
Verbenaceae	*Verbena incompta* P.W. Michael	Uttar Pradesh	W
Euphorbiaceae	*Croton joufra* Roxb.	Assam	C
Myrtaceae	*Syzygiumcordatum* Hochst. ex Krauss	Uttarakhand	C
Alliaceae	*Allium angulosum* L.		C
Alliaceae	*Allium negianum* Pandey & S. Rajkumar		C
Linaceae	*Linumlewissi* Pursh	New Delhi	C
Oxalidaceae	*Biophytum umbraculum* Welw.	Madhya Pradesh	W
Campanulaceae	*Codonopsis lanceolata* (Siebold&Zucc.) Benth. & Hook.f. ex Trautv.	Arunachal Pradesh	W
Cucurbitaceae	*Trichosanthes dolichosperma* Duyfjes & Pruesapan		W

* C: Cultivated; W: Wild

colour, size and shape and leaf anatomy. Molecular phylogenetic analysis using maximum likelihood method based on the Jukes-Cantor model indicated that *A. negianum* was phylogenetically very distinct from *A. przewaliskianum*. This species is largely cultivated in Niti valley and adjoining areas for commercial production and use as "seasoning spice".

1.6 Diversity mapping in chickpea (*Cicer arietinum*), mothbean (*Vigna aconitifolia*) and Ricebean (*Vigna umbellata*)

Chickpea: Geo-referencing and mapping of 16,246 accessions of chickpea collected from various parts of country was done (Fig. 1.22A). Mapping of assembled diversity has shown that Uttar Pradesh (1,595) followed by Madhya Pradesh (1,402), Maharashtra (1,206), Punjab (835), Rajasthan (694), Bihar (383), Andhra Pradesh (359), Gujarat (334), Haryana (290), Karnataka (223) Himachal Pradesh (211) and Tamil Nadu (122) were extensively explored states. Whereas under explored areas of chickpea identified for future collections are: Madhya

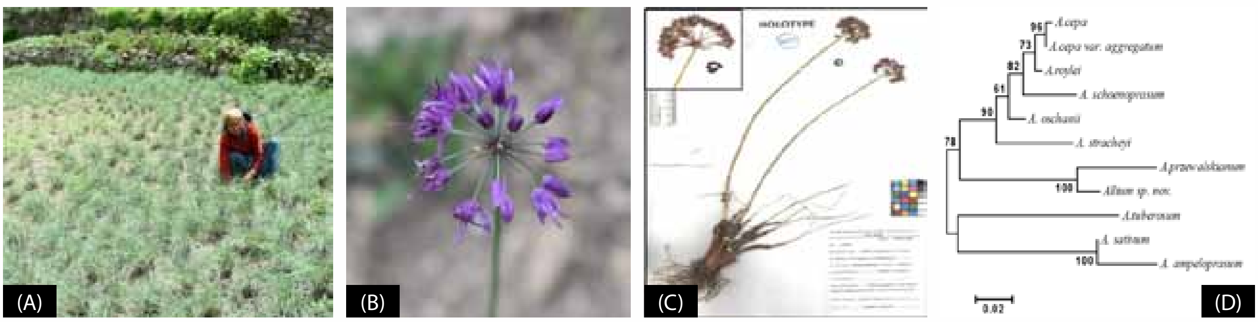


Fig. 1.21 New species *Allium negianum* (A) Crop growing in field, (B) Inflorescence of *A. negianum*, (C) Herbarium sheet of *A. negianum* and (D) Phylogenetic study using ITS sequence

Pradesh (Ashok Nagar, Guna, Jhabua, Mandsaur, Raisen and Sheopur); Maharashtra (Aurangabad, Jalna, Nanded and Raigad) and Rajasthan (Bundi, Dausa, Dholpurand Tonk) as gaps for collection.

Mothbean: Geo-referencing and mapping of 1,556 accessions of mothbean collected from various parts of country was done (Fig. 1.22B). Mapping of assembled diversity has shown that Rajasthan (562), followed by Gujarat (167), Haryana (80), Maharashtra (21), Madhya Pradesh (14),Tamil Nadu (13) and Punjab (10) were extensively explored states. Whereas under explored areas of mothbeanidentified for future collections are: Rajasthan (Bikaner, Barmer, Dungarpur, Jalore, Jaisalmer, Nagaur, Pali, Sikar, Sirohi and Udaipur) and Gujarat (Banaskantha, Panch Mahal and Sabarkantha).

Ricebean: Geo-referencing and mapping of 2,327 accessions of ricebean collected from various parts of country was done. Mapping of assembled diversity has shown that Meghalaya (225) followed by West Bengal (153), Nagaland (125), Uttarakhand (95), Arunachal Pradesh (90), Manipur (89), Odisha (81), Sikkim (76), Himachal Pradesh (80), Andhra Pradesh (58) and Mizoram (40) were extensively explored states. Whereas under explored areas of rice bean identified for future collections are: Meghalaya (East Garo hillsand West Jaintia hills), Sikkim (West Sikkim), Nagaland (Mon, Phek, Longleng, Zunheboto and Tuensang), Arunachal Pradesh (Dibang valley, East and West Siangand West Kameng), Tripura (South Tripura, Gomati and Shipahijala), Chhattisgarh (Bastar, Bijapur, Dantewada and Narayanpur), Odisha (Kalahandi, Malkangiri, Nabrangpur and Koraput) and Uttarakhand (Pithoragarh and Uttarkashi).

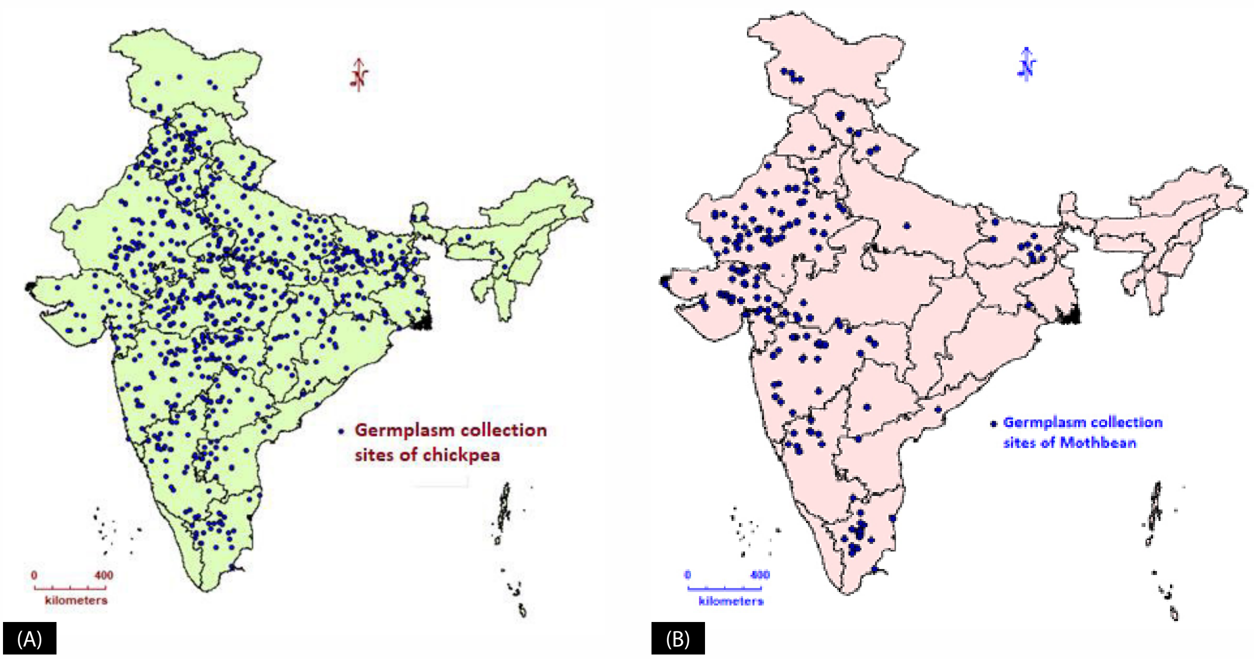


Fig. 1.22 (A) Collection site map of Chickpea and (B) moth bean

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**)

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

PGR/DPEGC-BUR-DEL-01.01: Exploration for collection of genetic resources of agricultural crops and their wild relatives (**SP Ahlawat**, KC Bhatt, RS Rathi, DP Semwal, Puran Chandra, Soyimchiten, S Nivedhitha (upto 22.1.2022), RK Pamarthi, PK Malav, Pankaj Kumar Kannaujia (wef. 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 (**KC Bhatt**, RS Rathi, DP Semwal, Puran Chandra, PK Malav, S Nivedhitha (upto 22.1.2022), Pankaj Kumar Kannaujia (wef.22-11-2021) *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,** KC Bhatt [wef. 01.04.2021], K Pradheep**,** RK Pamarthi, S Nivedhitha (upto 22.1.2022), Pankaj Kumar Kannaujia (wef. 22-11-2021) 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, N Sivaraj, Soyimchiten, RK Pamarthi, PK Malav and *NS Panwar*)

PGR/DPEGC-BUR-DEL-01.05: Survey, collection and assessment of *in-situ* /on-farm crop diversity in the Indian Himalayan Region (**RS Rathi**, KC Bhatt, Anjula Pandey, DP Semwal, PK Malav, *NS Panwar* and *PS Mehta* (Till 31st March, 2021)

GERMPLASM EXCHANGE AND POLICY UNIT

2

Summary: During the period under report 50,596 accessions (1,67,042 samples) were imported including 34,031 accessions (40,934 samples) of germplasm and 16565 entries (1,26,108) samples of CGIAR nurseries for trials. A total of 700 samples of wheat (350 to Bolivia and 350 to Bangladesh) were exported under ICAR-CIMMYT Project. A total of 13, 448 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, 40,615 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)

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 are as follows:

Germplasm accessions procured and processed	34,031 accessions(40,934 samples)
CGIAR nurseries for trials	16,565 entries (1,26,108) samples
No. of countries involved	34
No. of Import Permits issued	618
Resource generated	Rs. 1,03,47,994

(Rs. One crore three lakhs forty seven thousand and nine hundred ninety four)

Cereals: *Aegilops tauschii* (40) from USA; *Hordeum vulgare* (26) from Australia, (124) from Netherlands and (1,065) from USA; *Oryza nivara* (3) from Philippines, *Oryza sativa* (453) from Bangladesh, (101) from Brazil, (8,294) from Philippines, (353) from USA and (1,758) from Vietnam, *Oryza sativa* × *O. nivara* (1) and *Oryza sativa* ssp. *japonica* (1) both from Philippines; *Triticum aestivum* (54) from Afghanistan, (25) from Australia, (5) from Japan, (4) from South Africa, (36) from UK and (232) from USA, *T. aestivum* subsp. *aestivum* (62) from Mexico and (18) from USA, *T. aestivum* subsp. *sphaerococcum* (210) from Lebanon, *T. monococcum* subsp. *monococcum* (17) and *T. monococcum* x *T. aegilopoides* (42) both from USA, *T. sphaerococcum* (3), *T. sphaerococcum* var. *rotundatum* (2), *T. sphaerococcum* var. *rubiginosum* (2) all from Germany, *T. timopheevi* subsp. *timopheevi* (2), *T. timopheevii* subsp. *armeniacum* (33), *T. turgidum* subsp. *carthlicum* (9), *T. turgidum* subsp. *dicoccoides* (25), *T. turgidum* subsp. *dicoccum* (6), *T. turgidum* subsp. *durum* (4), *T. turgidum* subsp. *paleocolchicum* (1), *T. turgidum* subsp. *polonicum* (3), *T. turgidum* subsp. *turgidum* (8), *T. urartu* (19) all from USA; *Zea mays* (50) from Argentina, (25) from Australia, (808) from Brazil, (48) from Chile,

(326) from France, (381) from Guatemala, (100) from Indonesia, (88) from Italy, (23) from Kenya, (1,095) from Mexico, (1,269) from Philippines, (303) from South Africa, (1) from Switzerland, (5,455) from Thailand, (1,496) from USA and (91) from Zimbabwe, *Z. mays* var. *saccharata* (6) from Thailand, *Z. mexicana* (44) from Mexico and *Z. parviglumis* (33) from USA.

Mllets: *Eleusine coracana* (733) and *E. kigeziensis* (1) both from Kenya; *Sorghum bicolor* (121) from Argentina, (27) from Kenya and (126) from USA.

Oilseeds: *Brassica juncea* (364) from Canada; *Brassica napus* (17) from Australia; *Camelina sativa* (2) from Australia; *Capsella bursa-pastoris* (3) from Australia; *Crambe filiformis* (13), *C. glabrata* (20), *C. hispanica* (2), *C. hispanica* subsp. *abyssinica* (82), *C. hispanica* subsp. *hispanica* (27), *C. juncea* (1), *C. kralikii* (3), *C. maritima* (1), *Crambe* sp. (2), *C. tataria* (1) all from USA ; *Enarthrocarpus arcuatus* (2) from USA; *Eruca vesicaria* (11) *E. vesicaria* subsp. *sativa* (236) both from USA; *Erucastrum brevirostre* (1), *E. elatum* (3), *E. gallicum* (3), *E. ifniense* (1), *E. leucanthum* (3), *E. littoreum* subsp. *brachycarpum* (1), *E. littoreum* subsp. *glabrum* (1), *E. nasturtiifolium* (1), *E. nasturtiifolium* subsp. *sudrei* (1), *E. rifanum* (1), *E. strigosum* (1), *E. varium* (1), *E. varium* subsp. *varium* (3), *E. virgatum* subsp. *baeticum* (1), *E. virgatum* subsp. *pseudosinapis* (1) all from USA; *Glycine max* (119) from Taiwa; *Glycine arenaria*(1), *G. argyrea*(1), *G. canescens*(1), *G. clandestine*(1), *G. curvata*(1), *G. cyrtoloba*(1), *G. dolichocarpa*(1), *G. falcate*(1), *G. latifolia*(1), *G. latrobeana*(1), *G. tomentella (10), G. max* (65), *G. microphylla*(1), *G. peratosa*(1), *G. pindanica*(1), *G. rubiginosa*(1), *G. soja*(1), *G. stenophita*(1), *G. syndetika*(1), *G. tabacina*(3) all from USA; *Guizotia abyssinica* (5) from Ethiopia and *G. scabra* (4) from Kenya; *Helianthus annuus* (18) from Argentina, (28) from Netherlands and (3) from USA; *Linum aristatum* (4), *L. austriacum* (16), *L. bienne* (13), *L. campanulatum* (1), *L. catharticum* (3), *L. corymbiferum* (1), *L. flavum* (7), *L. grandiflorum* (1), *L. hirsutum* (8), *L. hudsonioides* (2), *L. lewisii* (30), *L. marginale* (2), *L. pallescens* (1), *L. perenne* (11), *Linum* sp. (4), *L. strictum* (2), *L. tenuifolium* (3) all from USA; *L. usitatissimum* (123) from Canada and (1) from USA; *Sesamum alatum* (9), *S. angolense* (5), *S. calycinum* subsp. *angustifolium* (5) from Kenya, *S. indicum* (227) from USA; *S. latifolium* (7) from Kenya, *S. radiatum* (3) from USA and *S. triphyllum* (1) from Kenya.

Grain legumes: *Cajanus cajan* (19) from Kenya; *Cicer arietinum* (24) from Lebanon, *C. bijugum* (16) from Australia, *C. echinospermum* (149) from Australia and (69) from USA; *C. judaicum* (18), *C. pinnatifidum* (8) both from USA, *C. reticulatum* (422) from Australia and (130) from USA; *Lathyrus annuus* (2), *L. aphaca* (4) from Hungary and (3) from USA, *L. boissieri* (1), *L. cassius* (1), *L. chloranthus* (2) all from USA; *Lathyrus cicera* (67) from Australia; (6) from Hungary and (4) from USA, *L. cirrhosus* (1), *L. clymenum* (2) from Hungary and (3) from USA, *L. gorgoni* (1), *L. hierosolymitanus* (2), *L. hirsutus* (4) from Hungary and (3) from USA, *L. inconspicuus* (3), *L. latifolius* (3), *L. nissolia* (3) from Hungary and (2) from USA, *L. ochrus* (2) from Hungary and (3) from USA, *L. odoratus* (2),

Fig. 2.1 CWRS of Oil seed crops imported from USA

L. pratensis (3), *L. rotundifolius* (1), *L. sativus* (14) from Hungary and (3) from USA, *Lathyrus* sp. (6), *L. sphaericus* (1), *L. stenophyllus* (2), *L. sylvestris* (3), *L. tingitanus* (1) from Hungary and (3) from USA, *L. tuberosus* (3), *L. vinealis* (1) all from USA; *Vigna unguiculata* (4) from Ghana.

Vegetables: *Abelmoschus caillei* (24) from Taiwan, (1) from USA, *A. crinitus* (1) from USA; *A. esculentus* (44) from Taiwan, (609) from USA; *A. manihot* (14) from Taiwan, (1) from USA, *A. moschatus* (11) from Taiwan, (11) from USA; *Abelmoschus* sp. (1) from Taiwan and *A. tuberculatus* (11) from Taiwan and 11 from USA; *Allium cepa* (20) from Israel, (88) from USA; *Brassica balearica* (1) from USA, *Brassica oleracea* var. *botrytis* (242) from Netherlands and (11) from USA; *Brassica oleracea* var. *capitata* (22) from China; (19) from Netherlands; *Capsicum annuum* (5) from Guatemala, (13) from Korea, (8) from Netherlands, (617) from Taiwan, (8) from Thailand and (62) from USA; *C. baccatum* (5), *C. chinense* (5), *C. frutescens* (2) from Taiwan; *Citrullus amarus* (12) from USA, *C. lanatus* (16) from Philippines, (25) from USA; *Cucumis sativus* (47) from Netherlands, (19) from Taiwan, (10) from USA, *C. sativus* var. *hardwickii* (2), *C. sativus* var. *sativus* (19) both from USA; *Cucurbita moschata* (10) from Taiwan; (147) from Thailand; *Lagenaria siceraria* (29), *Lagenaria* sp. (2), *L. sphaerica* (1) all from USA; *Luffa acutangula* (734), *L. cylindrica* (644) from Thailand; *Momordica charantia* (16) from Taiwan, (704) from Thailand, (32) from USA; *Solanum chilense* (1) from Taiwan,(5) from USA; *S. habrochaites* (4) from Taiwan and (4) from USA, *S. lycopersicum* (232) from Taiwan, (40) from Thailand and (151) from USA; *S. pennellii* (2), *S. pimpinellifolium* (2) from Taiwan and (1) from USA; *S. sitiens* (1) from USA. *S. melongena* (2) from Bangladesh,(36) from Japan and (4) from Taiwan.

Lagenaria spp (EC1085262)

Lagenaria sphaerica (EC1085260)

Avocado (EC1085262)- EC1088093-1088100/ Australia

Fig. 2.2: Bottle gourd accessions resistant to downy mildew and ZYMV imported from USDA, USA; improved varieties of Avocado imported from Australia

Fibres: *Gossypium areysianum* (1), *G. costulatum* (2), *G. darwinii* (3), *G. gossypioides* (4), *G. hirsutum* (7), *G. incanum* (1), *G. marchantii* (1), *G. mustelinum* (3) and *G. sturtianum* (3) all from USA.

Forages and agroforestry crops: *Brachiaria brizantha* (1) from Colombia; *Casuarina equisetifolia* (41) from China and (29) from Kenya; *Centrosema molle* (1) from Colombia; *Desmodium heterocarpon* (1) and *D. velutinum* (1) from Colombia; *Stylosanthes guianensis* (1) from Colombia and (1) from Thailand; *Trifolium alexandrinum* (20), *T. angustifolium* (3), *T.apertum* (3), *T. berytheum* (4), *T.canescens* (3), *T. caucasicum* (1), *T. cherleri* (4), *T. clypeatum* (2), *T. constantinopolitanum* (2), *T. dasyurum* (4), *T. dichroanthum* (2), *T. diffusum* (4), *T. echinatum* (3), *T. hirtum* (3), *T. lappaceum* (6), *T. leucanthum* (3), *T. meironense* (2), *T. obscurum* (3), *T. ochroleucon* (3), *T. pannonicum* (4), *T. plebeium* (1), *T. pratense* (11), *T. purpureum* (4), *T. salmoneum* (3), *T. scutatum* (3), *T. squamosum* (3), *T. stellatum* (4), *T. vavilovii* (2) and *T. vesiculosum* (13) all from Australia.

Fruits and Ornamentals: *Fragaria × ananassa* (1) from Netherlands; *Gladiolus carinatus* (2), *G. carneus* (1), *G. crassifolius* (1), *G. dalenii* (1), *G. hirsutus* (1), *G. tristis* (2), *G. virescens* (1) all from South Africa; *Hylocereus* sp. (40) from Philippines; *Malus domestica* (8) from Belgium, (1) from France, (3) from Italy, (1) from New Zealand and (3) from USA; *Musa* spp. (19) from Nigeria; *Persea americana* (9) from Australia; *Prunus avium* (5) from Germany; *Pyrus communis* (1) from Belgium and (1) from France.

Potential crops: *Chenopodium quinoa* (290) from Saudi Arabia; *Jatropha curcas* (107) from Germany.

Medicinal and Aromatic Plants: *Catharanthus* sp. (10) from Thailand; *Duboisia myoporoides* (1) from Australia; *Moringa stenopetala* (5) from Kenya.

Spices: *Ferula assa-foetida* (60) from Afghanistan.

Narcotics: *Nicotiana tabacum* (3) from Brazil and (6) from Zimbabwe.

Tubers: *Solanum bulbocastanum* (2) from USA, *Solanum tuberosum* (5) from Ireland; (18) from Netherlands and (83) from USA, *S. chacoense* (2),

Table 2.1: Wild species and trait specific (promising) seed/planting material imported in 2021

Crop/ EC No/Country	Traits	Indentor
Cereals		
Rice		
EC1075946-1076077/ IRRI, Philippines	Local cultivars of Bangladesh deep water types, source for identification of novel alleles or genes related to stress tolerance	ICAR-NRRI, Cuttack
EC1088209-1088708/USA	Early maturing, good grain quality, drought tolerant	Savannah Seeds Pvt Ltd., Gurugram
EC1102616- 1102632 /USA	Lines resistant to blast, bacterial blight, brown plant hopper and *Yellow mosaic virus*, tolerant to cold and salinity	Seed Works International Private Limited, Hyderabad
Wheat		
EC1074815-1074836/USA	Landraces from Portugal, Turkeminastan, Iran with characteristic large kernels, wide adaptation to different environments, drought tolerant in semi-arid & hot region, highly nutritious and inbred lines	ICAR-CSSRI, Karnal
EC1092538-1092747/ USA	Wild species-*Triticum timopheevii* ssp. *armeniacum, T. turgidum* ssp. *dicoccum, T. turgidum* ssp. *dicoccoides, T. turgidum* ssp. *turgidum, T. turgidum* ssp. *polonicum, T.turgidum* ssp. *carthlicum, T. turgidum*ssp. *paleocolchicum, T.urartu, Aegilops tauschii*	ICAR-NBPGR, New Delhi
EC1068403-1068409/USA	*Triticum sphaerococcum, T. sphaerococcum* var. *rubiginosum, T. sphaerococcum* var. *rotundatum*	ICAR-NBPGR, New Delhi
EC1068055-1068254/ ICARDA, Lebanon	*Triticum turgidum* subsp. *dicoccoides, T. turgidum* subsp. *dicoccum*	ICAR-NBPGR, New Delhi

Crop/ EC No/Country	Traits	Indentor
Maize		
EC1074700-743/ CIMMYT, Mexico	*Zea mexicana*	ICAR-NBPGR, New Delhi
EC1084237-269/ USA	*Zea parviglumis*	ICAR-NBPGR, New Delhi
Oilseeds		
Crambe		
EC1085274-1085425/ USA	*Crambe filiformis, C. glabrata, C. hispanica, C. hispanica* ssp. *abyssinica, C. hispanica* ssp. *hispanica, C. juncea, C. kralikii, C. maritima, C. tataria*	ICAR-NBPGR, New Delhi
Eruca		
EC1085428-1085697/ USA	*Eruca vesicaria, E. vesicaria* ssp. *sativa*	ICAR-NBPGR, New Delhi
Linseed		
EC1073020-1073125/ USA	*Linum aristatum, L. austriacum, L. bienne, L. campanulatum, L. catharticum, L. corymbiferum, L. flavum, L. grandiflorum, L. hirsutum, L. hudsonioides, L. lewisii, L. marginale, L. pallescens, L. perenne, Linum* sp., *L. strictum, L. tenuifolium*	ICAR-NBPGR, New Delhi
Mustard		
EC1085675-1085697/USA	*Erucastrum brevirostre, E. elatum, E. gallicum, E. ifniense, E. leucanthum, E. littoreum* ssp. *brachycarpum, E. littoreum* subsp. *glabrum, E. nasturtiifolium, E. nasturtiifolium* ssp. *sudrei, E. rifanum, E. strigosum, E. varium, E. varium* ssp. *varium, E. virgatum* ssp. *baeticum, E. virgatum* ssp. *pseudosinapis*	ICAR-NBPGR, New Delhi
Niger		
EC1090016-1090020/ Ethiopia	Selected varieties (Ginchi, Shambu, Kuyu, Fogera and Esta) for further breeding to improve specific group of minerals. Good source for phosphorus and potassium and macro minerals calcium, magnesium, sodium and sulphur	ICAR-IIOR, Hyderanbad
Sesame		
EC1076106-1076132/ USA	*Sesamum alatum, S. angolense, S. calycinum* subsp. *angustifolium, S. latifolium, S. radiatum, S. triphyllum*	ICAR-NBPGR, New Delhi
Soybean		
EC1075826/ USA	Registered germplasm line LG03-4561-14 (Reg.No. GP-434), high-yielding, late maturity group III, valuable source of genetic diversity	ICAR-NBPGR, New Delhi
1075827-1075889/ USA	Japanese heirloom cultivars, high yielding, excellent quality, shattering resistant	ICAR-NBPGR, New Delhi
1086831-1086860/ USA	*Glycine arenaria, G. argyrea, G. canescens, G. clandestine, G. curvata, G. cyrtoloba, G. dolichocarpa, G. falcate, G. latifolia, G. latrobeana, G. tomentella, G. microphylla, G. peratosa, G. pindanica, G. rubiginosa, G. soja, G. stenophita, G. syndetika, G. tabacina*	ICAR-NBPGR, New Delhi

Sunflower		
EC1079210-212/ USA	Registered germplasm having oleic acid and mutations that increase the *y* and *s* tocopherol level of the seed, leading to a more stable vegetable oil product.	ICAR-NBPGR, New Delhi
Grain legumes		
Chickpea		
1078462-1078842/ Australia	*C. bijugum, C. judaicum C. pinnatifidum C. reticulatum*	ICAR-NBPGR, New Delhi
Cowpea		
EC1084781-1084784/Ghana	Superior high yielding varieties, fast cooking, exhibit tolerance to common disease of insect pest	ICAR-NBPGR, New Delhi
Lathyrus		
EC1073130-149, 153-155, 159-172, 176-191/ USA	*L. annuus, L. aphaca, L. cassius, L. chloranthus, L. cicera, L. cirrhosus, L. clymenum, L. gorgoni, L. hierosolymitanus, L. inconspicuus, L. latifolius, L. nissolia, L.ochrus, L. odoratus, L. pratensis. L. rotundifolius, L. sphaericus, L. sylvestris, L. tingitanus, L. tuberosus, L. vinealis*	ICAR-NBPGR, New Delhi
EC1077632-698/ Australia	*L. cicera*	ICAR-NBPGR, New Delhi
EC1068321-341, 356/ Hungary	*L. aphaca, L. cicera, L. clymenum, L. hirsutus, L. ochrus, L. sphaericus, L. nissolia L. tingitanus*	ICAR-NBPGR, New Delhi
Vegetable crops		
Bottle gourd		
EC1085260/ USA	*Lagenaria sphaerica*	ICAR-NBPGR, New Delhi
PI 271351, PI 271356 / USA	Powdery mildew &*Zucchini yellow mosaic virus* (ZYMV) resistant lines repatriated	ICAR-NBPGR, New Delhi
26 accessions from USA	*Zucchini yellow mosaic virus* (ZYMV) resistant line repatriated	ICAR-NBPGR, New Delhi
Cucumber		
EC1085223, 24, 27/USA	Resistant to downy mildew	ICAR-NBPGR, New Delhi
EC1085230/ USA	Carotenoid rich line	ICAR-NBPGR, New Delhi
PI 605996, PI 197085/ USA	Downy mildew resistant lines repatriated from USA	ICAR-NBPGR, New Delhi
PI 197085, 197087/ USA	Downy mildew and *Tomato leaf curl New Delhi virus* (ToLCNDV) resistant line repatriated from USA	ICAR-NBPGR, New Delhi
Brinjal		
EC1099160-1099163/ Taiwan	Rootstocks resistant to bacterial wilt and fusarium wilt	ICAR-IIHR, Bangalore
Tomato		
EC1092530-1092537/ Taiwan	*Solanum habrochaites, S. pimpinellifolium, S. pennellii, S. chilense*	ICAR- NIASM, Pune
Pumpkin		
EC1098421-1098425/ Taiwan	Globular to flattened fruit with dark orange flesh	Nuziveedu Seeds Limited, New Delhi

Fruits		
Apple		
EC1101277-280/ Belgium	Genetic stock and improved varieties of good market value, excellent storage and shelf life, fruit has good sugar levels and moderate acid	Mahyco Private Limited, Jalna
EC1068357-359/USA	Cold hardy, tolerant to replant disease , resistant to crown and root rot, fire blight, powdery mildew	Mahyco Private Limited, Jalna
Avocado		
EC1088093-1088100/ Australia	Varieties and rootstocks-Zutano, Reed and Velvick	Mahyco Private Limited, Jalna
Cherry		
EC1095374-378/ Germany	Rootstocks slightly less vigorous with excellent yields, good tolerance to crown gall and virus, No. suckering. Ideal for deep and irrigated soils, even for heavy and asphyxing soils	Mahyco Private Limited, Jalna
Dragon fruit		
EC1098376-416/ Philippines	Big Red, Connie mayer, Dark star, Edger, Haleys comet,Hawaiian red, Makisupa, Maria roza, Natural mystic, Peruvian white, Purple haze, Sugar dragon, TLM white, Townsend pink, Zamorano, S8 sugar, Physical graffiti, Godzila 26, George, ISIS gold, Delght, Double color, Vietnam red, Vietnam white, Da hong, Chameleon, ISIS Yellow, Gautemelon Red, Isreal yellow, Malaysian red, Royal red, Ruby red, Siam red, Thai yellow, Orange, Palora, Pink flesh, Taiwan pink, Taiwan red, Vietnam giant	ICAR-NBPGR, RS, Hyderabad
Ornamentals		
Gladiolus		
EC1099553/ South Africa	Species *Gladiolus dalenii* -drought tolerant	ICAR-IARI, New Delhi
EC1099555-59/ South Africa	Species *Gladiolus virescens*, *G. carinatus* & *G. tristis* having fragrant flowers	ICAR-IARI, New Delhi
Fibres		
Cotton		
EC1092748-1092765/ USA	*Gossypium areysianum, G. costulatum, G. darwinii, G. gossypioides, G. incanum, G. marchantii, G. mustelinum, G.sturtianum*	ICAR-CICR, Nagpur
Potential crops		
Quinoa		
EC1090362-1090651/ Saudi Arabia	Improved varieties high yielding and vigorous, strong resistance to pre- harvest sprouting	ICAR-CSSRI, RS, Lucknow
Medicinal crops		
Moringa		
EC1077611-1077615/ Kenya	Drought tolerant species *Moringa stenopetala*	ICAR-NBPGR, New Delhi

Fig 2.3 : Promising accessions of Cucumber and bottle gourd imported from USDA, USA

S. tuberosum subsp. *andigenum* (1), *S. verrucosum* (3), *S. stoloniferum* (1) all from USA.

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 ICAR-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 2021 are indicated below.

Under Collaborative Research Projects: 700 samples of wheat (350 to Bolivia and 350 to Bangladesh) under ICAR-CIMMYT Project.

Under National Biodiversity Authority Approval: A total of 10 accessions to France (4 accessions of carrot and 6 accessions of chilli) and 94 accessions to USA (4 accessions of barley and 90 accessions of maize).

Also, facilitated supply of 19,144 samples of ICRISAT mandate crops (FAO designated accessions and breeding material developed from FAO designated accessions or exotic material) to different countries.

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 13,448 samples were supplied under the Material Transfer Agreement (MTA). The crop wise samples and the recipient institutes are listed in Table 2.2. In addition a total of 40,615 samples supplied for regeneration/ multiplication/ morphological characterization/ preliminary evaluation/ taxonomic identification/ DNA fingerprinting/ viability testing.

2.4 A: Policy Issues on Agrobiodiversity Management

Preparation for Ninth Meeting of the Governing Body of International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) to be held in India (2021-22)

- Inputs provided for the GB9 Bureau Meeting (India was Vice Chair from Asia Region)

Table 2.2: National supply of seed/planting material to recipients during 2021

Crop	Accns.	Indentor
Cereals (2,631)		
Barley	779	IARI, New Delhi; BHU, Varanasi; IARI, RS Shimla
Maize	439	IARI, Jharkhand; PJSTSAU, Telangana; SKUAST-K, J&K; CSAUAT, Kanpur; Mata Gujri College, Punjab; IGFRI, Jhansi ; Vasantrao Naik MKV, Parbhani
Rice	185	VPKAS, Almora;, Rasi Seeds (P) Ltd., Tamil Nadu; IARI, New Delhi; WASSAN, Hyderabad; University of Kerala
Wheat	1228	Shreeoswal Seed and Chemical Ltd., MP; SKUAST-K, J&K; LPU, Jalandhar; PAU, Ludhiana; Vasantrao Naik MK, Parbhani
Millets (358)		
Barnyard millet	15	JNKVV, MP
Browntop millet	15	JNKVV, MP
Finger millet	15	JNKVV, MP
Italian millet	15	JNKVV, MP
Kodo millet	15	JNKVV, MP
Little millet	15	JNKVV, MP
Prosomillet	15	JNKVV, MP
Sorghum	193	Sri Venkateswara University, AP; IIMR, Hyderabad
Pearl millet	60	Janta Vedic College, Baghpat
Grain legumes (6,496)		
Adzuki bean	5	IARI, Jharkhand
Cowpea	893	ICAR-NIASM, Pune; IIPR, RS, Dharwad; KAU, Kerala; SKUAST-K, J&K; IIT, Guwahati
Chickpea	921	LPU, Jalandhar; Himgiri Zee University, UK; JNU, New Delhi
Flemingia	1	IIPR, Kanpur
French bean	132	SKUAST-K, J&K; NARP,MS
Lentil	445	IGKVV, Raipur; CSSRI,Karnal; LPU, Jalandhar; Akal University, Bathinda, Punjab; Himgiri Zee University, UK
Mothbean	5	IARI, Jharkhand
Mungbean	2378	IARI, Jharkhand ; ILS, Bhubaneshwar; SKUAST-K, J&K; DU, Delhi; AVRDC-RCSA, Patancheru; Dr. Rajendra Prasad CAU, Pusa, Bihar; Yashwantrao Chavan Institute of Science, Satara; PAU, Ludhiana; NABI, Mohali; IARI, New Delhi
Pea	400	NARP, MS; SKUAST-K, J&K; PAU, Ludhiana; Dr. YSPUHF, HP; Vasantrao Naik MAU, MS
Rajmash	15	B.R.D.P.G. College, Deoria, UP
Rhyncosia	1	IIPR, Kanpur
Pigeon pea	26	ICAR-RCER, Patna; IIPR, Kanpur
Ricebean	256	IARI, Jharkhand; IIPR, Kanpur; PAU,Ludhiana; CTCRI- RC, Bhubaneswar;
Urdbean	979	AAU Jorhat; TNAU, Coimbatore; NABI, Mohali; UBKVV, Cooch Beha; IARI, Jharkhand; CRIDA, Hyderabad; SKUAST-K, J&K; MDU, Rohtak
Vigna sp.	39	IIPR RS, Dharwad
Oilseeds (1,252)		
Groundnut	76	UAS, Bangalore; Annamalai University, TN

Crop	Accns.	Indentor
Linseed	463	Amity University, Noida ;WASSAN, Hyderabad; LPU, Jalandhar; Jamia Hamdard, New Delhi; JNKVV, MP
Safflower	4	DU, Delhi
Sesame	276	IIOR, Hyderabad; KAU, Kerala; Sri Karan Narendra Agriculture University, Jaipur; Department of Agricultural Science and Rural Development, Loyola Academy, Secunderabad
Sinapsis alba	1	AAU, Assam
Mustard	432	Rasi Seeds (P) Ltd., Coimbatore, Tamil Nadu; Shreeoswal Seed and Chemical Ltd. MP; Tierra Agrotech Private Limited, Hyderabad; Himgiri Zee University, UK; BCKVV, WB
Vegetables (2,210)		
Bottle gourd	20	SKUAST-K, J&K
Allium sp.	10	Gaja Forest Range Office, Jeolikot, Nainital
Ash gourd	23	IIHR, Bangalore
Bitter gourd	325	Daftari Agro Bio-tech Pvt. Ltd. Nagpur; KAU, Kerala; Dr. YSRHU, AP; UHS, Bagalkot; KRC College of Horticulture, Arabhavi; RHRTS-Jachh, Kangra; IARI, New Delhi
Brinjal	538	WASSAN, Hyderabad; Daftari Agro Bio-tech Pvt. Ltd., MS; VNR Seeds Pvt. Ltd., Hyderabad; Dr. YSPUHF, Solan; ICAR-RCER, Patna; TNAU, Coimbatore; Annamalai University, TN; IARI, New Delhi; SKUAST-K, J&K; KAU, Kerala; Dr.YSRHU, Andhra Pradesh
Cauliflower	18	Tierra Agrotech Private Limited, Hyderabad
Chilli	546	Dr. YSPUHF, HP; SKUAST-K, J&K; IARI, New Delhi; Dr. YSRHU, AP; UHS, Bagalkot; UBKVV, WB; SVBPUAT, Meerut ; NIPHM, Telangana; KAU, Kerala; SKUAST-K, J&K; Mandsaur University, MP; Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi
Cucumber	37	IIVR Varanasi; VNR Seeds Pvt. Ltd., Hyderabad; UHS, Bagalkot; PAU, Ludhiana; ACSEN Hy. Veg Pvt Ltd, Gurugram;
Dolichos bean	16	Dr. YSRHU, AP; Raja Balwant Singh College (RBS College), Agra
Lab lab bean	20	Dr. YSRHU, AP
Knol khol	8	SKUAST-K, J&K
Okra	134	Janta Mahavidyalaya Ajeetmal; UHS, Bagalkot; KAU, Kerala; IIHR, Bangalore
Radish	40	VPKAS, Almora, ICAR-RCER Patna
Pumpkin	43	CAZRI, Jodhpur
Ridge gourd	67	Noble Seeds Pvt. Ltd;, Haryana; SKUAST-K, J&K; CCSHAU, Hisar
Sponge gourd	5	KAU, Kerala
Tomato	360	Dr. YSRHU, AP, Mali Agritech Pvt. Ltd., WB; Dr. YSPUAHF,HP; Monsoon Crop science LLP, Maharashtra; CAZRI, Jodhpur; ICAR-NIABSM, MS; TNAU, Madurai; Centurion University of Technology and Management, Bhubaneshwar; VNR Seeds Pvt. Ltd., Hyderabad; KAU, Kerala; Annamalai University, Tamil Nadu; GKVK, Bengaluru
Fruit crops (93)		
Banana	19	Chandigarh University, Mohali; NRCB, Trichy; DU, Delhi
Grape	49	NRC For Grapes, MS; IARI, New Delhi; CSK HPKVV, Palampur

Crop	Accns.	Indentor
Musk melon	15	Annamalai University, Tamil Nadu
Walnut	10	CITH Srinagar
Forages (6)		
Stylosanthes	6	Kerala Agricultural University, Kerala
Potential crops (285)		
Chenopodium	14	B.R.D.P.G. College, Deoria, UP; UHS, Bagalkot
Guar	135	Swami Keshwanand RAU, Bikaner; CAZRI, Jodhpur
Amaranth	30	Uttar Kannada, Karnataka
Fababean	38	SKUAST-K, J&K; Dr YSRHU, AP
Sesbania	14	Andhra University, Visakhapatnam
Vigna stipulacea	54	IIPR, Karnataka
Medicinal and Aromatic plants (39)		
Centella asiatica	8	Delhi Technological University, Delhi
Basil	30	Janta Vedic College, Baghpat, UP
Datura	1	UHS, Bagalkot
Ornamentals (10)		
Portulaca	10	Annamalai University, Tamil Nadu
Spices (66)		
Coriander	25	ICAR-Research Complex For Eastern Region, Patna
Ajwain	1	Patkar Varde College, Mumbai
Fennel	25	ICAR-Research Complex For Eastern Region, Patna
Fenugrrek	15	Agricultural University, Kota
Narcotics (2)		
Tobacco	2	UHS, Bagalkot

- Inputs provided to National Organising Committee meetings for GB 6 to finalize the EOI document, and screening bids and proposal submission to DAC&FW.
- Participated in the 5th and 6th meeting of the Ad Hoc Committee on Conservation and Sustainable Use under the ITPGRFA (held on line), as Member of the Committee . Inputs provided for the *TOOL BOX* prepared by the select committee on conservation and sustainable use.
- Inputs provided to Treaty Secretariat for selection procedure of the Secretary ITPGRFA on behalf of Asia group.

Analysis of the Biological Diversity Act 2020 towards revision of the Act, Rules and Guidelines

- Inputs provided to ICAR- DARE for meetings organised by MOEFCC to discuss proposed revisions of the BDA 2002.

Preparation of Third Report of the State of the World (SOW) on PGRFA

- Data on 18 priorities (62 Indicators) of the Reporting Format developed for the purpose by FAO was collected for the SOW-PGRFA from all relevant activities of PGR management.
- Data entries made in the WIEWS Portal of FAO for compilation of full Report from India.
- Summary tables and Third Report SOW-

PGRFA compiled and report submitted.

Participation in Commission on Genetic Resources for Food and Agriculture of FAO

- Attended the 18th Regular Session of the CGRFA
- Attended the 10th Meeting of the International Technical Group for PGRFA and provided inputs on various Agenda including ABS issues, SOW reporting, Cross cutting issues, and finalized the draft meeting report.
- India elected as Vice Chair of the Group for the next Biennium (2021-23)

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 meetings organised by MoSPI to discuss the reporting format shared by FAO

2.4. B: Policy Issues related to Biosecurity

Inputs provided to ICAR/ DARE/ MoA:

- The Plant Quarantine (Regulation of Import into India) Order 2003 was further analysed 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 go, rather it can be done only in a phased manner.
- Phosphine can 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
- Pointwise inputs were provided for SAARC Regional Consultative meeting in Nepal on Seeds without borders as follows:
- Quarantine system in our country (both ICAR and DAC&FW)
- Germplasm exchange system in India (brief note) including procedures for both import and export
- Quarantine system in SAARC member countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) and their comparison with Indian system
- NBPGR's view on "Seeds without Borders" among SAARC countries keeping the quarantine and other systems of seed regulation in view
- Undertook country specific, pathway-based generic PRA following crops facilitating import of (table 2.3) crops for the first time by ICAR-NBPGR.
- Comments given on the risk involved in import of several agricultural commodities, certain insect cultures, pathogens and other biocontrol agents.

2.5 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.: and review

Table 2.3: Pest Risk Analyses undertaken for import of germplasnm from different countries.

S.No.	Crop species	Pathway	Country
1	Heeng (*Ferula assa-foetida)*	Seed	Uzbekistan
2	Bamboo (*Phyllostachys pubescens)*	Seed	China
3	Vinca (*Catharanthus spp.)*	Seed	Thailand
4	*Festuca pratensis*	Seed	ISTA (Switzerland)
5	*Felicia* spp.	Seed	ISTA (Switzerland)
6	Mombasa guinea grass *(Panicum maximum* cv. *mombasa)*	Seed	Thailand
7	Tanzania guinea grass (*Panicum maximum cv. Tanzania)*	Seed	Thailand
8	Ubon paspalum (*Paspalum atratus cv. Ubon paspalum*)	Seed	Thailand
9	Ubon stylo (*Stylosanthes guianensis cv. Ubon)*	Seed	Thailand
10	Mulato ii hybrid brachiaria (*Brachiaria decumbens x brachiaria brizanth)*	Seed	Thailand
11	Casuarina (*Casuarina equisetifolia*)	Seed	Kenya
12	Avocado (*Persea americana*)	Tissue cultured material	Australia
13	*Thaunatococcus daniellii*	Rhizomes and plants	Nigeria
14	Dragon fruit *Hylocerus* spp.	Cuttings	Philippines
15	*Camelina alyssum*	Seeds	Germany,Hungary, Poland, Spain, UK, USA
16	*Camelina hispida*	Seeds	Spain, USA
17	*Camelina laxa*	Seeds	Spain,USA, UK
18	*Camelina microcarpa*	Seeds	Germany, Italy, Poland, Spain, UK, USA
19	*Camelina rumelica*	Seeds	Germany Spain, UK, USA
20	*Camelina sativa*	Seeds	Australia, Austria, Bulgaria, Czech Republic, Germany, Hungary, Israel, Italy, Poland, Romania, Slovakia, Spain, Sweden, Ukraine, USA
21	*Capsella bursa-pastoris*	Seeds	Australia, Austria, Azerbaijan, Croatia, Germany Poland, Israel, Spain, Taiwan, UK, USA
22	*Capsella grandiflora*	Seeds	Germany, Spain, USA
23	*Capsella rubella*	Seeds	Germany, Spain, USA, Israel, UK
24	*Casuarina equisetifolia*	Seeds	Malaysia
25	*Cenchrus ameericansa*	Seeds	USA
26	*Moricandia suffruticosa*	Seeds	Spain, UK, USA
27	*Nasturtium officinale*	Seeds	Austria, Azerbaijan, Belgium, Germany, Hungary, Israel, Spain, Sweden, Ukraine, UK, USA
28	*Peltaria angustifolia*	Seeds	Israel, UK, USA
29	*Raphanus raphanistrum*	Seeds	Australia, Germany, Hungary, Israel, Spain, UK, USA
30	*Sisymbrium linifolium, Sisymbrium* spp.	Seeds	USA
31	*Sisymbrium luteum*	Seeds	UK, USA

of developments in the field of science and technology related to BWC

- 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.

2.6 Inputs provided to MoEF&CC:

- Provided inputs to MoEF&CC for Draft National Policy and Action Plan on Management of Invasive alien species
- Provided inputs on National Report on the implementation of the Cartagena Protocol on Biosafety presented in the Meeting of Parties of the CBD.

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

Programme: Exchange of Plant Genetic Resources with Foreign Countries (Import/ Export) their National Supplies to the Scientists/Users in the Country along with related Information and Documentation of these Activities in the form of Plant Genetic Reporter On-line Publication : PGR/GEPUBUR-DEL -01.00 (PI: **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

PI- **Vandana Tyagi**; Co-PIs - Pratibha Brahmi,

Associates- 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.

PI- S K Yadav; Co-PI - Pragya

Associates-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.

PI – Pragya; Co-PI – S K Yadav ,Puran Chandra (w.e.f (w.e.f 14.07.2021)

Associates- SP Singh, Surender Singh, PC Binda

Programme 2: PGR management policy and back up research: PGR/GEPUBUR-DEL -02.00 (PL: **Pratibha Brahmi**)

Project 1: 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 (**Code:** PGR/GEPU- BUR-DEL-02-01)

PI: Pratibha Brahmi; Co-PIs: SC Dubey (upto January 28, 2021),Dr Celia Chalam (w.e.f January 29, 2021), Gurinder Jit Randhawa, Veena Gupta, Kavita Gupta, Vandana Tyagi, Sunil Archak, K Pradheep, Pragya, Ruchi Bansal, Puran Chandra (w.e.f 14.07.2021) and Rajeev Gambhir

Project 2: Policy Issues Related to Biosecurity (Code: PGR/GEPU- BUR-DEL-02-02)

PI: SC Dubey (upto January 28, 2021), Dr Celia Chalam (w.e.f January 29, 2021), Co-PIs: Kavita Gupta, Pratibha Brahmi, Gurinder Jit Randhawa, KS Hooda (w.e.f 14.07.2021)

DIVISION OF PLANT QUARANTINE

03

Summary: A total of 1,37,671samples 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 (7730) comprised insects (6550), nematodes (429), fungi (736), viruses (15) and weeds (53) including several exotic pests. Of the 7730 infested/ infected/ contaminated samples, 7623 were salvaged through physico-chemical methods *viz.,* fumigation, X-ray radiography, pesticidal treatment, mechanical cleaning and growing-on test while107 infected samples could not be salvaged, hence rejected. These rejected samples included 31 samples of soyabean from Taiwan (2 samples) and USA (29 samples) due to *Peronospora menshurica* and 60 samples of rice due to *Tilletia barclayana* from Vietnam (28 samples) and USA (32 samples), 16 samples of barley from USA due to *Claviceps purpurea*. A total of 137 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 51 post-entry quarantine inspections were carried out at various indenter's sites during this period.A total of 1871 samples of various crops were processed for export of which 37 infested samples were salvaged, 16 samples contaminated with 04 types of weed species were salvaged and 11 Phytosanitary Certificates were issued. Quarantine processing of 37 samples of imported transgenic planting material resulted in interception of fungal pathogens in both soybean and cotton. 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 12,689 samples were received from Division of Germplasm Conservation , As a result of SHT, 547 samples were found infected with different pathogens including fungi (520 samples) and bacteria (2 samples) and viruses (25 samples). A total of 31 infected samples including 10 *Triticum aestivum* samples infected with *Tilletia carries* (6) and *T. indica* (4); one *Hordeum vulgare* sample infected with *T. carries*; six *Oryza sativa* samples infected with *T. barclayana*; one *Echinochloa esculenta* sample infected with *Ustilago panici-frumentacei*a nd one *Glycine max* sample infected with *Peronospora manshurica* were rejected as they could not be salvaged and *Setaria italica* (9), *Eleusine coracana* (2) from Hyderabad and *Cajanus cajan* (1) from Madhya Pradesh were also rejected due to heavy fungal contamination. A total of 292 indigenous samples were infected with nematodes.In addition, 83 samples were received from TCCU for seed health testing before/ after cryo-preservation, of which 34 samples were found infected with different fungi and all were salvaged.

3.1 Import quarantine

3.1.1 Quarantine examination: A total of 1,37,671samples 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, 3,143 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids. Of these, 6,550 samples were found infested with insects/ mites, including 76 with hidden infestation; 292 samples infected with nematodes, 736 infected with fungi, 15 with viruses

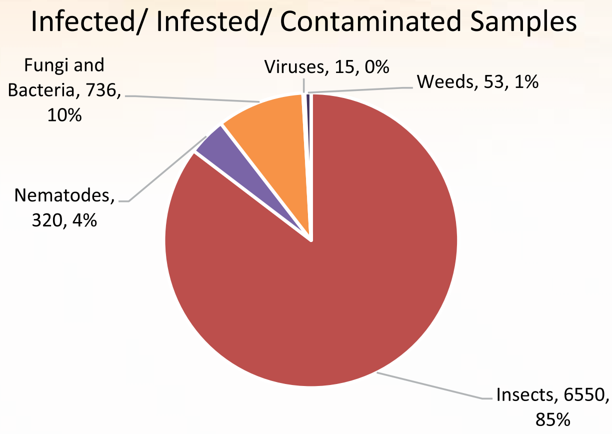


Fig. 3.1: Infected/ infested/ contaminated samples detected through quarantine examination

and 53 with weeds (**Fig. 3.1**).The photographs of some of the quarantine weeds are given in **Fig 3.2**.

3.1.2 Salvaging of infested/ infected/ contaminated germplasm: Of the total 7,730 infested/ infected/contaminated samples, 7,623 were salvagedby 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 gcu 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 6550 insect infested samples, all were salvaged by X-ray radiography (76), fumigation (6080) using aluminium phosphide (Phosphine @ 2 g per cubic metre for 72 hrs)/Ethylene dichloride Carbon tetrachloride @ 320 mg/litre for 48 hrsand mechanical cleaning (394).Of these, 736 infected samples with fungi were 629 were salvaged by various disinfection techniques/ treatments such as fungicidal seed treatment and ethyl alcohol wash and remaining 107 infected samples were rejected. In addition, four mechanically damaged tubes of *Solanum lycopersicum* from USA were also rejected. The rice samples infected with nematodes (343) were salvaged by hot water treatment. Apple and pear samples (86) infected with nematode were salvaged by formalin root dip treatment. A total of 53 samples contaminated with weed seeds were salvaged by mechanical cleaning.

3.1.3 Prophylactic treatments: A total 71,398 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 733 vegetative propagules were given pesticidal dip/ spray treatment against insect-pests.A total of 7495 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 (792) and tomato(**210**) were subjected to prophylactic seed treatment with 10% tri-sodium orthophosphate.(**Fig 3.3**).

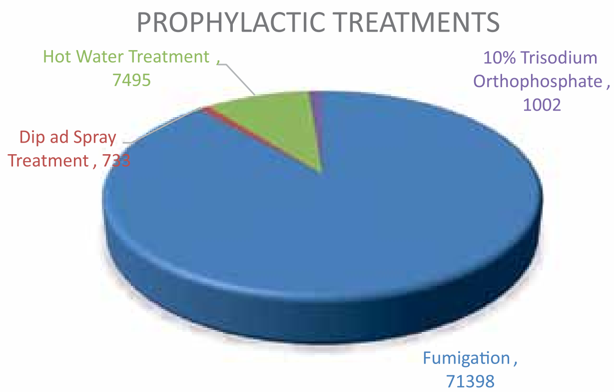


Fig. 3.3: Prophylactic treatments of introduced germplasm samples

Bromus secalinus | *Polygonum lapathifolium* | *Echinochloa crus-pavonis* | *Ipomoea plebeia* | *Avenasterilis*

Fig 3.2 Weeds of quarantine significance intercepted during quarantine processing

Table 3.1: Pests intercepted in the exotic germplasm during 2021

Pests	Host	Source/ Country
Insect pest		
**Acanthoscelides obtectus*	*Zea mays*	Thailand
**Bruchus dentipes*	*Vicia faba*	Lebanon
Bruchus Lendis	*Lens culinaris*	Lebanon
Immature form of Bruchid	*L. culinaris*	Lebanon
Rhizopertha dominica	*Cucurbita moschata*	Thailand
	Helianthus annuus	Netherlands
	Hordeum vulgare	Morocco
Sitotroga cerealella	*O. sativa*	Bangladesh, Philippines USA
	Z. mays	Chile
Sitophilus oryzae	*H. vulgare*	Morocco
	O. sativa	Bangladesh, Brazil, Philippines
Trogoderma granarium	*T. aestivum*	Mexico
**T. variabile*	*T. aestivum*	Mexico
Tribolium castaneum	*H. annuus*	Netherlands
	O. Sativa	Philippines
	T. aestivum	Mexico
Fungi and Bacteria		
Alternaria sp.	*Guizotia* sp.	Kenya
Bipolaris maydis	*Zea mays*	Philippines
B. maydis	*Z. mays* var *rugosa*	Thailand
B. nodulosa	*Triticum* sp.	USA
B. oryzae	*Oryza sativa*	Brazil, Philippines
B. sorokiniana	*Triticum aestivum*	USA
B. tetramera	*Sesamum* sp.	Kenya
	Soalnum lycopersicum	AVRDC Taiwan
Botryodiplodia theobromae	*Jatropha curcas*	Germany
	Luffa cylindrica	Thailand
	Luffa acutangula	Thailand
	Crambe sp.	USA
Botrytis cinerea	*Capsicum annuum*	Taiwan
Chaetomium sp.	*O. sativa*	Philippines
	Capsicum annuum	USA
Cladosporium cladosporioides	*C. annuum*	Taiwan
Claviceps purpurea	*Eruca & Erucastrum sp*	USA
C. purpurea	*Hordeum vulgare*	USA
Colletotrichum capsici	*L. cylindrica*	Thailand

Pests	Host	Source/ Country
Colletotrichum gloeosporioides	*J. curcas*	Germany
	L. cylindrica	Thailand
	L. acutangula	Thailand
Curvularia lunata	*Momordica charantia*	Thailand
Diaporthe phaseolorum	*J. curcas*	Germany
Diaporthesp	*L. cylindrica*	Thailand
	L. acutangula	Thailand
Exserohilum rostratum	*M. charantia*	Thailand
Fusarium oxysporum	*C. annuum*	Taiwan
	L. acutangula	Thailand
	L. cylindrica	Thailand
	M. charantia	Thailand
	Moringa stenopelta	Kenya
	O. sativa	Brazil, Philippines
	S. lycopersicum	Taiwan
Fusarium poae	*Triticum* sp.	Australia
Fusarium semitectum	*Jatropha curcas*	Germany
Fusarium solani	*C. annuum*	Taiwan
F. solani	*M. charantia*	Thailand
	Sesamum sp.	Kenya
Fusarium sp.	*S. lycopersicum*	Taiwan
Fusarium subglutinans	*L. cylindrica*	Thailand
Fusarium verticillioides	*Abelmoschus esculentus*	Taiwan
	Allium cepa	USA
	C. annuum	Netherlands, Taiwan, Thailand, USA
	Cicer sp.	Australia
	Crambe sp.	USA
	Cucumis sativus	USA
	Eruca & Erucastrum sp.	USA
	Gladiolus sp.	South Africa
	J. curcas	Germany
	Lagenaria sp.	USA
	Lathyrus spp	USA
	Linum usitatissimum	Canada
	L. acutangula	Thailand
	L. cylindrica	Thailand
	S. lycopersicum	Taiwan
	M. charantia	Thailand
	O. sativa	Brazil, Philippines, Vietnam

Pests	Host	Source/ Country
	S. lycopersicum	Taiwan
	Trifolium sp.	Australia
	T. aestivum	Australia
	T. turgidum polonicum	USA
	Z. mays	Chile, Mexico, Philippines, Thailand, USA
	Z. mays var *rugosa*	Thailand
Graphia mulmi	*L. cylindrica*	Thailand
	Lagenaria sp.	USA
	*Crambe*sp.	USA
Myrothecium roridium	*Crambe*sp.	USA
Myrothecium sp.	*M. charantia*	Thailand
Myrothecium verrucaria	*Chenopodium quinoa*	South Arabia
Peronospora manshurica	*Glycine max*	Taiwan, USA
Phoma exigua	*Crambe* sp	USA
	C. quinoa	South Arabia
	Cucurbita moschata	Thailand
	M. charantia	Thailand
Phomasorghina	*O. sativa*	Philippines, Vietnam
Pseudomnas sp.	*Citrullus lanatus*	USA
Tilletiabarclayana	*O. sativa*	Bangladesh, Philippines, USA, Vietnam
Ustilaginoidea virens	*O. sativa*	Bangladesh, Brazil, Philippines, USA, Vietnam
Verticillium albo-atrum	*S. lycopersicum*	USA
Xanthomonas campestris pv. *campestris*	*Brassica oleracea* var. *capitata*	China
Viruses		
alfalfa mosaic virus	*Glycine max*	USA
	Vigna unguiculata	Mali
▲arabis mosaic virus	▲*Glycine max*	USA
	▲*Vigna unguiculata*	Mali
bean common mosaic virus	*G. max, V. radiata*	USA
broad bean wilt virus	▲*Capsicum annuum*	USA
grapevine fan leaf virus	▲*G. max*	USA
*pepino mosaic virus	*Solanum lycopersicum*	USA
*pepper mild mottle virus	*C. annuum, S. lycopersicum*	USA
soybean mosaic virus	*G. max*	USA
tobacco mosaic virus	*C. annuum, S. lycopersicum*	USA
tobacco streak virus	*G. max*	USA
tomato black ring virus	*C. annuum*	USA

Pests	Host	Source/ Country
tomato mosaic virus	*C. annuum*	USA
	S. lycopersicum	USA
watermelon mosaic virus-2	*Momordica charantia*	Thailand
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Bangladesh, Brazil, Philippines, USA, Vietnam
Pratylenchus penetrans, Pratylenchus spp.	*Malus domestica*	Italy, France, Belgium
	Pyrus communis	France, Belgium
Meloidogyne spp.	*M. domestica*	Italy, Belgium
Aphelenchus avenae	*M. domestica*	Italy, Belgium
	P. communis	Belgium
Helicotylenchus sp.	*M. domestica*	France
	P. communis	Belgium
Rotylenchus sp.	*M. domestica*	Belgium
Weeds		
Avenafatua	*T. aestivum*	Afghanistan
**Avenasterilis*	*T. aestivum*	Afghanistan
**Bromus diandrus*	*T. aestivum*	Australia
▲*Bromus secalinus*	*T. aestivum*	Australia
Convolvulus arvensis	*T. aestivum*	Afghanistan
**Convolvulus erubescens*	*T. aestivum*	Afghanistan
Digitariasanguinalis	*O. sativa*	Bangladesh
Echinochloa crus-galli	*O. sativa*	Bangladesh, Philippines, Vietnam
E. colona	*O. sativa*	Bangladesh
▲*E. crus-pavonis*	*O. sativa*	Philippines, Vietnam
	T. aestivum	Mexico
**Ipomoea hederacea*	*T. aestivum*	Lebanon
**Ipomoea plebeia*	*T. aestivum*	Afghanistan
**Phalaris paradoxa*	*T. aestivum*	Lebanon
Polygonum aviculare	*T. aestivum*	Afghanistan
▲*Polygonum lapathifolium*	*O. sativa*	Bangladesh
Oryza sativa f. spontanea	*O. sativa*	Vietnam

▲Pest regulated under PQ Order, 2003

* Pest not yet reported from India

▲Virus present in India but with restricted distribution (exclusively in Faizabad), hence it is of quarantine significance

▲Virus present in India but not recorded on the host on which intercepted

3.1.4 Growing out test for detection of viruses

A total of 137 accessions of exotic germplasm comprising *Glycine max* (16), *Vigna unguiculata* (18), *Pisum sativum* (18) and *Vicia faba* (85) 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 1.

3.1.5 PEQ Inspection at Indenter's site: A total of 54 post-entry quarantine inspections of various crops consisting of 68,844 samples of apple (130), avocado (50), barley (2903), bitter gourd (168), bottle gourd (32), cauliflower (32), chickpea (707), citrus (449), crocus (20), cucumber (20), Duboisia (20), faba bean (460), okra (26), jatropha (107), lathyrus (692), lentil(2553), maize (21588), pepper (991), rice (421), tomato (618) and wheat (36855) 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 inspection at ICARDA's Station, loose smut was observed in eight entries of barley including five entries of MFBYT vide entry nos. 25, 36, 46, 55 and 385 and three entries of FFBYT vide entry nos. 7, 332 and 69 and all the infected plants were uprooted and incinerated. In another inspection at Research Farm of Savannah Seeds, all the entries were observed with sever paddy bunt infection and *Septoria nodorum* was isolated from suspected sample in one entry, hence uprooted all the entries and incinerated. (Table 3.2). As a result of inspections, suspected samples were uprooted and properly destructed in the field.

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

IQ No.	Country	Crop	Sample	Indentor	Date	Scientist
234/2020	Mexico	*Triticum aestivum*	3,750	Mahyco Pvt Ltd, Jalna	Feb 16 2021	J Akhtar, AK Maurya
231/2020	Mexico	*T. aestivum*	963	Ajeet Seeds Pvt Ltd Aurangabad	Feb 17 2021	J Akhtar, AK Maurya
296/2020	Mexico	*T. aestivum*	289	Ankur Seeds Pvt Ltd Nagpur	Feb 18 2021	J Akhtar, AK Maurya
229/2020	Mexico	*T. aestivum*	2269			
235/2020	Mexico	*T. aestivum*	3,934	Kaveri Seed Company Ltd, Agra	Feb 20 2021	BH Gawade, P Kumar, Sadhna
170/2020	USA	*Hordium vulgare*	815	Anheuser Busch Inbev India Ltd Gurugram	Feb 22 2021	P Kumar, R Kiran
345/2020	Mexico	*T. aestivum*	35	BISA Ludhiana	Feb 23 2021	J Akhtar, P Kumar
233/2020	Mexico	*T. aestivum*	8,604			
238/2020	Mexico	*T. aestivum*	120			
299/2020	Mexico	*T. aestivum*	578			
419/2019	UK	*T. aestivum*	620	Punjab Agricultural University Ludhiana	Feb 24 2021	J Akhtar, P Kumar
273/2020	Lebanon	*T. durum*	673	ICARDA Amlaha	Feb 24 2021	Z Khan, BR Meena, P Kumari
274/2020	Lebanon	*Hordeum vulgare*	2,088			
275/2020	Lebanon	*Cicer arientinum*	707			
276/2020	Lebanon	*Lens culinaris*	2,553			
277/2020	Lebanon	*Lathyrus sativus*	668			
278/2020	Lebanon	*Vicia faba*	460			

IQ No.	Country	Crop	Sample	Indentor	Date	Scientist
227/2020	Mexico	*T. aestivum*	801	Eagle Seeds & Biotech Ltd Indore	Feb 25 2021	Z Khan, P Kumari, BR Meena
284/2020	Turkey	*T. aestivum*	178	ICAR-IIWBR Karnal	Mar 2, 2021	MC Singh, Z Khan, BR Meena, Naresh Kumar
226/2020	Mexico	*T. aestivum*	2,592	Nuziveedu Seeds Ltd Karnal	Mar 3, 2021	MC Singh, Z Khan, BR Meena, Naresh Kumar
31/2021	Japan	*T. aestivun*	05	ICAR-IARI, New Delhi	Mar 3 2021	VC Chalam, K Gupta, BH Gawade
297/2020	Mexico	*T. aestivum*	01			
344/2020	Mexico	*T. aestivum*	06			
237/2020	Mexico	*T. aestivum*	2,135	Ganga Kaveri, Pvt Ltd Jaipur	Mar 5 2021	K Gupta, R Kiran
145/2020	Netherlands	*Capsicum annnuum*	08	Syngenta India Ltd Aurangabad	Mar 5 2021	VC Chalam, J Akhtar, BH Gawade (Virtual)
147/2020	Thailand	*C. annnuum*	04			
I66/2020	Taiwan	*Capsicum spp.*	12			
230/2020	Mexico	*T. aestivum*	3,130	JK AgriGenetics Ltd., Jaipur	Mar 6 2021	K Gupta, R Kiran
228/2020	Mexico	*T. aestivum*	2,966	Rasi Seeds Pvt Ltd, New Delhi	Mar 8 2021	K Gupta, MC Singh, R Kiran
306/2020	USA	*Zea mays*	01	ICAR-VPKAS Almora	Mar 8 2021	VC Chalam, J Akhtar, BH Gawade, BR Meena (Virtual)
134/2020	Thailand	*Z. mays*	364	Syngenta India Ltd Hyderabad	Mar 16 2021	VC Chalam, J Akhtar
136/2020	Chile		5390			
137/2020	Chile		5,390			
37/2020	Brazil		256			
12/2020	Chile		279			
66/2020	Thailand		500			
236/2020	Mexico	*T. aestivum*	1,378	Krishidhan Jalna	Mar 17 2021	VC Chalam, J Akhtar, BR Meena (Virtual)
239/2020	Mexico	*T. aestivum*	1,828	Suraj Crop Sciences Ltd Gandhinagar	Mar 18 2021	VC Chalam, K Gupta, BH Gawade, R Kiran, P Kumari (Virtual)
192/2020	Netherlands	*Brassica oleracea* var. *botrytis*	32	Syngenta India Pvt Ltd Karnal	Mar 18 2021	VC Chalam, K Gupta, BH Gawade, P Kumar, P Kumari (Virtual)

IQ No.	Country	Crop	Sample	Indentor	Date	Scientist
172/2020	France	*Solanum lycopersicum*	576	Syngenta India Ltd Aurangabad	Apr 2 2021	VC Chalam, Z Khan, J Akhtar, BH Gawade, R Kiran, P Kumari
464/2020	France	*S. lycopersicum*	04			
325/2020	Spain	*Cucumis sativus*	20			
221/2020	Spain	*Crocus* spp.	20	CSIP-IHBT, Palampur	Apr 23 2021	VC Chalam, J Akhtar, BH Gawade
258/2020	Mexico	*Z. mays*	02	GBPUA&T Pantnagar	Apr 24 2021	VC Chalam, Z Khan, J Akhtar, R Kiran, Sadhna
367/2020	Mexico	*Z. mays*	02	ICAR-IIMR, Begusarai	Apr 27 2021	VC Chalam, J Akhtar, BH Gawade
190/2020	Taiwan	*S. lycopersicum*	5	Sungro Seeds New Delhi	May 10 2021	VC Chalam, J Akhtar, BH Gawade, P Kumari, Sadhna
319/2020	Mexico	*Z. mays*	16	ICAR-VPKAS Almora	May 12 2021	VC Chalam, K Gupta, J Akhtar, BH Gawade, P Kumari
315/2020	Mexico	*Z. mays*	52	Nirmal Seeds Pvt Ltd Jalgaon	May 14 2021	VC Chalam, BH Gawade, P Kumar, R Kiran, P Kumari, DS Meena
309/2020	Thailand	*Momordica charantia*	47	Nath Biogenes Ltd Aurangabad	May 15 2021	VC Chalam, J Akhtar, BR Meena, Sadhna
50/2020	Australia	*Duboisia* spp.	20	Mahyco Pvt Ltd. Jalna	May 18 2021	VC Chalam, J Akhtar, BH Gawade, P Kumar, AK Maurya
240/2019	USA	*C. annuum*	306	Nunhems India Ltd Hyderabad	May 22 2021	Z Khan, BR Meena, P Kumari, AK Maurya
288/2020	Taiwan	*Abelmoschus manihot*	01	Sungro Seeds, Hyderabad	May 24 2021	VC Chalam, BR Meena, P Kumari
289/2020	Taiwan	*C. annuum*	06	Sungro Seeds, Bangalore		
240/2019	USA	*C. annuum*	306	Nunhems India Ltd Hyderabad	May 22 2021	Z Khan, BR Meena, P Kumari, AK Maurya
39/2021	Mexico	*Z. mays*	36	Punjab Agricultural University Ludhiana	May 25 2021	VC Chalam, J Akhtar, BR Meena, R Kiran, P Kumari
334/2020	Thailand	*M. charantia*	104	Bayer Crop Science Bangalore	Jun 7 2021	VC Chalam, J Akhtar, BR Meena, DS Meena
282/2020	USA	*S. lycopersicum*	33			
165/2020	Taiwan	*C. annum*	31	Nunhems India Pvt Ltd Bangalore	Jul 5 2021	Z Khan, BH Gawade, BR Meena, P Kumari, AK Maurya

IQ No.	Country	Crop	Sample	Indentor	Date	Scientist
271/2020	Brazil	*Z. mays*	347	Syngenta India Pvt Ltd Hyderabad	Jul 5 2021	VC Chalam, J Akhtar, BH Gawade, P Kumar, DS Meena (Virtual)
268/2020	Brazil	*Z. mays*	4			
14/2021	Thailand	*Z. mays*	6			
4/2021	Mexico	*Z. mays*	02	Central Agricultural University, Imphal	Jul 23 2021	VC Chalam, BH Gawade, R Kiran, P Kumari, Sadhna
55/2021	Thailand	*C. annum*	1	Monsanto India Pvt Ltd, Bangalore	Jul 26 2021	K Gupta, R Kiran, BH Gawade, P Kumari
56/2021	Thailand		3			
336/2019	Kenya	*Avocado*	50	Mahyco Pvt. Ltd, New Delhi	Jul 29 2021	K Gupta, P Kumar, BR Meena, P Kumari, N Yadav
94/2020	USA	*Malus domestica*	26	Mahyco Pvt. Ltd, New Delhi	Jul 29 2021	Z Khan, R Kiran, P Kumar, DS Meena
200/2020			50			
16/2021			42			
132/2021	France		12			
205/2020	USA	*Citroncirus* spp.	1	Mahyco Pvt. Ltd, New Delhi	Jul 30 2021	VC Chalam, MC Singh, Z Khan, R Kiran, P Kumari, DS Meena
178/2020	USA	*Poncirus trifoliata*	2			
74/2020	USA	*Citrus limon*	60			
11/2020	South Africa	*C. limon*	144			
10/2020	South Africa	*C. limon*	2			
102/2019	South Africa	*C. limon*	215	Mahyco Pvt. Ltd, New Delhi	Jul 30 2021	VC Chalam, MC Singh, Z Khan, R Kiran, P Kumari, DS Meena
31/2019	South Africa	*C. limon*	2			
32/2019	South Africa	*C. limon*	25			
41/2021	Philippines	*Z. mays*	61	Syngenta India Ltd, Hyderabad	Jul 31 2021	VC Chalam, MC Singh, BH Gawade, R Kiran, P Kumari, Sadhna
142/2020	Philippines	*Z. mays*	130			
137/2020	Chile	*Z. mays*	3579			
302/2020	Chile	*Z. mays*	4073			
12/2021	Germany	*Jatropha curcas*	107	BAIF Development Research Foundation, Pune	Aug 2 2021	K Gupta, J Akhtar, BR Meena, AK Maurya
231/2021	Taiwan	*Abelmoschus* sp.	25	Mahyaco Ltd, Jalna	Aug 27 2021	Z Khan, BR Meena, R Kiran, P Kumari (Virtual)
234/2021	Thailand	*C. annuum*	12		Sep 1 .2021	
235/2021	Taiwan	*C. annuum*	151			
184/2021	Thailand	*M. charantia*	17			
022/2019	Philippines	*Oryza sativa*	29	Savannah Seeds Pvt Ltd, Gurugram	Sep 7 2021	BH Gawde, BR Meena
056/2020	USA	*O. sativa*	12			
052/2020	USA	*O. sativa*	80			
200/2021	USA	*Lagenaria siceraria*	32	ICAR-IARI New Delhi	Oct 4 2021	VC Chalam, K Gupta, Z Khan, R Kiran, P Kumari

IQ No.	Country	Crop	Sample	Indentor	Date	Scientist
53/2021	Thailand	*Z. mays*	131	Ankur Seeds Pvt Ltd Nagpur	Oct 7 2021	MC Singh, J Akhtar, P Kumar, AK Maurya (Virtual)
111/2020	Philippines	*O. sativa*	30	Savannah Seeds Pvt Ltd Gurugram	Oct 29 2021	J Akhtar, BR Meena
105/2020	USA	*O. sativa*	250			
327/2020	USA	*O. sativa*	20			
232/2021	Taiwan	*C. annum*	151	Nunhems Seeds Pvt. Ltd Bangalore	Nov 10 2021	VC Chalam, J Akhtar (Virtual)
127/2021	Philippines	*Z. mays*	967	Syngenta India Ltd Hyderabad	Nov 22 2021	MC Singh, J Akhtar
308/2020	Spain	*Lathyrus* spp.	24	ICAR-NBPGR New Delhi	Dec 22 2021	VC Chalam, K Gupta, J Akhtar, BH Gawade, AK Maurya
338/2020	Hungary		36			

3.2 Export quarantine

A total 1871 samples of crops comprising *Oryza sativa* and *Triticum aestivum* were exported to Bangladesh, Bolivia, France, Mexico, Philippines, UK, USA and Uzbekistan. Thirty seven samples of *T.aestivum*and *O. sativa* 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 666 samples. A total of 14 samples were found infected with fungal pathogens. Thirteen samples of wheat intended for export to Bangladesh and Mexico and 3 samples of rice meant for export to Philippines and UK were found contaminated with weed seeds.A total of 11 phytosanitary certificates were issued.

Table 3.3 Detection of pests in germplasm samples for export during 2021

Pest Detected	Crop	Source	Export to
Pathogen			
Myrothecium roridum	*Daucus carota*	ICAR-IIHR, Bangaluru	France
Colletotrichum capsici	*Capsicum annuum*	ICAR-IIVR, Varanasi	France
Fusarium equiseti *F. verticillioides* *Tilletia barclayana*	*Oyza sativa*	IRRI-South Asia Hub, Hyderabad	UK
F. verticillioides	*O. sativa*	Bayer Bio Science Ltd, New Delhi	Philippines
Insect			
Rhizopertha dominica *Sitotroga cerealella*	*T. aestivum*	IIWBR, Karnal	Bangladesh, Mexico
Sitophilus oryzae	*O. sativa*	IRRI-South Asia Hub, Hyderabad	UK
Weeds			
Chenopodium album	*Triticum aestivum*	Bayer Crop Science Ltd., New Delhi	Bangladesh
Echinochloa crus-galli	*O. sativa*	Bayer Crop Science Ltd., New Delhi	Philippines, United Kingdom
Melitotus indicus	*T. aestivum*	ICAR- IIWBR, Karnal	Bangladesh
Phalaris minor	*T. aestivum*	ICAR- IIWBR, Karnal	Mexico

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

A total 12,689 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 Gene Bank.A total of 711 samples infested by various insect-pests. As a result of SHT, 547 samples were found infected with different fungal (520 samples) and bacterial (2 samples) pathogens and viral diseases (25 samples) and 34 cryo samples were found infected with different fungi and all were salvaged.

Visual/ stereoscopic examination resulted in detection of fugal (297) and viral (25) pathogens in germplasm samples which included purple stain (*Cercospora kikuchii*) in two soybean samples and one downy mildew (*Peronospora manshurica*); 225 sunflower samples infested with rust (*Puccinia helianthi*); six samples of rice infected with *T. barclayana* and 39 samples with false smut (*Ustilagenoidea virens*); four samples of wheat infected with *T. indica* and five samples of wheat one sample of barley infected with *T. carries;* one sample of *Echinochloa esculenta* infected with *Ustilagopanici-frumentacei*. Viral symptoms included tennis ball (11 samples) and split seed coat in *Pisum sativum* (13), *C. cajan* (1) from Himachal Pradesh.

Blotter test revealed detection and identification of many seed-borne fungi/ bacteria in 225 accessions of various crop germplasm. The important fungi detected include *Bipolarisoryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsici*, *Fusarium oxysporum*, *F. solani*, *Macrophomina phaseolina*, *Phoma exigua*, *Rhizoctonia solani*, *Xanthomonas campestris* pv. *campestris*, etc. and the details of patho gens detected are given in Table 3.3 A total of 31 samples including *Triticum aestivum* infected with *Tilletia carries* from Himachal Pradesh (5), Jammu (1); *T. indica* from Haryana (4); *Hordeum vulgare* infected with *T. carries* from Jammu (1) and *Oryza sativa* infected with *T. barclayana* from Nagaland (4), Odisha (1) and Assam (1); *Echinochloa esculenta* infected with *Ustilagopanici-frumentacei* from Uttarakhand (1) and *Glycine max* infected with *Peronospora manshurica* from Uttarakhand (1) were rejected as they could not be salvaged. Additionally, *Setariai talica* (9), *Eleusine coracana* (2) and *Cajanus cajan* (1) due to heavily contaminated with fungal saprophytes were also rejected.

A total of 57 samples accessions of indigenously collected seed material and multiplied material at various centers were found contaminated with 16 types of weed seeds and all these samples were salvaged by mechanical cleaning. The details of pests detected are given in Table 3.4.

A total 2,463 samples were exposed to X-ray radiography for detection of hidden infestation of bruchids and chalcids and 174 samples were found infested while visual infestation of insect-pests was recorded in 101 samples. A total 711 samples were found infested by various insect-pests. The insect pests detected are given in Table 2. Out of total 787 infested samples, 711 were salvaged by X-ray radiography (174), cold treatment (436) and mechanically (101) while 76 samples could not be salvaged hence rejected. A total of 292 samples were found infected with nematodes from eighteen different states / UT of the India.

In addition, 83 cryo-preserved samples or for cryo-preservation were received from TCCU for seed health testing of which 34 cryo samples were found infected with different fungi and all were salvaged. A toal 12 samples were X-rayed to detect any hidden infestation of insect pests and all were found free from any hidden infestation.

3.4 Detection of viruses in *In-vitro* cultures of germplasm meant for conservation

A total of 128 *in vitro* accessions were tested against different viruses comprising 54 acc. of *Dioscorea* spp. against dioscorea latent virus (DLV) and yam mosaic virus (YMV) and 74 acc. of *Pyrus* spp. against six viruses viz., apple mosaic virus (ApMV), apple chlorotic leaf spot virus (ACLSV), apple stem grooving virus (ASGV), carnation ringspot virus (CRSV), tobacco mosaic virus (TMV) and tobacco necrosis virus (TNV). Out of 54 accessions of *Dioscore*a spp., five accessions, namely IC087366, IC087375, IC087355, IC087393 & IC087365 were found infected with DLVand two accessions, IC087366 & IC087393 with YMV. Out

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

Pests	Host	Source/Collection site
Insects		
Acanthoscelides obtectus	*Vicia faba*	Himachal Pradesh
Bruchus lentis	*Lens culinaris*	Andhra Pradesh, Jammu & Kashmir, New Delhi, Uttar Pradesh, Uttarakhand,
B. pisorum	*Pisum sativum*	Himachal Pradesh, Jammu & Kashmir
Callosobruchus analis	*Cicer arietinum*	Madhya Pradesh
	Lathyrus sativus	New Delhi
	Vigna radiata	Bihar, New Delhi
C. cajanus	*Cajanus cajan*	Karnataka, Kerala, Madhya Pradesh, Maharashtra, New Delhi, Uttarakhand,
	Vigna radiata, V. unguiculata	Jammu & Kashmir
C. chinensis	*Cicer arietinum*	Rajasthan
	Macrotyloma uniflorum	Uttarakhand
	Vigna radiate, Vigna mungo	Telangana
	Vigna umbellata	Meghalaya
	Vigna unguiculata	Meghalaya
C. dolichus	*Lablab purpureus*	Madhya Pradesh
C. maculatus	*Abelmoschus esculentus*	Gujarat
	Macrotyloma uniflorum	Uttarakhand
	Phaseolus vulgaris L	Rajasthan
	Vigna mungo	Assam, Karnataka, Meghalaya, New Delhi, Uttarakhand
	Vigna unuiculata	Jammu & Kashmir, New Delhi
C. phaseoli	*Lablab purpureus*	Kerala
	Phaseolus vulgaris	Himachal Pradesh
C. theobromae	*Lathyrus sativus*	Bihar
Caryedon serratus	*Arachis hypogea*	Andhra Pradesh
Cryptolestes ferrugineus	*Avena sativa*	Uttar Pradesh
	Oryza sativa	Karnataka
Immature form of insects	*Cajanus cajan*	New Delhi
	Lablab purpuriens, Cajanus cajan	Kerala
	Lathyrus sativus L.	West Bengal
	Lens culinaris	Madhya Pradesh, New Delhi
	Macrotyloma uniflorum	Himachal Pradesh, New Delhi
	Oroxylum indicum	Assam
	Pisum sativum	Uttar Pradesh, Madhya Pradesh, Himachal Pradesh, West Bengal
	Sesbania grandiflora	New Delhi
	Vigna mungo	Jammu & Kashmir, Andhra Pradesh, Jharkhand
	V. radiata	Jammu & Kashmir, Punjab, Andhra Pradesh, West Bengal, New Delhi
	V. unguiculata	Gujarat Jammu & Kashmir, Telangana

Pests	Host	Source/Collection site
Lasioderma serricorne	*Coriandrum sativum*	Kerala
	Gossypium barbadense	Tamil Nadu
	Lagenaria siceraria	Uttar Pradesh
Oryzaephilussurinamensis	*Solanum melongena*	New Delhi
Rhizopertha dominica	*Avena sativa*	Haryana, Punjab, Uttar Pradesh
	Hordeum vulgare	New Delhi
	Millets	Telangana
	O. Sativa	Andhra Pradesh, Assam, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, New Delhi, Odisha, Tamil Nadu, Tripura, Uttarakhand,
	Triticum aestivum	Haryana, New Delhi, Punjab, Tamil Nadu,
	Z. mays	Himachal Pradesh, New Delhi,
Sitophilus oryzae	*Oryza sativa*	Andaman &Nicobar islands, Assam, Bihar, Kerala, Maharashtra, Mizoram, Nagaland, New Delhi, Meghalaya, Odisha,
	Z. mays	NEH Region
	Triticum aestivum, Sorghum bicolor	New Delhi
Sitophilus zeamais	*Z. mays*	Himachal Pradesh, Uttarakhand, Meghalaya, Mizoram, New Delhi,
Sitotroga cerealella	*Avena sativa*	Uttar Pradesh
	Hordeum vulgare	New Delhi
	O. sativa	Andaman & Nicobar Islands, Bihar, Gujarat, Haryana, Jharkhand, Karnataka, Meghalaya, Telangana, Madhya Pradesh, Arunachal Pradesh, Andhra Pradesh, Kerala, Maharashtra, Mizoram, New Delhi, Odisha, Tamil Nadu,
	Z. mays	Meghalaya, Uttar Pradesh
	Sorghum bicolor	Haryana
Specularis spp.	*Rhyncosia* spp.	Kerala
Tribolium castaneum	*Gossypium* spp.	Maharashtra
	Helianthus annuus	Telangana
	Lagenaria siceraria	Uttar Pradesh
	O. sativa	New Delhi, Telangana, Tamil Nadu, Odisha, Karnataka
	Sorghum bicolor	Telangana, Haryana
	Z. mays	New Delhi
Trogoderma granarium	*O. sativa*	Meghalaya
	Avena sativa, Lagenaria siceraria	Uttar Pradesh
Pathogen		
Acremonium strictum	*Luffa acutangula*	Rajasthan
	O. sativa	Meghalaya
	Solanum melongena	Assam

Pests	Host	Source/Collection site
B. sorokiniana	*Triticum aestivum*	HP
Bipolaris hawaiiensis	*Momordica charantia*	Telangana
Bipolaris oryzae	*O. sativa*	Karnataka, Odisha, Jharkhand, J&K
Bipolaris sorokiniana	*Hordeum vulgare*	Haryana
Bipolaris tetramera	*Sorghum bicolor*	Telangana
Botrytis cinerea	*Avena sativa*	UP
	O. Sativa	J&K
Cercospora kikuchii	*Glycine max*	MP
Chaetomium sp.	*S. melongena*	Punjab
Colletotrichum capsici	*Capsicum annuum*	TN, Meghalaya
	Chenopodium quinoa	HP
	Datura stramonium	TN
	Glycine max	MP
Colletotrichum gloeosporioides	*Acacia senegal*	Rajasthan
Curvularialunata	*O. sativa*	Assam
	Pennisetum glaucum	Telangana
Diaporthephaseolorum	*G. max*	Maharashtra
Diaporthe sp.	*Abelmoschus esculentus*	Mizoram
	Cajanus cajan	MP
Exserohilum rostratum	*M. charantia*	Telangana
	Pennisetum glaucum	Maharashtra
	Urochloa ramosa	Karnataka
Fusarium verticillioides	*Abelmoschus esculentus*	Rajasthan
	Avena sativa	UP
	Brassica juncea	Rajasthan, Bihar
	Brassica taramira	Rajasthan
	C. cajan	Karnataka, MP
	C. annuum	TN, Telangana
	Chenopodium botrys	Delhi
	Cicer arietinum	Rajasthan
	Coccinia grandis	Odisha
	Corchorus olitorius	Odisha
	Cucumis sp.	Kerala
	Cyamopsis tetragonoloba	Haryana
	Echinochloa esculenta	Telangana
	Eleusine coracana	Assam, TN
	Guizotiaa byssinica	Madhya Pradesh, Maharashtra
	Luffa muricata	Rajasthan
	M. charantia	Telangana, Kerala

Pests	Host	Source/Collection site
	Mukiama deraspatana	Haryana
	Nigella sativa	Bihar
	O. sativa	Odisha, TN, Telangana, Uttarakhand, Punjab
	Panicum sumatrense	Telangana
	Paspalum scrobiculatum	Telangana
	Phaseolus vulgaris	J&K
	Sesamum sp.	Assam
	Setariaitalica	Telangana
	Solanum lycopersicum	Telangana
	S. melongena	Assam, Kerala
	Solanum sp.	TN
	Solanum torvum	Odisha
	Solanum violaceum	Kerala
	Sorghum bicolor	AP
	T. aestivum	Punjab
	Vigna mungo	Rajasthan
	Vigna unguiculata	Delhi
	Zea mays	Delhi, Rajasthan
Fusarium oxysporum	*Abelmoschus manihot*	Odisha
	Cucumis melo subsp. *agrestis*	TN
	Cyamopsis tetragonoloba	Haryana
	Datura stramonium	TN
	Leucas aspera	Kerala
	L. acutangula var. *amara*	Rajasthan
	Luffa aegyptiaca	Bihar
	M. charantia	Telangana
	M. muricata	Rajasthan
	O. Sativa	UP
	Panicum sumatrense	Telangana
	Pennisetum glaucum	Maharashtra
	Perilla frutescens	Assam
	Sida acuta	Kerala
	Trichosanthes cucumerina	UP, Rajasthan
	Vigna radiata	Rajasthan
Fusarium semitectum	*Cyamopsis tetragonoloba*	Haryana
	G. max	Maharashtra
	Hibiscus calyphyllus	Rajasthan
	Luffa sp.	Rajasthan
	Mukia maderaspatana	Haryana
	Panicum sumatrense	Telangana

Pests	Host	Source/Collection site
Fusarium solani	*C. annuum*	HP
	Cucumis melo subsp. *agrestis*	TN
	Solanum insanum	TN
Fusarium sp.	*Euryale ferox*	Bihar
Glomerella sp.	*Cucumis sativus*	Uttarakhand
Lasiodiplodia theobromae	*Oroxylum* sp.	Assam
	Vigna unguiculata	Kerala
Macrophomina phaseolina	*C. annuum*	Rajasthan
	Cucumis melo var.*argrestis*	Haryana
	Tribulus terrestris	Rajasthan
Myrothecium roridum	*M. charantia*	Telangana
	Setariaitalica	Telangana
	Vigna mungo	Rajasthan
Ophio stoma ulmi	*L. acutangula*	Rajasthan
Peronospora manshurica	*G. max*	Uttarakhand
Phoma exigua	*M. charantia*	Telangana
	Solanum americanum	Kerala
Phoma sorghina	*O. sativa*	TN
Phoma sp.	*S. insanum*	TN
	C. cajan	Madhya Pradesh
Puccinia helianthi	*Helianthus annuus*	Telangana
Rhizoctonia solani	*O. sativa*	Assam, Uttarakhand, Odisha
Ustilagopanici-frumentacei	*E. esculenta*	Uttarakhand
Tilletia barclayana	*O. sativa*	Odisha, Nagaland
Tilletia caries	*T. aestivum*	HP, J&K, Haryana
Tilletia indica	*T. aestivum*	Bihar, Haryana
Ustilaginoidea virens	*O. sativa*	Karnataka, Meghalaya, Telangana, Bihar, AP, Odisha, Uttarakhand, TN
Xanthomonas campestris pv *campestris*	*Brassica* sp.	Telangana, Punjab
Nematodes		
Aphelenchoides besseyi	*O. sativa*	Andaman and Nicobar Islands, Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tamil Nadu, Telangana, Tripura, West Bengal
Weeds		
Albizia lebbeck	*Pisum sativum*	Madhya Pradesh
Avena fatua	*Avena sativa*	Uttar Pradesh
Chenopodium album	*T. aestivum*	Haryana
Dactyloctenium aegyptium	*O. sativa*	Andaman & Nicobar, Uttarakhand

Nematodes		
Digitariasanguinalis	*Eleusine coracana*	Telangana
Echinichloacolona	*O. sativa*	Chhattishgarh, Uttarakhand
Echinichloa crus-galli	*O. sativa*	Andaman &Nicobar,Chhattishgarh, New Delhi, Uttarakhand
	Setaria italica	Kerala
Emex australis	*Fagopyrum esculentum*	Jammu & Kashmir
*Galium*sp.	*Sesamum indicum*	Kerala
Ipomoea purpurea	*Cajanus cajan*	New Delhi
Melilotus alba	*T. aestivum*	Haryana
Melilotus indica		
Phalaris minor		
Rumex crispus	*Avena sativa*	Uttar Pradesh
Vicia hirsuta	*Lens culinaris*	Madhya Pradesh
Vicia sativa		

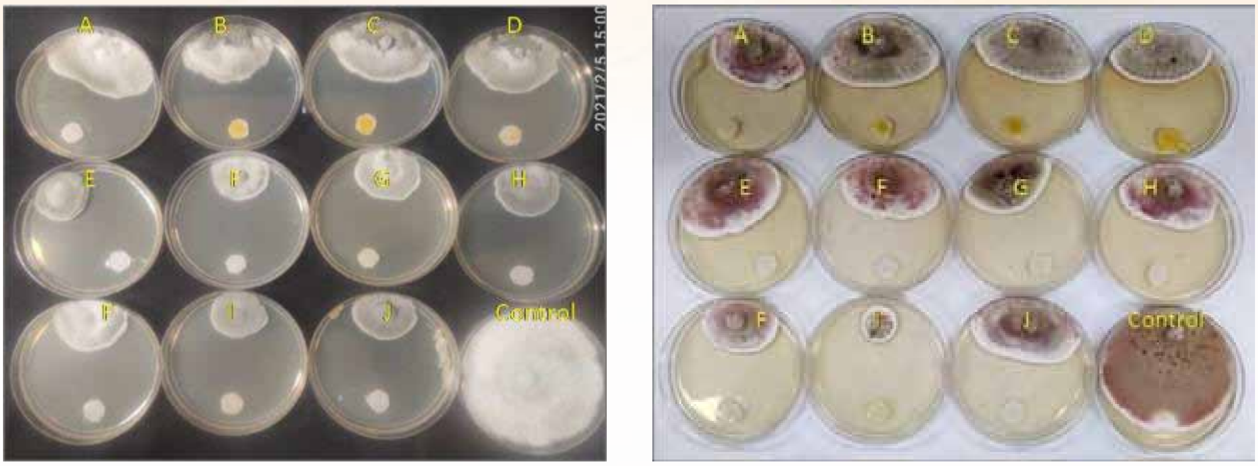
of 74 accessions of *Pyrus* spp., ApMV was detected in 4 accessions, ASGV in 3 accessions, TMV in 14 accession and TNV in 19 accessions. None of the accessions were found infected with ACLSV and CRSV.

3.5 Supportive Research

3.5.1 Antifungal efficacy of *Ocimum*-based essential oils against some important seed-borne fungal pathogens: In order to find out environment friendly substitute of heath hazardous fungicide, determination of antifungal efficacy of 10 *Ocimum*-derived crude essential oils against *Bipolaris oryzae*, *Botryodiplodia theobromae*, *Colletotrichum capsici*, *C. gloeosporioides*, *Diaporthe helianthi*, *D. phaseolorum*, *Fusarium verticillioides*, *Macrophomina phaseolina* and *Phoma sorghina* using disc diffusion method revealed that all the essential oils are effective against only two pathogens, *B. theobromae* and *P. sorghina* showing more than 50 per cent growth inhibition. None of the oils was found effective against *D. helianthi*, *F. verticillioides* and *M. phaseolina* as growth inhibition was less than 50 per cent (**Fig. 3.1**). Among *Ocimum* accessions, IC589191 was most effective as it showed promising antifungal potential against most of the pathogens i.e., *C. capsici* (65.6%), *B. oryzae* (64.4%), *B.theobromae* (61.0%), *P. sorghina* (60.5%), *D. phaseolorum* (55.7%) and C. *gloeosporioides* (52.2%) followed by IC626384, IC599345 and IC599326 which were found effective against *B. oryzae*, *B.theobromae*, *D. phaseolorum* and *P. sorghina* with more than 50 per cent growth inhibition. These observations confirm the antifungal properties of Oscimum-based essential oil.

3.5.2 Development of species-specific marker for PCR based detection of *Pyrulariaoryzae*causing rice blast: The isolates of *Pyrucularia oryzae* were confirmed based on spore morphology and ITS gene sequencing. Species-specific primers (MPo1-F and MPo1-R) were designed based on *hydrophobin-like protein* (*MPG1*) gene to detect *P. oryzae*. The DNA was extracted from pure culture of *P. oryzae,* PCR conditioned were standardized and an expected PCR product size of 520 bp was observed in *P. oryzae* isolates, but failed to amplify in other related fungal and bacterial species (**Fig. 3.4**).The primer set is highly specific and sensitive as it could detect 0.5 ng μl^{-1} *P. oryzae*DNA.

3.5.3 Development of duplex PCR for detection of *Alternaria padwickii* and *Pyricularia oryzae* infecting rice: *Alternariapa dwickii*causing stackburn and, *Pyrucularia oryzae*causing blast are major seed-borne fungal pathogens of rice. A set of primers namely Po M-1F and PoM-1R designed



Botryodiplodia theobromae *Phoma sorghina*

Fig. 3.1: Mycelial growth of *Botryodiplodia theobromae* and *Phoma sorghina* inhibited by essential oils derived from 10 accessions of *Ocimum* sp.

from *Pyriculariaoryzae hydrophobin-like protein* (*MPG1*) gene region whereas ApEF-1F and ApEF-1R were designed from elongation factor 1 region of *A. padwickii*. The specific bands of 175 bp and 520bp for *A. padwickii* and for *P. oryzae* were obtained in duplex PCR (**Fig.** 3.3). 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 μl^{-1} of template DNA of both the pathogens.

3.5.4 Development of species-specific marker for PCR based detection of *Ustilaginoidea virens* causing false smut of rice: The isolates of *Ustilaginoidea virens* were confirmed based

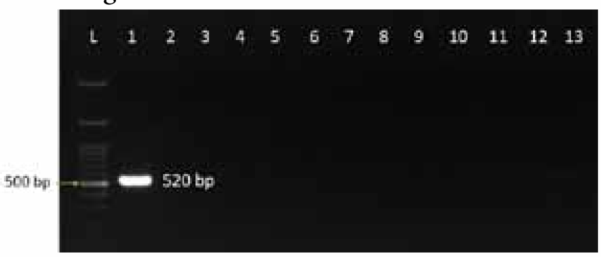


Fig. 3.2: PCR based amplification of *Pyricularia oryzae* and other related fungal and bacterial pathogens using *P. oryzae* specific primers. L: 100 bp plus DNA ladder, 1: *P. oryzae*, 2. *A. padwickii*, 3: *A. alternata*, 4: *Bipolarisoryzae*, 5: *B. rostrata*, 6: *B. sorokiniana*, 7: *B. maydis*, 8: *Curvularialunata*, 9: *Fusarium verticillioides*, 10: *Tilletiabarclayana*, 11: *X. oryzae.* pv.*oryzae*, 12: Healthy seed, 13: Negative control.

on spore morphology and ITS gene sequencing. Species-specific primers (UvP1-F and UvP1-R) were designed based on *ITS* gene region to detect *U. virens.* The DNA was extracted directly form of *U. virens* spore, PCR conditioned were standardized with

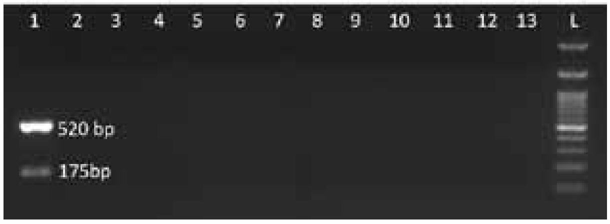


Fig. 3.3: PCR based amplification of fungal and bacterial pathogens using *P. oryzae* and *A. padwickii* specific primers. L: 100 bp plus DNA ladder, 1: *P. oryzae* + *A. padwickii*, 2: *A. alternata*, 3: *Bipolarisoryzae*, 4: *B. rostrata*, 5: *B. sorokiniana*, 6: *B. maydis*, 7: *Curvularialunata*, 8: *Curvulariahawaiiensis*, 9: *Fusarium verticillioides*, 10: *Tilletiabarclayana*, 11: *X. oryzae.* pv.*oryzae,* 12: Healthy seed, 13: Negative control.

annealing temperature of 65 ˚C and an expected PCR product size of 242 bp was observed in *U. virens* isolates, but failed to amplify in other related fungal and bacterial species (**Fig.** 4).The primer set is highly specific as it could detect only *U. virens* DNA.

3.5.5 PCR based identification of coix smut (*Ustilagocoicis*) using ITS gene sequence: Head smut caused by *Ustilagocoicis*Bref. is one

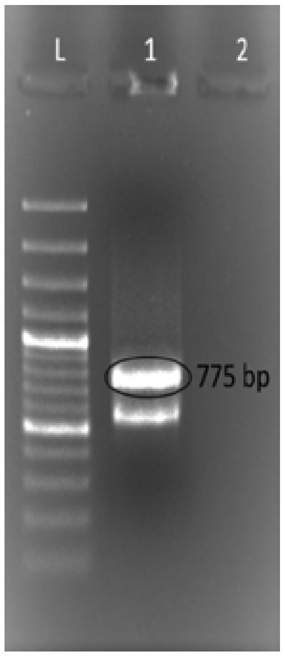


Fig 3.5a: Amplification of ITS gene of *Ustilagocoicis*directly from spore DNA; L: 100 bp plus DNA ladder, 1:*Ustilagocoicis,* 2:Negative control

of the most serious threats affecting coix cultivation in many countries and literature revealed that there are limited resistant sources of coix against *U. coicis*. Based on teliospores morphology, the associated fungus was identified as *U. coicis*. The identity of the smut fungus was re-confirmed by DNA sequencing

Fig 3.4 : PCR based amplification of *Ustilaginoidea virens* and other related fungal and bacterial pathogens using *P. oryzae* specific primers. L: 100 bp plus DNA ladder, 1: *U. virens*, 2: *A. alternata*, 3: *Bipolarisoryzae*, 4: *B. rostrata*, 5: *B. sorokiniana*, 6: *B. maydis*, 7: *Curvularialunata*, 8: *Fusarium verticillioides*, 9: *Tilletia barclayana*, 10: *P. oryzae* 11: *X. oryzae*. pv.oryzae, 12: Healthy seed, 13: Negative control.

using ITS gene primers, which gave a PCR product of 775 bp (**Fig.** 5a). The 775 bp band was eluted and sequenced and sequence submitted to NCBI (GenBank accession: MW320518.1). BLAST result showed 99.72% percentage identity with Genbank accession no. JX219371. Phylogenetic analyses of the ITS sequence dataset showed that the strain under study with Genbank accession no. MW320518.1 was placed within the same clade of *Ustilagocoicis*strains (**Fig.** 5b).

3.5.4 Screening of pulse germplasm for root-knot nematode: A total of 2600 accessions of various agri-horticultural crops, *viz*., rice (700), cowpea (402), chickpea (798), lentil (139), pea (158), urdbean (219), cucumber (134) and brinjal (50) were evaluated for resistant source to a species of root-knot nematode, *Meloidogyne incognita* in pots with artificial inoculation. (Fig 3.6 & 3.7) Based on number of root-galls induced by nematode, resistant accessions with less than 10 root-galls per plant were identified (Table 3.5).

Table 3.5 Accas. resptant to root-knot nematode

Crop (accessions screened)	Resistant accessions (Less than 10 root galls per plant)
Rice (700)	IC400565-X, IC386345, IC518814, RL11658
Cowpea (402)	EC472264, IC381584, IC397455
Chickpea (798)	Nil
Lentil (139)	Nil
Pea (158)	Nil
Urdbean (219)	IC355588, IC326077, IC485645, IC530615, IC423034
Cucumber (134)	IC410654
Brinjal (50)	Nil

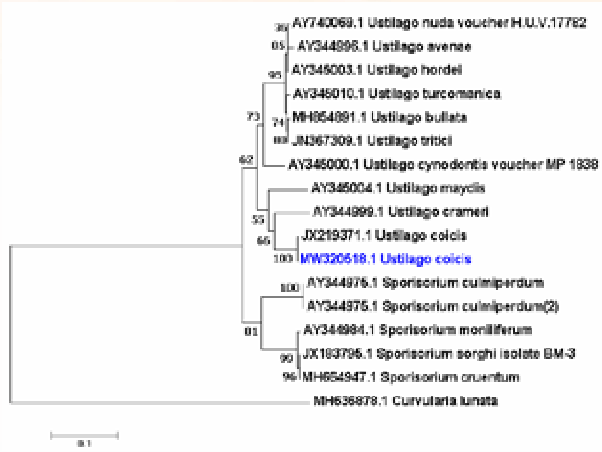


Fig. 3.5b: Phylogram generated through Neighbor-Joining method inferred from ITS gene sequences of *Ustilago* and *Sporisorium*spp. *Curvularia lunata* was used as outgroup.

3.5.5 Seasonal weeds as habitat for locusts and grasshoppers: The impact of lifespans of *Tribulus alatus, Indigofera cordifolia* and *Cenchrus*

Fig-3.6 Resistant cow-pea accession IC397455

Fig-3.7 Highly suscep-tible cowpea accession EC101981

biflorus was was studied on the incidence of locusts and grasshoppers with reference to rainfall. The study reveals that since life period of weeds was more than 4 months, locust surveillance should be conducted regularly from July to October each year because of sufficient food availability for building up of locust and grasshoppers population. Tree locust

(*Anacridiumruhrispinum*) population dominated in Jodhpur region as compared to other locusts. Among grasshoppers, the population of *Poekiloeerus pictus* was recordedon higher side than *Acrotylus, Oedaleus* and *Chrotogonus* spp.

3.5.6 Molecular detection of Phytoplasma: Molecular detection of phytoplasma was carried out at group level in tomato, wild brinjal, linseed, pea, cumin and jasmine.

3.5.7 Screening germplasm against viral diseases: One year field screening of 75 tomato accession were carried out against whitefly transmitted tomato leaf curl virus disease. EC443369, EC520075, EC002977 and EC057742 accessions were found resistant to tomato leaf curl virus disease.

3.5.8. Detection, identification and validation of mungbean germplasm resistant to bean common mosaic virus (BCMV) using serological and molecular diagnostics: A total of 65 diverse mungbean germplasm along with two 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 823nm. 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 98.9%, 99.3% and 98.9% nucleotide similarity with BCMV. Among these, IC0148525 and IC0568946 were identified as highly susceptible with 83.33% disease incidence and five accessions viz., IC0418452, IC0394728, IC0392343, IC0610380 and IC0472089 showed immune response to BCMV infection both under natural and controlled conditions.s

3.5.9 Potential quarantine pests for India in Solenaceous and Cucurbitaceous Vegetables: Information on insects, mites, fungi, bacteria, viruses, viroids phytoplasma and weeds of solenaceous and cucurbitaceous vegetables is being compiled on the parameters *viz.*, scientific name of the pest/ synonym(s), order/ family, pathway of introduction, host range, geographical distribution, economic losses/ physiological variation and phytosanitary risk.

3.6 Externally funded projects

3.6.1 National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material: Quarantine processing of imported genetically engineered (GE) plant material: With the approval of RCGM, 37 samples (Soybean -1 and Cotton -36) of imported transgenics from USA were received, processed during quarantine and intercepted *Diaporth longicolla*, *Fusarium verticilloides* and *Cercospora kikuchii*in soybean seeds and *Fusarium verticillioides*in cotton. Infected seeds of soybean were salvaged and released to indenters. *D. longicolla*, not reported from India; if not intercepted, would have got introduced and caused yield losses in soybean. Seeds of transgenic soybean (1) 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 (2) of one sample of soybean imported from soybean were undertaken and tested for 28 different viruses using ELISA supplemented with EM and RT-PCR. None of the samples showed presence of 28 viruses tested.

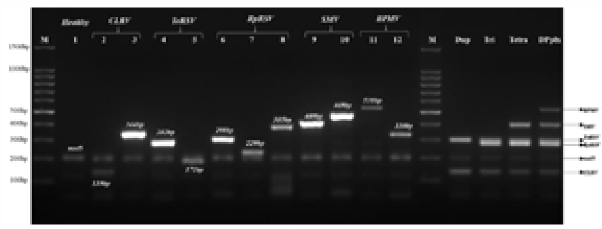


Fig 3.8 Singleplex and multiplex RT-PCR assays of soybean viruses BPMV, CLRV, RpRSV, SMV and ToRSV

Development of diagnostics for plant viruses: Simplex, duplex, triplex, tetraplex and pentaplex RT-PCR protocols for individual as well as simultaneous detection of quarantine significant viruses *viz.*, BPMV, CLRV, RpRSV, ToRSV and SMV infecting soybean were developed. (3.8)

Multiplex and qPCR-based diagnosis to delineate major quarantine and non-quarantine fungal pathogens infecting soybean crop: For precise simultaneous detection of soybean pathogens namely, *Diaporthe phaseolorum* causing stem blight, *D. longicolla* causing seed decay, *Pernospora manshurica* causing downy mildew, *Macrophomina phaseolina* causing dry root rot, multiplex and qPCR assays targeting the sequences of different genes have been developed such as Histone-3 based marker for *M. phaseolina* (MpHisF1&R1) and *D. longicolla* (DlHisF2&R2) which could produce 309 bp and 265 bp amplicons, respectively. While, Actin based marker developed for *D. phaseolorum* (DpActF1&R2) could produce 113 bp amplicon and COX2 based marker developed for *P. manshurica* (PmCoxF2&R2) could amplify a product of 152 bp. Using qPCR, these markers proved highly specific and sensitive to detect pathogens to the level of 0.0001 ng of template DNA. Multiplex PCR protocol was also developed by combining these markers that

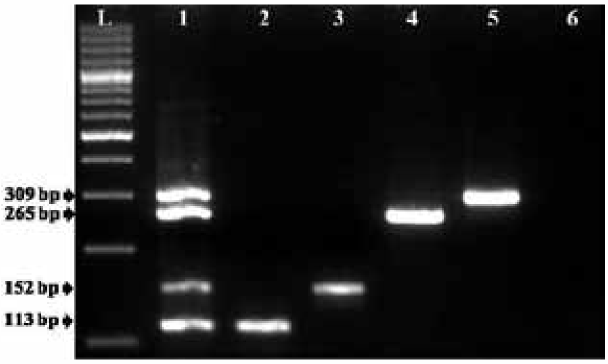


Fig. 3.9: Multiplex PCR developed for simultaneous detection of *D. phaseolorum, D. longicolla M. phaseolina* and *P. manshurica*

are able to distinguish all of the targeted pathogens concomitantly in a single reaction. (Fig. 3.9) These diagnostic protocols developed in the present study would be extremely valuable during quarantine clearance to ensure the safe transboundary exchange of pathogen-free soybean germplasm.

Duplex PCR based diagnostics for seed bruchids *Callosobruchus chinensis* and *C. maculatus* infesting soybean: Species-specific molecular markers were developed for detection of *Callasobruchus maculatus* and *Callasobruchus chinensis*. The molecular markers showed high specificity and sensitivity for detecting the insects. A duplex PCR based method has also been developed for rapid and simultaneous detection of *C. maculatus* and *C. chinensis* causing insect damage. (**Fig 3.10**)

Operational maintenance of national containment facility: The Containment Facility is maintained in full functional condition with necessary safety and security measures and installation of new 16 Ton package air conditioner in one of the bay is completed.

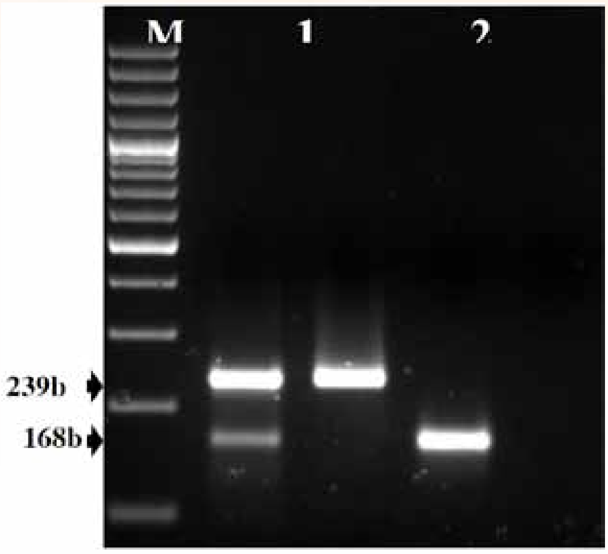


Fig. 3.10: Duplex PCR developed for simultaneous detection of *C. maculatus* and *C. chinensis*

3.6.2 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): For phenotyping of 500 accessions of rice landraces against sheath blight (*Rhizoctonia solani*) under artificial inoculation conditions, first lot of 250 accessions including 5 checks viz., C1-Pusa 44, C2-IR 64, C3-Swarna, C4-Jaya and C5 Pusa Samba 1850 were sown in protrays on July 1st 2021 and second lot of remaining 250 accessions were sown on July 9th 2021. Thereafter, first lot was transplanted in pots on July 16th 2021 and second lot was transplanted on July 22nd 2021. Out of 500 accessions, 480 accessions got established and remaining 20 accessions having 1 or 2 plants in the pots were again sown on August 3rd and transplanted in pots on August 18th 2021. Artificial inoculation was done at the maximum tillering stage with *Rhizoctonia solani* colonized typha pieces. First observation was recorded after 10-15 days of inoculation following 0-9 standard evaluation system (SES) scale adopted by IRRI for sheath blight, second observation was recorded at the flowering stage. The incubation period varied from 3-10 days and relative lesion length ranged from 0-5, 5-10, 10-15 and 15-20 cm in resistance, moderately resistance and moderately susceptible and susceptible lines, respectively. None of the varieties showed complete resistant reaction against sheath blight. Based on relative lesion height length, 4 accessions viz., RL-46, RL-211, RL-737 and RL-3913 found to be resistantagainst sheath blight of rice.

3.6.3 Mainstreaming of Sesame germplasm for productivity enhancement throughgenomics assisted core development and trait discovery (Subproject-3; Component-4) Identification of biotic stress (Root rot) tolerant sesame genotypes: Molecular diversity analysis of Macrophominaphaseolina using ISSR markers and beta tubulin gene: *Macrophominaphaseolina* 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 markers and beta tubulin gene conserved region. The dendrogram of ISSR 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.** 6). Similarly, there was no geographical region based clustering reported using beta-tubulin gene (**Fig.** 7).

3.6.4 Mainstreaming of sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Sub-Project 3: Component 1 Phyllody: A total of 5,906 accessions of sesame germplasm have been evaluated against phytoplasma under field conditions and 624 accession were found infected with phyllody. 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.

3.6.5 Characterization, Evaluation, Genetic Enhancement and generation of Genomic Resources for Accelerated Utilization and Improvement of Minor Pulses (DBT).

3.6.5.1 Sceening of black gram germplasm and selected wild *Vigna* spp. against bruchid [*Callosobruchus maculatus*] A diverse sample of 69 black gram germplasm accessions, representing landraces and crop wild relatives (CWR) were assessed for resistance against *Callosobruchus maculatus* under no-choice infestation protocol. Alongwith seed traits, the key growth parameters viz., adult emergence (AE), percent seed weight loss (PSWL) and growth index (GI) displayed significant variations based on which the accessions were classified into six groups viz., immune (I), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS). Accessions IC259504 (*V. vexillata*) and IC424616 (*V. mungo*) were immune and resistant

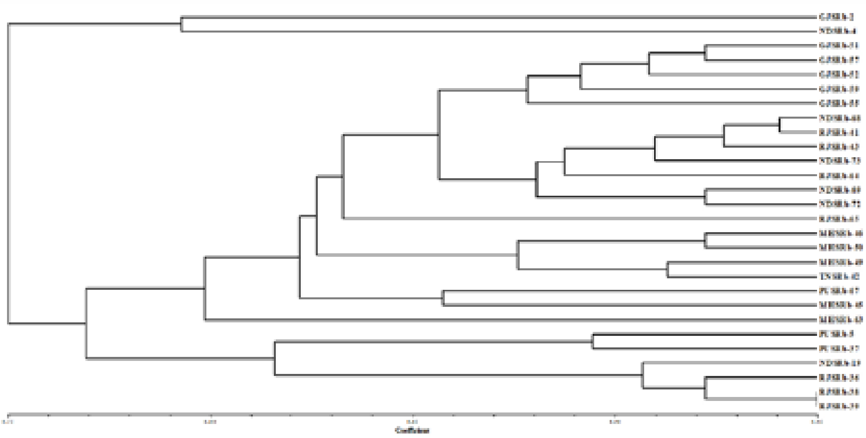


Fig. 3.11. UPGMA clustering based dendrogram of ISSR markers showing the genetic relationship among *Macrophominaphaseolina* isolates

Fig. 3.12. Phylogeny of *Macrophominaphaseolina* isolates using beta-tubulin gene with the Maximum-likelihood approach

to bruchid infestation respectively supported by X-ray radiographic evidence. Correlation heat matrix indicated GI was positively correlated with AE (r= 0.80) and PSWL (r= 0.72). Seed hardness showed a significant negative correlation with AE (r= -0.38). The reported immune and resistant accessions could be utilized in various breeding programs for the development of bruchid resistant cultivars in black gram and its other related *Vigna* species.

3.6.5.2 Screening of cowpea germplasm against viruses:A total of 332 accessions of cowpea were screened against yellow mosaic disease under natural field conditions. A total of 99 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 RT-PCR.

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** (w.e.f. January 29, 2021),SC Dubey (till January 28,2021),Pardeep Kumar, Raj Kiran, Bharat Raj Meena, *AK 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,** SP Singh (till January 29, 2021),*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,** *DS Meena*)

PGR/DPQ-BUR-DEL-01.06 Quarantine Treatments for Disinfestation and Disinfection of Planting Material against Pests under Exchange and Supportive Research (**Bharat H Gawade**(w.e.f January 30, 2021)**,** SP Singh (till January 29, 2021),Kavita Gupta, Jameel Akhtar, Bharat Gawade, Pardeep Kumar, Raj Kiran, Pooja Kumari, Bharat Raj Meena, *AK 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 and virus indexing of in vitro **cultures** (**Pardeep Kumar** (w.e.f. January 29, 2021), Jameel Akhtar (till January 28, 2021)**,** V Celia Chalam, Kavita Gupta, MC Singh, SP Singh(till January 29, 2021), Zakaullah Khan, Bharat H Gawade, Pardeep Kumar, Raj Kiran, Pooja Kumari, Bharat Raj Meena, Veena Gupta, Sushil Pandey, *AK Maurya, DS Meena, Smita Lenka Jain)*

Externally Funded Projects

- National containment/ quarantine facility for transgenic planting material Phase IV Component A: **V Celia Chalam**, Kavita Gupta, Z Khan, Jameel Akhtar (DBT)
- Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Sub-Project 3: Identification of Biotic Stress (Phyllody & Dry Root Rot) Tolerant Sesame Genotypes (DBT)
- **Component 1** Phyllody (w.e.f. 29.2.2020) **V Celia Chalam,** Kavita Gupta, Pardeep Kumar
- **Component 4** Dry Root Rot (w.e.f. 29.2.2020) Pardeep Kumar, Celia Chalam; Kavita Gupta
- Leveraging genetic resources for accelerated genetic improvement of Linseed using comprehensive genomics and phenotyping approaches (DBT)
- **Sub-Project 4: Component 6** -Evaluation of Linseed Germplasm for Major Biotic Stresses (*Alternaria* blight and Linseed bud fly**Kavita Gupta**, Mamta Singh.
- Mainstreaming of rice landraces diversity in varietal development through Genome wide association studies: A model for large scale utilization of genebank collection of rice (Phenotyping of rice landraces against sheath blight (*Rhizoctonia solani*) (DBT) Co-PI:Jameel Akhtar

DIVISION OF GERMPLASM EVALUATION

4

Summary: During 2021, a total of 32,337 accessions of various agro-horticultural crops were characterised/evaluated/regenerated/multiplied which comprised wheat (2374 acc.), maize (227), barley (700), buckwheat (250 acc.), brassica (2159 acc.), sesame (6500), linseed (2657), soybean (8029 acc.), chickpea (5084), mungbean (410), dolichos (827 acc.), pea (2443 acc.), ricebean (252 acc.), fababean (216 acc.) cowpea (425 acc.), brinjal (110 acc.) and cucumber (22 acc.). Regarding trait specific evaluation, a total of 1065 accessions of different crops viz. maize, brassica, chilli, pea, okra and cucumber were evaluated for crop specific biotic stresses and a total of 7286 accessions belonging to wheat, barley, linseeds, and lentil were evaluated under abiotic stresses. In addition, a total of 3,231 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 722 accessions comprising wheat (662 acc.) and okra (60 acc.) were evaluated at AICRP centres/hotspots for quality traits, abiotic and biotic stresses. Germplasm Field Days on 'Chickpea' and 'Wheat and Barley' were organized at NBPGR, Issapur farm, New Delhi on 28 and 29 March, 2022 respectively. A total of 6971 accessions of various crops were supplied to 79 indenters for use in crop improvement programmes.

4.1 Germplasm characterization and evaluation

4.1.1 Characterization and evaluation of wheat germplasm

A total of 2374 wheat accessions comprising *T. aestivum* (306), *T. durum* (1778), *T. dicoccum* (248), *T. sphaerococcum* (42) were grown for characterization and evaluation at ICAR-NBPGR Experimental Farm, Issapur in Augmented Block Design using ten checks HD-2967, WR-544, HD-3086, C-306, DWR-1006, UAS-415, UAS-428, DDK-1025, DDK-1029 and HW-1093. There was good range of variability in the different species of wheat germplasm (Fig 4.1 & 4.2). 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 Wheat

Species	Traits	Accessions
Triticum aestivum	Days to heading (< 86)	IC128174, IC542032, EC697725, IC116276, IC381144, EC871974, EC872045
	Grains per spike (> 80)	IC585933, IC531862, IC335998, IC296727, IC619443, IC531849, IC340976, EC573647
	1000 grain weight (>56g)	IC549392, IC542494, IC566633, IC401976, IC585933, IC539316, IC402022, IC619443
T. durum	Days to heading (< 81)	IC138356, IC138344, IC113731, EC38001, IC128230, IC138334, IC252569, IC535278, IC535579
	Grains per spike (> 82)	EC574108, EC295474
	1000 grain weight (>63g)	IC335772, IC252755, IC128230, EC299082, IC296756, IC296483
T. dicoccum	Days to heading (<88)	IC118763, IC35079, IC28596, IC35093 IC35097, IC35119, IC118765, IC47034, IC47035, IC28603, IC78706
	Grains per spike (> 52)	IC535110, IC593663, IC28603, IC547564, IC78706, IC402020, IC551397, IC535099, IC402045, EC609395
	1000 grain weight (>55g)	IC28603, IC28604, IC32502, IC138471, IC35093, IC602442

Species	Traits	Accessions
T. sphaer-occum	Days to heading (< 96)	IC53387, IC534882, IC420038, EC10494, EC576654, EC613055, EC613057, EC10494, EC10492
	Grains per spike (> 60)	IC533826, EC187172, EC187181, EC187183, EC187167, EC180067
	1000 grain weight (>38g)	IC53387, EC187182, EC10494

Fig 4.1: Field view of durum wheat germplasm grown at NBPGR, Issapur Farm

Fig 4.2: Dicoccum wheat accessions with early spike emergence

4.1.2 Characterization and evaluation of maize germplasm:

A total of 227 maize accessions were grown for characterization and evaluation in *kharif* 2021 (Fig 4.3). Promising accessions for some agronomic traits are given in Table 4.2.

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

CHARACTERS	PROMISING ACCESSIONS
Days to 50% Tasselling	IC0624767, IC0624766, IC0624765, IC77463, IC637575, IC338450, IC0624910, IC568701, IC568706, IC569176, IC77087, IC427129 (<35.00)
Ears/Plant	IC569176, IC568706, IC634026, IC563962, IC589130, IC0624766, IC253977, IC253988, IC405281, IC584586, IC584591, IC584592(>2.00)
Plant Height(dwarf)	IC584584, IC584591, IC411283, IC637576, IC544590, IC589130, IC77463, IC584588, IC563958, IC589131 (<140 cm)
Plant Height(tall)	IC130764, IC260186, IC656106, IC77195, IC213120, IC200247, IC130801, IC77165, IC427129, IC0625178, IC254025, IC128792 (>200 cm)

CHARACTERS	PROMISING ACCESSIONS
Ear Length	IC253988, IC634019, IC253977, IC254031, IC568296, IC559904, IC568307, IC569174, IC0625179, IC200272, IC550360, IC77395 (>16 cm)
Kernels/Row	IC624629, IC625131-1-1, IC253977, IC568298, IC338450, IC254006, IC568286 (>33)
100-grain weight	IC296026, IC77395, IC77195, IC262803, IC254036, IC568296, IC624629 (>30 g)

Fig 4.3: Prolific maize accessions (IC568706, IC624069-1, IC569176)

4.1.3 Characterization and evaluation of buckwheat germplasm at NBPGR RS Shimla

A total of 250 accessions of buckwheat were characterized and evaluated for important agro-morphological traits, during the *kharif* 2021, along with 4 check varieties (PRB-1, Himpriya, VL-7 and Shimla B-1) in Augmented Block Design. remarkable variability was observed for important traits viz, days to flowering (27-72 days), plant height (47.14-241.4 cm), seed yield per plant (0.92-11.55 g), days to maturity (69-151 days) and 1000 seed weight (12.19-41.18 g). Some identified promising accessions for desirable traits are presented in Table 4.3

In addition, elite accessions were identified as parental lines for hybridization programme, possessing early maturity, high seed yield and easy de-hulling. IC16552 and IC24300 were used as donor parents for early maturity and Himpriya as recipient parent. Likewise, for easy de-hulling, IC258233 (donor parent) was crossed with Shimla B-1 and Himpriya (recipient parents). Hybridization was carried out following manual hand emasculation (Table 4.4). Since it is difficult technique and results in fewer seed set, therefore, hot water emasculation technique at varying temperature ranges (40°C to 48°C with increments of 1°C) and time duration (2 to 7 min.) is being standardized.

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

Crop	Trait	Accessions
Buckwheat	Days to flowering	IC16552, IC37279, EC977211
	Days to maturity	IC16552, IC26755, IC24300
	Plant height (cm)	IC204080, IC107807, IC107973
	No. of infl./plant	NIC8817, IC324299, IC37277
	Seed yield/plant(g)	IC15393, IC381204, EC125940
	1000- seed wt. (g)	EC125940, IC381465, IC109438

Table 4.4: Buckwheat Hybridization programme

Sr. No.	Crosses		Donor Traits	No. of crosses attempted	No. of Seeds
	(♀)	(♂)			
1	Himpriya × IC 16552		Earliness	30	3
2	Himpriya × IC 24300		Earliness	25	2
3	IC 329570 × IC14889		Rutin content	10	2
4	Shimla B-1 × IC258233		Easy de-hulling	20	1

4.1.4 Characterization and evaluation of *Brassica* spp. germplasm

Total 1,505 accessions of *Brassica* spp. & its wild relatives were evaluated for different agro-morphological traits and for biotic stresses. A total 654 accessions of *Brassica* spp. (264 accessions at RS, Jodhpur and another set of 390 accessions at ICAR-NBPGR, New Delhi) were evaluated in ABD for 2nd year validation for different agro-morphological traits. In Indian mustard germplasm variability for qualitative traits was found as EC206723 with dark green non-waxy stem and apressed siliquae, IC426381P5 and IC491648 found with white flower, IC401578 with pigmented leaves & flowers. Promising accession for different quantitative agro-morphological traits found are listed in Table 4.5.

A total of 100 accessions of *Brassica juncea* var. *rugosa* was characterized and evaluated for its use as leafy vegetable at 2 locations (NBPGR, New Delhi & ICAR Research Complex for Eastern Region, Patna. Variability in traits important for leafy vegetable purpose like flower initiation, biomass yield anthocyanin content and shape of leaves was found (Table 4.6) **(Fig 4.4)**

Table 4.5: List of promising accessions for important agro-morphological traits in *Brassica*

Traits	Promising accessions
Dwarf type (<95 cm)	EC766127 (70.00), IC422028 (67), IC343199 (72), IC347947 (73.00), IC491641 (75.8)
Main shoot length (>95 cm)	IC312514 (131)
Early maturing (<98days)	IC521378 (93), IC560729 (97), IC11721 (97), IC121690 (97), IC399887 (97)
Dwarf & early maturing	IC76735 (75 cm, 75 days), IC363656 (61cm, 80 days), IC262994 (82 cm, 78 days), IC392314 (61 cm, 75 days), IC424412 (76 cm, 78 days)
No. of silique on main branch (>81)	EC367885 (170.4), IC491077 (112), IC266810 (92), EC765810 (84)
Siliqua length (6cm)	EC338997 (6.2)
Seeds/siliqua (>20)	IC571627 (22)
Yield/plant (g)	IC10976 (131), IC491485 (127), EC657014 (125)

Table 4.6: List of promising accessions for important agro-morphological traits in *Brassica juncea* var. rugosa germplasm for its utilization as leafy vegetable

Traits	Promising accessions
Flower initiation (> 90 days)	IC597836 (119), IC386746 (100), IC766341 (99), IC317528 (97), IC399888 (95), IC597905 (93), IC264898 (92)
Anthocyanin pigmentation	IC386746, IC386746, IC597922, IC597917,
Curled leaves	IC597518, IC597928, IC597934, IC597834

Traits	Promising accessions
Biomass fresh wt./plant (g) (at I[st] cut after 50 DAS)	IC399884 (216.0), IC337378 (146.7), IC597944 (136.5), IC597921 (134.5), IC597882 (125.5)
Biomass fresh wt./plant (g) (at II[nd] cut after 81 DAS)	IC597891 (356), IC597889 (289.5), IC264946 (235.5), IC399888 (164.5), IC350800 (146), IC264986 (126), IC410298 (103)

Fig 4.4: Variability in a) anthocyanin pigmentation b) leaf margins c) flower initiation *B. juncea* var. *rugosa*

4.1.5 Validation of trait specific accessions in different *Brassica* species:

Two accessions of *B. carrinata* were identified for short height (IC491745) (180 cm) and early flowering (IC555891) (53DAS). In *B. juncea* EC766064, EC766061, EC766275, EC766136, EC766316, EC634291, IC261764 were found rust resistant under field conditions. Apart from this 41 accessions of *Brassica rapa* var. toria were evaluated in RBD design with three replications to evaluate rust resistance and early maturity genotypes. *Brassica rapa* var *toria* IC20167 was found early flowering (38 days) and resistant to rust under natural field conditions.

4.1.6 Characterization and evaluation of soybean germplasm

In the year *Kharif* 2020-21, five hundred soybean accessions procured from USDA-ARS, Unites States of America and National Gene Bank (NGB), New Delhi were preliminarily characterized for various agro-morphological traits including resistance against yellow mosaic disease (YMD). Based on their performance, 20 YMD resistant accessions were selected for further detailed evaluation and planted each in paired rows in a thrice replicated randomized block design (RBD) along with one susceptible infector (JS335) and one resistant check (DS3110) during *Kharif* 2021-22. Resultantly, 2 accessions viz. EC993255 and EC1037786 were validated as highly resistant against YMV, as the plants in these two accessions showed minimum disease severity in terms of disease incidence and appeared almost free from the YMD symptoms (Fig 4.5). White fly population was also recorded across different time intervals to establish their association with YMD incidence. Apart from YMD resistance, the 2 accessions EC993255 and EC1037786 also exhibited early maturity (less than ≤ 95 days). As there is rarity of soybean germplasm which possess dual traits of YMD resistance and early maturity, these accessions may serve as potential donors for soybean improvement with respect to both of these aspects.

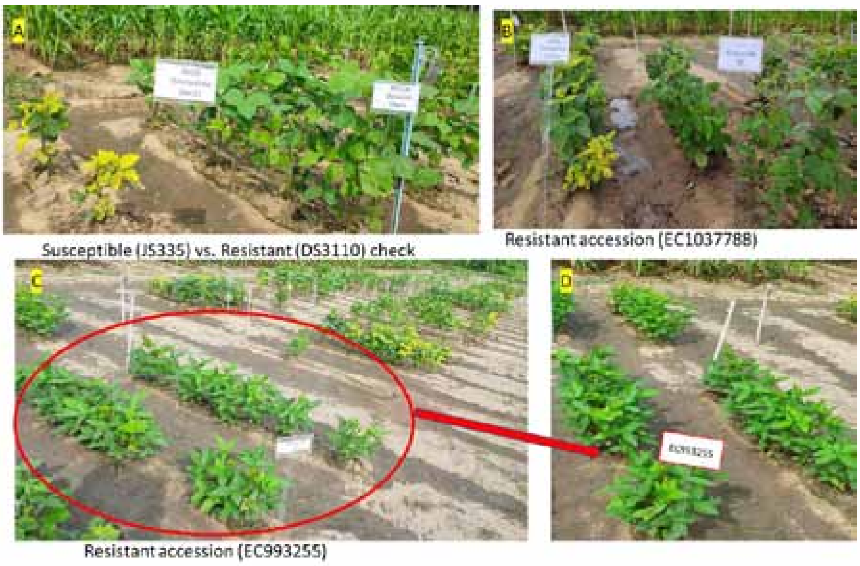


Fig 4.5: A) Resistant (DS3110) vs. Susceptible (JS335) check; B) Resistant accession (EC1037786) on right vs. susceptible check (JS335) on left; C & D) Disease free expression of resistant accession (EC993255).

To meet the growing demand of edible oil, fitting the soybean as intercrop among sugarcane inter-spaces especially during early stages of sugarcane establishment may be a viable option. For attaining this goal, availability of suitable early maturing soybean germplasm adaptable to summer cultivation is essentially required. Therefore, a total of 8029 genotypes including all accessions of National Gene bank (NBPGR) along with breeding lines from IISR, Indore were sown during spring season of 2021 in an augmented block design (ABD) along with five check varieties at Issapur farm. Though most of the germplasm accessions including check varieties continued their vegetative growth without much flowering and podding, 251 accessions were found to exhibit earliness for maturity and were thus identified as potential lines for summer season cultivation. These selected accessions were further sown during *Kharif* 2021-22 season for characterization and seed multiplication. Eleven table-purpose types were identified due to bold and non pubescent seed. In addition, 30 accessions were also found suitable for fodder purpose due to their luxuriant growth and high green biomass for summer season when there is scarcity of green fodder (Fig 4.6).

Fig 4.6: A&B) Field view of 8029 soybean accessions grown at Issapur farm, C) Early podding accession D) Lush green fodder type soybean accession (EC250586) for summer season

4.1.7 Characterization of ricebean and development of core set

During the season *Kharif*, 2021 ricebean core germplasm conssting of 252 accessions were evaluated for agromorphological traits and seed multiplication. The qualitative traits recorded are hypocotyl colour, terminal leaflet type, flower ground colour, growth habit, leafiness, leaf colour, branching pattern, pod colour, leaf senescence, mature pod colour, seed colour and seed shape. Quantitative traits recorded are terminal leaf length, terminal leaf width, plant stem diameter (cm), canopy height, number of branches/plant, number of pods/plant, number of peduncles/plant, number of pods/cluster, days to 80% maturity, pod length, number of seeds/pod, grain yield/plant and 100 seed weight (Figs 4.7 & 4.8).

Fig 4.7: Partial field view of ricebean core characterization field at Issapur Farm

Fig 4.8: IC351508, a unique ricebean germplam with semi-determinate growth habit, early maturing (80 days) and higher yielding

4.1.8 Characterization of Mungbean germplasm and development of core set

Mungbean core was derived from entire collection of Mungbean germplasm (4100 acc.) conserved in Indian national genebank, ICAR-NBPGR. The morphological data on 17 quantitative traits, seven qualitative traits and passport information were used for statistical analysis to extract diverse set (ca. 10% of the entire collections). The core was exentensively characterized further using 37 agro-morphological traits comprising of 19 quantitaitve and 18 qualitative traits. Quantitative traits are: plant height, no. of branches, stem diameter, terminal leaf length, terminal leaf width, petiole length, peduncle length, days to first flowering, days to 50% flowering, days to end of flowering, days to 80% maturity, no. of pods/ cluster, no. of pods/plant, pod length, no. of seeds/pod, pod weight, grain yield/plant, 100 seed weight and plant dry biomass. Qualiatative traits are: leaf colour, growth habit, photoperiodism, branching pattern, leafiness, lodging tolerance, twining tendency, leaf senescence, raceme position, pod attachment to peduncle, pod pubescence, pod constriction, pod curvature, seed colour, mottling on seeds surface, seed surface lustre, seed shape and hilum shape.

4.1.9 Characterization of pea germplasm conserved in Indian National Genebank

A total of 2,443 germplasm accessions (IC: 1817 and EC:626) of pea were characterized (second year) for agro-morphological descriptor traits at Issapur farm , ICAR-NBPGR, New Delhi during *Rabi* 2020-2021. The experiment was conducted in ABD with three checks (**C1**-IPFD-12-2, **C2**-IPFD-99-13, **C3**-Kashi Uday). Variability was observed for desired traits such as earliness, plant type, seed size and leafiness. Promising accessions were selected for further validation.

4.1.10 Development of core collection of cowpea germplasm conserved in Indian National Genebank for enhancing utilization

The Indian National Genebank, housed at the Indian Council of Agricultural Research (ICAR)-National Bureau of Plant Genetic Resources, New Delhi, India, currently has 3,720 accessions comprising 2,156 indigenous and 1,564 exotic collections. Under DBT funded Minor pulses project, this study was conducted to unveil the potential of cowpea germplasm by assessing its agro-morphological characteristics and diversity, identifying trait-specific germplasm, and developing a core set. The complete germplasm set was characterized for two years, i.e., 2019 and 2020, at two locations ICAR-NBPGR, New Delhi and UAS, Bengaluru and data were recorded on 27 agro-morphological traits. High phenotypic variability was observed for 12 quantitative and 15 qualitative traits. A core set comprising 425 accessions (230 Indian and 195 exotic) was derived based on the characterization data as well as geographical origin using a heuristic method. Based on the results, this core set is believed to represent the entire collection, completely. Therefore, it constitutes a potential set of germplasm that can be used in the genetic enhancement of cowpea. In 2021, Core set was planted at four locations, Delhi, Bengaluru, Ranchi and Badnapur for evaluation and validation of agro-morphological traits.

4.1.11 Development of Agro-morphological Descriptors of Tuber cowpea

Vigna vexillata (L.) A. Rich [Family: Fabaceae] is a high-value potential and under-exploited legume popularly known as tuber cowpea, zombi pea, or wild cowpea. In India, its distribution is confined to hilly-sub hilly tracts of peninsular India and partially distributed in the Himalayan region. It is used for its tuberous roots, protein-rich seed, forage and erosion control plant. Tuber Cowpea [*Vigna vexillata* (L.) A. Rich.] accessions conserved in Indian National Genebank was grown for developing key morphological descriptors and descriptor states for its characterization and preliminary evaluation. During the characterization process, enormous variability was observed in agro-morphological descriptors, including qualitative and quantitative traits. Important morphological traits such as leaf shape and size, flowering behaviour, seed shape, size and colour, tuber shape and tuber weight showed sufficient variability in the germplasm available in the Indian National Genebank. Root tuber is one of the essential and economic parts of this legume. 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 56 (37 qualitative and 19 quantitative) key morphological descriptors have been proposed for characterization and preliminary evaluation of tuber cowpea germplasm (Fig 4.9).

4.1.12 Characterization of Indian collections of *Dolichos lablab* germplasm

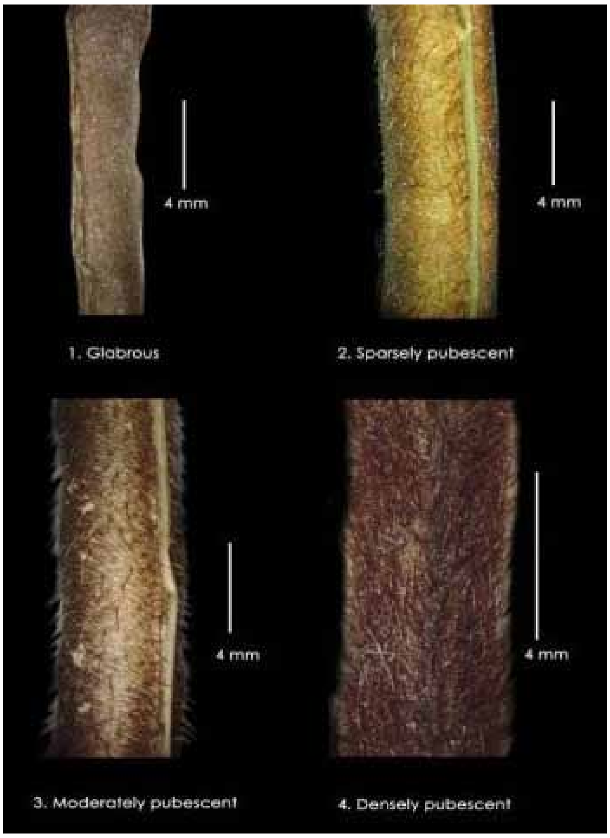


Fig 4.9: Pod Pubescence

Dolichos lablab syn *Lablab purpureus* is a drought hardy legume. The species is extensively used throughout India except in the temperate regions as a vegetable in the form of green pod, and *Dal* from the mature seeds. The species has also good potential to be used as a fodder crop by virtue of its high biomass yield and protein rich leaves. Therefore, 1724 accessions/collections of the species available in the Indian National Genebank and some shared by GKVK, Bengaluru were grown at Issapur farm during *Kharif* 2021 in ARBD experimental design to characterize them for different agro-morphological traits and segregate the genotypes suitable for fodder traits to further the fodder development programme of the country. Seven popular checks procured from IARI, IVRI, GKVK and IIHR were also grown alongside the germplasm in five replicates for comparison. Wide range of variability was observed in most of the morphological traits (Fig 4.8). A total of 725 accessions (541 from national genebank and 286 from GKVK) germinated because of excessive rains and field submergence during July-Aug of 2021. Among the established plants, promising accessions for desirable traits that performed better than the check varieties are mentioned in the Table 4.7.

4.1.13 Evaluation of fababean germplasm

4.1.13.1 Evaluation of fababean from ICARDA

Fig 4.10: Variability in pod characters and flower colours in *Dolichos lablab*

Nurseries

1 A total of 91 genotypes of two Faba bean International nurseries i.e. Faba Bean International Nursery for South Asian Countries 2021 (SAC-21) and Faba Bean International Segregating Nursery for Diverse Environments 2021 (SDE-21) were subjected to post entry quarantine and simultaneously evaluated for traits of economic importance during *Rabi* 2020-21 at ICAR-NBPGR Issapur farm, Delhi. The details of superior accessions are given in Table 4.7.

2 A total of 95 genotypes along with respective checks of four Faba bean International nurseries i.e. Faba Bean International Heat Tolerance Nursery, Faba Bean International Elite Nursery – Earliness & Disease Resistance, Faba Bean International Elite Nursery – Large Seeds and Faba Bean International F3 Nursery-South Asia & East Africa were evaluated in RBD with three replications at ICAR-NBPGR, New Area farm for evaluation of morphological traits of economic importance during *Rabi* 2020-21. The mean data on various quantitative traits were collected and presented in Table 4.7.

3 Selections were effected in these 181 genotypes based on pod and seed characters separately. Accordingly, two trials were formulated to evaluate and select superior genotypes for vegetable purpose and seed purpose uses. Initially, these two trials will be conducted at New Delhi, Ranchi and Bhowali stations of ICAR-NBPGR to select well adapted and higher yielding genotypes. These selected genotypes will be introduced into AICRP for multi-location testing and release of superior cultivars.

4 Two trials have been conducted in RBD with three replications at Ranchi to select high yielding well adapted genotypes. Trial 1 comprised of 30 genotypes (seed purpose) with five checks i.e. Ascot, Huma-2, Hudeiba-93, HFB-1 and Vikrant, while Trial 2 comprised of 30 genotypes (pod purpose) with five checks i.e. Hashbenge, Rebya-40, SLL, HFB-1 and Vikrant. The trial is in progress and selections will be effected after collection of post-harvest data.

5 A total of thirty entries of Fababean along with five checks were evaluated for fresh green pod as vegetable by following Randomized Block Design with three replications. Entry 272829, 273821 and 273801 were found superior for plot yield of fresh pod and hence could be advanced as promising genotypes for vegetable purpose in the region in comparison to best check Hama 2 (559.57). Similarly, a total of thirty entries of Fababean along with five checks were evaluated for grain yield by following Randomized Block Design with three replications. Entry number 272832, 273797 and 273796 found superior for 100 seed weight in comparison to check SLL

(52.3g).

6 Four nurseries had been sown on 20th November, 2021 in RBD with three replications at Bhowali to select high yielding genotypes. These are FBI SAEA (15 genotypes with three checks i.e. HFB-1, Vikrant, Hashbenge); FBI Early and Rained (20 genotypes with four checks i.e. Rebaya 40, Hashbenge, HFB-1, Vikrant); FBI Large seed (13 genotypes with four checks i.e. Yehya, Aguadulce, HFB-1, Vikrant) and FBI HTN (19 genotypes with three checks i.e. Basabeer, HFB-1, Vikrant). The trial is in progress and selections will be effected after collection of post-harvest data.

4.1.13.2 Evaluation of fababean as intercrop

Table 4.7: List of promising accessions for important agro-morphological traits in pulses

Crop	Trait	Accessions
Ricebean	Stem diameter (>14.66 mm)	IC36966 (16.7), IC554735 (16.07), IC116129 (16.01), IC352931 (15.68), IC552995 (15.65), IC15642 (15.12), IC526465 (14.85), IC899646 (14.76), IC545606 (14.66),
	High number of pods/cluster (>10.67)	IC369663 (14), IC426793 (12.67), IC573515 (12.33), IC573518 (10.67)
	Larger pod length (>10.6 cm)	IC19315 (9.3), IC397763 (10), IC422927 (11.37), IC422853 (10.6),
	High number of seeds/pod (>9)	IC521177 (9.67), IC557283 (9.67), IC573518 (9), IC351508 (9)
	Early maturity (<90 days)	EC934379 (65), EC934417 (67), EC18261 (73), EC934368 (70), EC130191 (73), IC351508 (80), EC615198 (90)
Pea	Early flowering	IC276596, IC613118, IC613353, IC296119, IC276597, IC276598, IC0209092, IC0255412
	High number of seeds/pod	P-3172, P-3176, EC0398595, IC0276603, EC0013055, EC0015322, EC0008532, EC0015299
	Unique plant type with waxiness	IC0220286
	Erect at maturity	EC838139, EC0865944, EC0865945, EC0865968, EC0865970, EC0865984, IC0220402
	Purple podded type	IC613132, EC0598540, EC0381859
	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
	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

Crop	Trait	Accessions
Sem (*Dolichos lablab*)	Early flowering (<50 days after sowing)	IC489279, IC556803, IC556808, IC556813, IC556815, IC556878, IC586943, IC588958, IC588960, IC594529
	High pod length	IC556745, IC556706, IC556750, IC556740, IC556875, IC556742, IC556873, IC427436, IC427452, IC556708
	High pod width	IC397630, IC586957, IC556715, IC427457, IC556722, IC556723, IC285115, IC424475, IC556713
	Erect at maturity	IC602379, IC588959, IC411069, IC588960, IC556794, IC426975, IC424470, IC586943
	High pods/ plant	IC424470, IC426975, IC565935, IC586943, IC556794, IC631577
	High Biomass	IC0411152 , IC0411153, IC0411154, IC0411155, IC0411157, IC565935, IC631577
	High leaf area	IC426974, IC556877, IC588959, IC631577, IC421575
Faba Bean International Nursery for South Asian Countries 2021 (61 genotypes)	Plant height (cm)	ET273771, ET273773, ET273779, ET273783, ET273784, ET273786, ET273813, ET273819, ET273828 (>100)
	Days to 50% flowering	ET273767, ET273774, ET273783, ET273785 (<65)
	Days to 80% maturity	ET273766, ET273767, ET273769, ET273785, ET273786, ET273789, ET273790, ET273822, ET273823 (<133)
	Pods per plant	ET273767, ET273786, ET273793, ET273814, ET273817 (>30)
	Pod wt. per plant (g)	ET273773, ET273780, ET273786, ET273794, ET273797, ET273809, ET273824, ET273825, ET273827 (>200)
	Pod length (cm)	ET273778, ET273819, ET273821, ET273822, ET273824, ET273825, ET273826 (>110)
	Pod width (mm)	ET273787, ET273801, ET273821, ET273826 (>15)
	100 seed wt. (g)	ET273768, ET273795, ET273796, ET273803, ET273808, ET273818, ET273819, ET273820, ET273827 (>75)
	Seed yield per plant (g)	ET273780, ET273782, ET273789, ET273796, ET273820 (>50)
Faba Bean International Segregating Nursery for Diverse Environments 2021 (30 genotypes)	Plant height (cm)	ET272843, ET272846, ET272842, ET272840 (>110)
	Days to 50% flowering	ET272846, ET272840 (≤ 64)
	Days to 80% maturity	ET272829, ET272837, ET272838, ET272839 ET272848, ET272853, ET272857, ET272858 (≤ 133)
	Pods per plant	ET272856, ET272837 (>24)
	Pod wt. per plant (g)	ET272849, ET272858, ET272838, ET272837, ET272841, ET272856 (>150)
	Pod width (mm)	ET272849, ET272841 (>15.50)
	Seed yield per plant (g)	ET272856, ET272838, ET272839, ET272837, ET272853, ET272831 (>45)

Crop	Trait	Accessions
Faba bean International Heat Tolerance Nursery-20	Plant height (cm)	ET273771, ET273773, ET273779, ET273783, ET273784, ET273786, ET273813, ET273819, ET273828 (>100)
	Days to 50% flowering	ET273767, ET273774, ET273783, ET273785 (<65)
	Days to 80% maturity	ET273766, ET273767, ET273769, ET273785, ET273786, ET273789, ET273790, ET273822, ET273823 (<133)
	Pods per plant	ET273767, ET273786, ET273793, ET273814, ET273817 (>30)
	Pod wt. per plant (g)	ET273773, ET273780, ET273786, ET273794, ET273797, ET273809, ET273824, ET273825, ET273827 (>200)
	Pod length (cm)	ET273778, ET273819, ET273821, ET273822, ET273824, ET273825, ET273826 (>110)
	Pod width (mm)	ET273787, ET273801, ET273821, ET273826 (>15)
	100 seed wt. (g)	ET273768, ET273795, ET273796, ET273803, ET273808, ET273818, ET273819, ET273820, ET273827 (>75)
	Seed yield per plant (g)	ET273780, ET273782, ET273789, ET273796, ET273820 (>50)
Faba Bean International Early & Disease Resistant Nursery-20 (21 genotypes)	Plant height (cm)	ET252786, ET252788, ET252792 (> 96)
	Pod wt. per plant (g)	ET252780, ET252782, ET252783, ET252786, ET252792 (> 130)
	Pod length (cm)	ET252777, ET252782 (> 9)
	Pod width (mm)	ET252777, ET252792 (> 16)
	100 seed wt. (g)	ET252777, ET252781 (> 85)
Faba Bean International Large Seed Nursery-20 (22 genotypes)	Plant height (cm)	ET252799, ET252801, ET252803, ET252809, ET252817 (> 100)
	Days to 50% flowering	ET252799, ET252802, ET252803, ET252806, ET252819 (≤ 71)
	Pods per plant	ET252800, ET252803, ET252805, ET252813, ET252814, ET252798 (> 20)
	Pod wt. per plant (g)	ET252803, ET252819 (≥ 165)
	Pod width (mm)	ET252802, ET252819 (> 16)
	100 seed wt. (g)	ET252810, ET252811, ET252813 (≥ 96)
Faba Bean International F3 SAEA Nursery-20 (30 genotypes)	Plant height (cm)	ET252822, ET252837, ET252841, ET252848, ET252849 (> 100)
	Days to 50% flowering	ET252822, ET252824 (≤ 58)
	Pod wt. per plant (g)	ET252831, ET252837, ET252840, ET252849 (>150)
	Pod length (cm)	ET252828, ET252831, ET252832, ET252848 (> 95)
	Pod width (mm)	ET252831, ET252844 (>15)
	100 seed wt. (g)	ET252831, ET252832, ET252835, ET252837 (> 85)

Crop	Trait	Accessions
Faba Bean International Nursery for South Asian Countries 2021 (61 genotypes)	Plant height (cm)	ET273771, ET273773, ET273779, ET273783, ET273784, ET273786, ET273813, ET273819, ET273828 (>100)
	Days to 50% flowering	ET273767, ET273774, ET273783, ET273785 (<65)
	Days to 80% maturity	ET273766, ET273767, ET273769, ET273785, ET273786, ET273789, ET273790, ET273822, ET273823 (<133)
	Pods per plant	ET273767, ET273786, ET273793, ET273814, ET273817 (>30)
	Pod wt. per plant (g)	ET273773, ET273780, ET273786, ET273794, ET273797, ET273809, ET273824, ET273825, ET273827 (>200)
	Pod length (cm)	ET273778, ET273819, ET273821, ET273822, ET273824, ET273825, ET273826 (>110)
	Pod width (mm)	ET273787, ET273801, ET273821, ET273826 (>15)
	100 seed wt. (g)	ET273768, ET273795, ET273796, ET273803, ET273808, ET273818, ET273819, ET273820, ET273827 (>75)
	Seed yield per plant (g)	ET273780, ET273782, ET273789, ET273796, ET273820 (>50)
Faba Bean International Segregating Nursery for Diverse Environments 2021 (30 genotypes)	Plant height (cm)	ET272843, ET272846, ET272842, ET272840 (>110)
	Days to 50% flowering	ET272846, ET272840 (≤ 64)
	Days to 80% maturity	ET272829, ET272837, ET272838, ET272839, ET272848, ET272853, ET272857, ET272858 (≤ 133)
	Pods per plant	ET272856, ET272837 (>24)
	Pod wt. per plant (g)	ET272849, ET272858, ET272838, ET272837, ET272841, ET272856 (>150)
	Pod width (mm)	ET272849, ET272841 (>15.50)
	Seed yield per plant (g)	ET272856, ET272838, ET272839, ET272837, ET272853, ET272831 (>45)
Faba bean International Heat Tolerance Nursery-20	Plant height (cm)	ET273771, ET273773, ET273779, ET273783, ET273784, ET273786, ET273813, ET273819, ET273828 (>100)
	Days to 50% flowering	ET273767, ET273774, ET273783, ET273785 (<65)
	Days to 80% maturity	ET273766, ET273767, ET273769, ET273785, ET273786, ET273789, ET273790, ET273822, ET273823 (<133)
	Pods per plant	ET273767, ET273786, ET273793, ET273814, ET273817 (>30)
	Pod wt. per plant (g)	ET273773, ET273780, ET273786, ET273794, ET273797, ET273809, ET273824, ET273825, ET273827 (>200)
	Pod length (cm)	ET273778, ET273819, ET273821, ET273822, ET273824, ET273825, ET273826 (>110)
	Pod width (mm)	ET273787, ET273801, ET273821, ET273826 (>15)
	100 seed wt. (g)	ET273768, ET273795, ET273796, ET273803, ET273808, ET273818, ET273819, ET273820, ET273827 (>75)
	Seed yield per plant (g)	ET273780, ET273782, ET273789, ET273796, ET273820 (>50)
Faba Bean International Early & Disease Resistant Nursery-20 (21 genotypes)	Plant height (cm)	ET252786, ET252788, ET252792 (> 96)
	Pod wt. per plant (g)	ET252780, ET252782, ET252783, ET252786, ET252792 (> 130)
	Pod length (cm)	ET252777, ET252782 (> 9)
	Pod width (mm)	ET252777, ET252792 (> 16)
	100 seed wt. (g)	ET252777, ET252781 (> 85)

Crop	Trait	Accessions
Faba Bean International Large Seed Nursery-20 (22 genotypes)	Plant height (cm)	ET252799, ET252801, ET252803, ET252809, ET252817 (> 100)
	Days to 50% flowering	ET252799, ET252802, ET252803, ET252806, ET252819 (≤ 71)
	Pods per plant	ET252800, ET252803, ET252805, ET252813, ET252814, ET252798 (> 20)
	Pod wt. per plant (g)	ET252803, ET252819 (≥ 165)
	Pod width (mm)	ET252802, ET252819 (> 16)
	100 seed wt. (g)	ET252810, ET252811, ET252813 (≥ 96)
Faba Bean International F3 SAEA Nursery-20 (30 genotypes)	Plant height (cm)	ET252822, ET252837, ET252841, ET252848, ET252849 (> 100)
	Days to 50% flowering	ET252822, ET252824 (≤ 58)
	Pod wt. per plant (g)	ET252831, ET252837, ET252840, ET252849, (>150)
	Pod length (cm)	ET252828, ET252831, ET252832, ET252848 (> 95)
	Pod width (mm)	ET252831, ET252844 (>15)
	100 seed wt. (g)	ET252831, ET252832, ET252835, ET252837 (> 85)

A field experiment comprising thirteen treatments was conducted during Rabi 2020-21 at ICAR-NBPGR, Issapur, Delhi to test the feasibility and profitability of fababean as intercrop with the major crops i.e. sugarcane, winter maize and chickpea. Faba bean has been sown with sugarcane and maize in the additive series under different crop geometry and with chickpea in replacement series. A total of 13 treatments were laid out in RBD with three replications. The varieties of fababean, sugarcane, winter maize and chickpea used in the experiment were HFB 1, Co 0238, Meethas and Pusa 547, respectively. Fababean, taken as intercrop in sugarcane was found most profitable, not only it produced additional yield of intercrop (fababean) but also enhanced sugarcane yield as compared to chickpea+ fababean and maize + fababean. Intercropping fababean with sugarcane (planted in staggered spacing of 30:120 cm) with three rows of fababean on 120 cm space between sugarcane rows yielded green pods of 9.6 t/ha as compared to sole fababean (10.9 t/ha). The sugarcane yield was the highest (112.3 t/ha) under the treatment of sugarcane (planted in staggered spacing of 30:120 cm) with three rows of fababean on 120 cm space between sugarcane rows (Table 4.8). It was also observed that sugarcane yield was enhanced to the tune of 9.1 to 10.4 per cent in sugarcane (75cm) + fababean (two rows) and sugarcane (90cm) + fababean (two rows) intercropping system, respectively, over sole sugarcane (75 cm and 90cm) due to the intercrop (fababean). Taking fababean as intercrop might have improved the rhizospheric and atmospheric micro-environment conducive to sugarcane growth.

4.1.14 Characterization, evaluation and

Table 4.8: Performance of fababean intercropping

Treatments	crop geometry	Yield attributes of sugarcane					Crop yield (t/ha)	
		NMC ('000/ha)	Cane length (cm)	Single cane weight (g)	Internodes (number)	Cane diameter	Fababean (green pod)	Cane yield
Fababean (45 cm)	Sole	-	-	-		-	10.95	-
Sugarcane (75 cm)	sole	89.46	208	1178	24.8		-	91.43
Sugarcane (90 cm)	sole	80.80	210	1221	26.0		-	86.64
Sugarcane (75 cm) + Fababean	1:2	84.53	236	1323	25.6		9.57	99.75

Treatments	crop geometry	Yield attributes of sugarcane					Crop yield (t/ha)	
		NMC ('000/ha)	Cane length (cm)	Single cane weight (g)	Internodes (number)	Cane diameter	Fababean (green pod)	Cane yield
Sugarcane (90 cm) + Fababean	1:2	78.54	235	1344	26.4		10.62	95.67
Sugarcane (30:120 cm) + Fababea	2:3	85.71	260	1417	27.0		9.61	112.31
Sugarcane (45:135 cm) + Fababean	2:4	77.35	252	1408	25.4		10.36	101.18

documentation of vegetable, fruits and ornamental crops germplasm:

4.1.14.1 Characterization of brinjal wild species germplasm:

A total of 110 accessions of Brinjal wild species alongwith 6 checks (Pusa Shyamla, PPL, Punjab Sadabahar, Pusa Bindu, Pusa Uttam and Pusa Ankur were characterized in kharif-2020 for descriptors 54 (Qualitative: 28 and Quantitative: 26) and evaluated for brinjal fruit and shoot borer. The variability parameters are given the below Table 4.9:

4.1.14.2 Evaluation of chilli and carrot

Table 4.9: Variability parameters and promising accessions for important agro-morphological characters in brinjal wild species

Character	Mean	Range	PCV (%)	Best Check (value)	Superior Accs.
Days to 50 % flowering	102.5	40.0-205.0	45.5	Pusa Ankur (37.3)	-
No. of leaf prickles	7.6	0-19.7	69.0	-	-
No. of prickles on calyx	8.3	0-25.0	75.7	-	-
Corolla diameter (mm)	26.6	14.6-38.7	21.0	Pb Sadabahar (33.3)	IC392445, IC256161 ≥(37.2)
Anther length (mm)	6.1	2.9-8.7	20.8	Pb Sadabahar (8.2)	IC392445 (8.7)
Flowers/inflorescence	3.2	1.0-10	42.2	Pusa Uttam (6.3)	IC283147 (10.0)
Fruit pedicel prickles	4.1	0-18.7	97.7	-	-
Fruit calyx prickles	7.2	0-28.3	91.9	Pusa Ankur (0)	-
Fruit calyx length (cm)	1.7	0.3-3.7	38.2	Pusa Ankur (3.9)	-
Fruit pedicel length (cm)	3.0	1.1-5.0	33.9	Pusa Shyamla (6.4)	-
Fruit pedicel diameter (mm)	4.2	1.0-9.8	35.2	Pusa Ankur (8.1)	IC256161 (9.8)
Fruit length (cm)	3.9	0.6-10.6	45.0	Pb Sadabahar (18)	-
Fruit breadth (cm)	3.1	0.4-8.8	37.2	Pusa Bindu (7.0)	IC256161 (8.8)
3 fruit weight (g)	79.0	6.1-709.9	106.5	Pusa Ankur (516.5)	IC256161 (709.9)
Plant height (cm)	48.7	19.2-105.1	32.6	Pb Sadabahar (68.6)	IC283147, IC552571 (≥96.6)
Plant spread (cm)	90.6	39.8-153.8	27.8	Pusa Shyamla (104.8)	IC283147, IC552571 (≥141.2)
Primary branches	12.7	8.7-27.0	21.8	Pusa Shyamla (12.0)	IC283147, IC552571 (≥22.0)
Stem diameter (mm)	17.9	8.6-31.9	29.1	Pb Sadabahar (28.4)	IC283147, IC531767-A (≥30.0)
1000 seed weight (g)	3.1	1.7-4.7	24.3	Pusa Uttam (5.9)	-

germplasm:

Chilli accessions EC772729, EC772772, EC787141, IC445618, EC773142, IC360866, and EC772771 were found early than the check varieties (Pusa Jwala, Kashi Anmol). Accessions EC769386, EC769427 and EC772705 were recorded to have more than 5 flowers per inflorescence and EC772739, EC7727297. Carrot accessions IC144375, IC312928, IC325193, IC371696 and IC596514 were identified with small core. The promising accessions are given in Table 4.10:

4.1.14.3 Evaluation of cucumber germplasm:

A total of 22 accessions along with four checks (Pusa Uday, Pusa Long Green, Punjab Naveen, Pahari Harit) were characterized during kharif 2021. The variability parameters are presented in the following Table 4.11:

Identification of germplasm with Stay Green

Table 4.10: Promising accessions for important agro-morphological characters in Chilli and Carrot

Crop	Trait	Promising Accessions
Chilli	Days to 50% flowering (<35 days)	EC772729, EC772772, EC787141, IC445618, EC773142, IC360866, EC772771
	>5 flowers per inflorescence	EC769386, EC769427, EC772705, IC119549, IC119523
	Long fruits	EC769439
	Paprika type	EC772739, EC7727297, EC692287
Carrot	Small Core size(cm)	IC144375 (0.4), IC312928 (0.35), IC325193(0.3), IC371696(0.5), IC596514 (0.48)

Table 4.11: Variability parameters for important agro-morphological characters in cucumber

Trait	Range	Mean	CV (%)
Node at which first female flower appears	5.0-22.0	11.3	41.7
Days to female flower induction	29.7-65.5	50.9	17.8
Node at which first male flower appears	4.3-14.0	8.1	32.4
Days to male flower induction	25.8-40.8	33.2	14.7
Male flower/node	1.5-9.0	4.1	38.8
Leaf length(cm)	11.2-19.5	14.2	19.1
Leaf breadth	5.8-16.6	12.7	28.8
Fruit length at marketable stage (cm)	6.1-17.2	13.7	18.1
Fruit breadth at marketable stage (cm)	4.5-5.6	5.1	6.6
Seed cavity length at marketable stage (cm)	4.6-15.1	12.1	20.1
Seed cavity breadth at marketable stage (cm)	3.0-4.5	3.6	9.4
Fruit length at maturity (cm)	8.2-25.4	14.4	40.8
Seed cavity length at maturity (cm)	6.2-21.3	12.2	39.9
Fruit breadth at maturity (cm)	4.2-8.1	6.2	22.1
Seed cavity breadth at maturity (cm)	2.2-6.3	4.0	31.6
Fruit colour at market stage	Light green, yellowish green, dark green	-	-
Skin colour at maturity	Lemon yellow, brownish orange, netted brown	-	-
Spine colour	White, brown, black	-	-

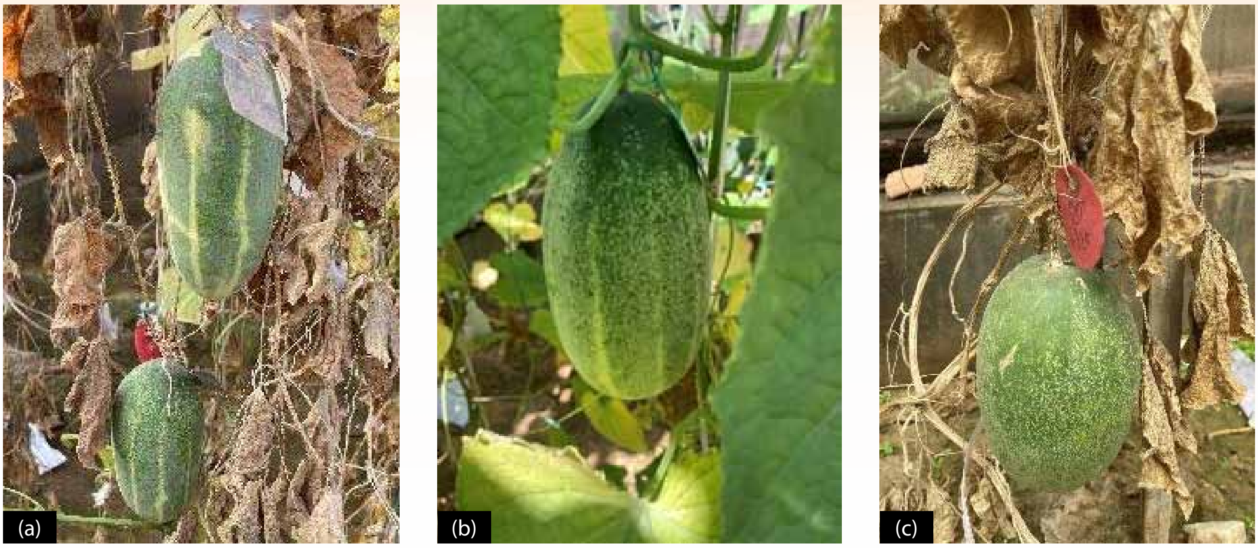


Fig 4.11: Fruits stay green on plants for more than 45 days after anthesis in (A) KG/VK/SKT-195, (B)KG/VK/SKT-125 and (C) JB 12-217

trait in cucumber: It was observed that the fruits of KG/VK/SKT-195, KG/VK/SKT-125 and JB 12-217 remain green on plants for more than 45 days after anthesis (Fig 4.11). This trait can be important for longer shelf life in cucumber. Delay of senescence in fruits in these accessions was noted in reference to check variety which starts yellowing in 20 days after anthesis.

4.2 Screening of germplasm for biotic stress resistance:

4.2.1 Screening of maize germplasm for biotic stress resistance:

Maydis leaf blight (MLB) caused by [*Bipolarismaydis* [(Nisikado& Miyake) Shoem; Race 'O'] [Teleomorph: *Cochliobolus heterostrophus* (Drechsler) Drechsler] is a serious fungal disease of maize throughout the world. The disease causes significant losses both in quality and quantity of the crop. Being primary pathogen of MLB in India, it is prevalent in almost all maize growing areas of India including Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat, Jammu and Kashmir, Sikkim, Meghalaya, Rajasthan, Andhra Pradesh, and Maharashtra.

The host-plant resistance is one of the potential strategies and can be effectively integrated to avoid losses caused due to MLB. Thus, a set 100 maize inbred lines were evaluated during *kharif* 2020 under artificial epiphytotic conditions in Delhi, the hot-spot location for MLB. The genotypes were screened by following alpha-design with two replications and the data on reaction to MLB was recorded by following standard disease screening techniques (Hooda *et al.*, 2018). The genotypes were sown in single row plot of 3m length at spacing of 20 cm × 75 cm. The reaction of genotypes to MLB inoculation were compared with CM 500, a highly susceptible check genotype included in the trial as susceptible check and the same was also sown after every 10th row to provide a uniform and adequate source of inoculum. The lines were exposed to artificial MLB epiphytotic condition created through inoculation of *Bipolaris maydis* grain culture in the whorl leading to expression of mean score of 7.7 on the susceptible check CM 500 ensuring high disease pressure during field screening experiment. Out of 100 lines, 44 lines showed either resistance or moderate resistance to MLB during *kharif* 2020. Based on one-year data, 44 genotypes with resistance or moderate resistance were further evaluated during *kharif* 2021 along with another set of 38 additional lines in the trial for further identification/ confirmation of resistance in the lines. The disease severity was recorded following a uniform rating scale of 1-9 (≤3.0 = Resistant; >5.0 = Susceptible/highly susceptible). The disease data were analysed online at IASRI NARS portal. The genotypes showed significant differences for reaction to MLB. Based on two years' pooled data, 8 genotypes were found resistant to MLB. The disease score of 8 inbred lines are as follows, DML-1278

(Score 2.51-2.65), DML-1390 (Score 1.95-2.85), DML-1575 (Score 0.47-2.50), DML-1634 (Score 2.66-3.00), DML-1828 (Score 2.74-2.90), DML-1834 (Score 2.78-2.95), DML-1851 (Score 2.32-2.45) and DML-212-1 (Score 3.00-2.15. None of the 38 additional lines evaluated for the first time recorded a score of ≤3.0 (Resistant reaction) and therefore, rejected for further evaluation in *kharif* 2022 season.

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 multiple disease resistance in the backdrop. In addition, outcome of the present study will provide base materials to study genetics of MLB disease and the material can further be used for mapping of resistant genes and probable mobilization of such genes for fine tuning of otherwise best inbred lines through marker assisted selection.

4.2.2 Evaluation for biotic stress resistance in Rapeseed & mustard

Rape seed & 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.*

4.2.3 Field evaluation of Brassica germplasm against white rust

325 Br*assica* species accessions evaluated under natural field conditions ICAR-NBPGR, Delhi and NBPGR RS, Jodhpur for second year validation, *B. juncea* accessions viz. IC265495, EC766135, EC766164, EC766230 and two accessions of *B. carinata viz.*, EC206641 and EC206642 at Delhi were validated for 3rd year as immune for white rust disease under natural field condition and also under artificial inoculated condition against Ac-Del isolate of *A. candida* (Fig 4.12). Other sources of resistance for white rust in Indian mustard are listed in table 4.5.

Fig 4.12 White rust resistance in indian mustard

4.2.4 Screening and evaluation of *Brassica* accessions/advanced introgressed lines/ Resynthesized *Brassica* (RBJ) lines under artificial inoculated conditions

A total of 350 *Brassica* species accessions screened for resistance against nine *A. candida* isolates. Among *B. juncea* accessions EC766192 and EC766164 showing immune reaction against 6-7 isolates of the pathogen at both cotyledonary and true leaf growth stages of the plants. Similarly, other accessions, EC766191, EC766193, EC313380 EC766272, IC414324, IC399312 found resistant against 4-5 isolates of the pathogen. *B. carinata* accessions EC206642, EC206653 and EC206654 identified as immune to 5-6 isolates of the pathogen (Fig 4.13).

Fig 4.13 Introgressed and resynthesized *Brassica juncea* lines resistant against *Albugo candida*

4.2.5 Screening and evaluation of wild germplasm of *Brassica* species under artificial inoculated conditions

Wild germplasm of *Brassica* species (20 species) against 10 isolates of *Albugo candida* and found some resistant germplasm *viz*., *Brassica oxyrrhina*, *Camelina sativa*, *Diplotaxis erucoides*, *D. muralis*, *D. siettiana*, *Erucastrum lyratus*, *Erucastrum canariense*, two accessions of *Crambe abyssinica viz*, EC694071 and EC694138; three accessions of *Eruca sativa viz.*, IC57706, I62597, IC62599 and one accession of *Lepidium* IC572843 were found immune (PDI = 0) against the five isolates (*Ac*-Del, *Ac-Pnt*, *Ac-Morna*, *Ac-Skn* and *Ac-Wlgtn)* of *A. candida* under environmentally controlled artificially inoculated conditions whereas, six indigenous accessions of *E. sativa*; IC508400, IC508401, IC508402, IC508404, IC310971 and IC369447 resulted in resistant reaction against 2-4 isolates.

4.2.6 Field evaluation of *Brassica* germplasm against powdery mildew

76 accessions of Indian mustard were evaluated at three locations i.e. NBPGR, New Delhi; NBPGR RS, Jodhpur and Dolphin Institute, Dehradun against powdery mildew and PM-22, PM-24, EC 520747, EC 766142 were found Immune/ Highly Resistant (PDI=0). The promising germplasm are given in Table 4.12:

4.2.7 Screening of Chilli germplasm against biotic stress:

A set of 25 accessions of chilli resistant to ChiLCD were grown for validation under natural epiphytotic conditions during *Kharif* season 2021-22 at ICAR-NBPGR, IARI New Area Farm and SKNAU, Jobner. Fourteen accessions viz. EC692283, EC759958, EC769427, EC769434, EC769376, EC769434, EC771555, EC771556, EC771556-1, EC771557, EC773729, EC772795, EC787141, and EC790579 were found resistant to Chilli leaf Curl Disease, mites and thrips at Delhi, fifteen accessions viz., EC772722, EC769398, EC773728, EC920860, EC769378, EC772795, EC928983, IC570408, EC759958, EC769377, EC769427, EC787119, EC338490, EC759964, EC787119 (*C. frutescens*) and EC772795 (*C. baccatum*) at SKNAU, Jobner. Whereas, six accessions viz., EC759958, EC769427, EC773729, EC772795, IC570408 and EC787119 were found resistant to ChiLCD at both the locations i.e. Delhi and SKNAU Jobner. The promising germplasm are given in Table 4.13:

4.2.8 Evaluation of pea germplasm and wild species of garden pea for Fusarium wilt:

Artificial inoculation of pathogen under challenge condition is most appropriate to search novel source of resistance against Fusarium wilt. For this purpose about 110 accessions of garden pea were grown in artificially created sick pots against *Fusarium oxysporum* fsp. *pisi* (Fop-1) at the Division of Vegetable Research farm, IARI, Pusa Campus, New Delhi during *Rabi* season, 2021. The accessions *viz.*, EC598616, EC598687, EC598656, IC279217, EC387624, EC269301, EC865952, EC598656, EC593753, IC552767 and IC469139 were found highly resistant to fusarium wilt. The promising germplasm are given in Table 4.13:

Table 4.12: List of promising accessions identified against biotic stresses

Crop	Trait	Disease reaction	Promising germplasm lines
Indian mustard	White rust tolerance	Immune	IC265495, IC597932, EC766275, EC766134, EC766141, EC206651, EC766311, EC766313, EC766133, EC766134, EC766144, EC766145, EC766148, EC766164, EC766193
Brassica germplasm	Powdery mildew	Immune	IC414303, IC399881, IC491402, IC355391, IC355363, IC424166, EC302488, IC361512, IC405232, EC206653, IC363795, EC338997, EC339005, IC392314, IC426381, IC555891

Table 4.13: List of promising germplasm resistant in Chilli and pea

Crop	Trait	Promising Accessions
Chilli	Resistant to ChilLCD, mites and thrips at Delhi	EC692283, EC759958, EC769427, EC769434, EC769376, EC769434, EC771555, EC771556, EC771556-1, EC771557, EC773729, EC772795, EC787141, IC570408, EC787119 (*C. frutescens*), EC787133 (*C. baccatum*), EC772795 (*C. baccatum*)

Crop	Trait	Promising Accessions
	Resistant to ChilLCD at SKNAU Jobner	EC772722, EC769398, EC773728, EC920860, EC769378, , EC790579, EC928983, IC570408, EC759958, EC769377, EC769427, EC787119, EC338490, EC759964, EC787119 (*C. frutescens*), EC772795 (*C. baccatum*)
	Resistant to ChilLCD at both locations (Delhi and SKNAU Jobner)	EC759958, EC769427, EC773729, IC570408, EC787119 (*C. frutescens*), EC772795 (*C. baccatum*)
Pea	Resistant to fusarium wilt	EC598616, EC598687, EC598656, IC279217, EC387624, EC269301, EC865952, EC598656, EC593753, IC552767, IC469139

4.2.9 Standardization of artificial screening technique of OELCD in okra

The artificial screening technique was perfectly standardized and used to screen five wild okra and one susceptible check (VRO-6) with initial lower population of whitefly and without any chance for escape under artificial conditions for consecutive two years. Out of three inoculation treatment tested using five, ten and fifteen viruliferous whiteflies for standardization of inoculation technique to produce okra enation leaf curl disease in five wild okra (Fig 4.14 & 4.15)(*Abelmoschus moschatus* ssp. *moschatus*) accessions *viz.*, EC360794, EC360586, EC360830, EC361171 and EC361148 along with VRO-6 (susceptible check). Only inoculation with fifteen viruliferous whiteflies were found to be efficient to develop complete okra enation leaf curl symptom in wild okra (EC361148) tested plant after 20-25 days of inoculation whereas for susceptible check (VRO-6) ten viruliferous whiteflies were sufficient to produce okra enation leaf curl symptom after 15-20 days of inoculation (Table 4.14).

It was found that 15 viruliferous whiteflies per plant efficiently transmit OELCV in 20 days old wild okra seedlings and the whiteflies were subjected to 24h AAP and 24h IAP (Table 4.15). Wild okra accession EC361148 and VRO-6 susceptible check developed a conspicuous OELCD symptom whereas four wild okra accessions viz., EC360794, EC360586, EC360830 and EC361171 found resistant against OELCD (Fig 8).

Table 4.14: Transmission efficiency of okra enation leaf curl virus (OELCV) by whitefly vector using 24h of Acquisition Access Period (AAP) and Inoculation Access Period (IAP)

S.No.	Number of whiteflies used (I)	Plants infected (R)/Plants inoculated (N)	Transmission rate T=R/N)
1.	0	0/5	0.00
2.	5	2/5	0.40
3.	10	4/5	0.80
4.	15	5/5	1.00

Table 4.15: Response of okra germplasm after treatment with different number of viruliferous whiteflies under artificial conditions

S.No	Accessions	Treatment	Number of plants infected/Plant inoculated	Days taken to appear symptoms
1.	EC361148	Inoculation with 5 viruliferous whiteflies	2/5	20-25 Days
2.	EC361148	Inoculation with 10 viruliferous whiteflies	4/5	20-25 Days
3.	EC361148	Inoculation with 15 viruliferous whiteflies	5/5	20-25 Days
4.	EC361148	Control	0/5	NA (not appeared)
5.	EC361171	Inoculation with 5 viruliferous whiteflies	0/5	NA
6.	EC361171	Inoculation with 10 viruliferous whiteflies	0/5	NA

S.No	Accessions	Treatment	Number of plants infected/Plant inoculated	Days taken to appear symptoms
7.	EC361171	Inoculation with 15 viruliferous whiteflies	0/5	NA
8.	EC361171	Control	0/5	NA
9.	EC360794	Inoculation with 5 viruliferous whiteflies	0/5	NA
10.	EC360794	Inoculation with 10 viruliferous whiteflies	0/5	NA
11.	EC360794	Inoculation with 15 viruliferous whiteflies	0/5	NA
12.	EC360794	Control	0/5	NA
13.	EC360586	Inoculation with 5 viruliferous whiteflies	0/5	NA
14.	EC360586	Inoculation with 10 viruliferous whiteflies	0/5	NA
15.	EC360586	Inoculation with 15 viruliferous whiteflies	0/5	NA
16.	EC360586	Control	0/5	NA
17.	EC360830	Inoculation with 5 viruliferous whiteflies	0/5	NA
18.	EC360830	Inoculation with 10 viruliferous whiteflies	0/5	NA
19.	EC360830	Inoculation with 15 viruliferous whiteflies	0/5	NA
20.	EC360830	Control	0/5	NA
21.	VRO-6	Inoculation with 5 viruliferous whiteflies	4/5	15-20 Days
22.	VRO-6	Inoculation with 10 viruliferous whiteflies	5/5	15-20 Days
23.	VRO-6	Inoculation with 15 viruliferous whiteflies	5/5	15-20 Days
24.	VRO-6	Control	0/5	NA

Fig 4.14 Okra enation leaf curl disease symptom on susceptible okra cultivar in field.

Fig 4.15: 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 five test accessions viz., EC360794, EC360586, EC360830, EC361171 and EC361148 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.

4.2.10 : Screening of cucumber germplasm for powdery mildew resistance:

A total of 38 genotypes of cucumber were screened during Spring-summer 2021 under artificial epiphytotic conditions. Artificial inoculation was done at seedling stage and scoring was done at 7, 14 and 21 days after inoculation. Accessions viz., IC261145, IC262954, IC266891, IC410657, KG/VK/SKT-014, KG/VK/SKT-183, KG/VK/SKT-195 were found resistant with Plant Disease Index (PDI) 0 to 10% while IC527418, KG/VK/SKT-101, KG/VK/SKT-153, KG/VK/SKT-207, KG/VK/SKT-227, KG/VK/SKT-313 were moderately resistant with PDI 10-

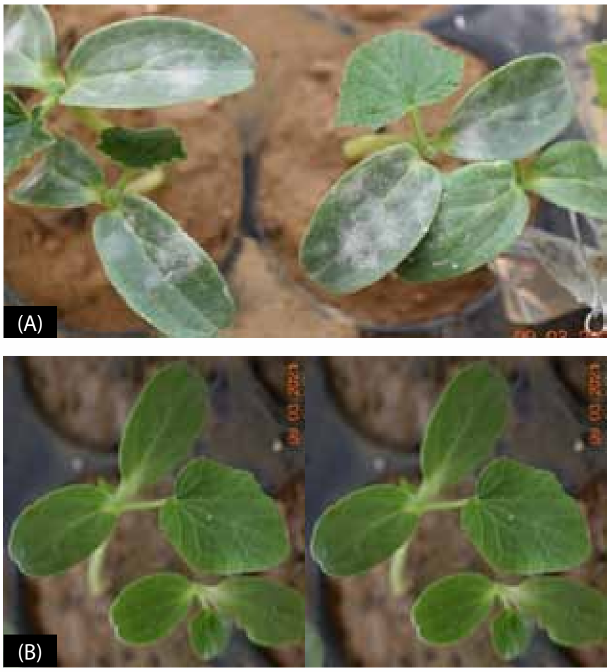


Fig 4.16 cucumber germplasm for powdery mildew reaction (A) Susceptible line, (B) IC261145 Cucumis melo var agrestis: Resistant to powdery mildew

Fig 4.17 IC262954 *Cucumis sativus*: resistant to powdery mildew

20% (Fig 4.16&4.17).

4.2.11 Screening for *Cucumis* genoypes for ToLCNDV resistance:

Tomato Leaf Curl New Delhi Virus (ToLCNDV) is the most devastating problem while raising cucurbitaceous crops during Kharif season. A total of 16 genotypes of *Cucumis* was planted in RBD for screening against ToLCNDV during Kharif 2021 under natural epiphytotic conditions. It was found that no accession of Arya landraces is affected due to any of the viral diseases. Hence, Arya landraces

Fig 4.18 *Cucumis* genoypes for ToLCNDV reaction (A) Arya-4A resistant to ToLCNDV , (B) IC261145 highly susceptible to ToLCNDV

can serve as a potential source of resistance to other melons (Fig 4.18).

4.3 Evaluation for abiotic stresses

4.3.1 Evaluation of wheat germplasm for terminal heat stress tolerance:

A set of 25 wheat accessions (previously selected from 100 accessions based on phenotypic data) including six checks (HD-2967, C-306, Raj-3765, WR-544, HI-1531, HD-2932) was evaluated at NBPGR Experimental farm New Delhi in 5 X 5 double lattice design with two replications during *Rabi* 2020-21. These accessions were grown under normal and late sown conditions. Data were recorded for 12 morpho-physiological traits. Superior accessions identified over the best check (Raj3765) based on Heat Susceptibility Index for grain yield were IC589300, IC627711, IC615010, IC393880, EC577626, EC425335, IC619435, IC621221, IC615006, IC75246, IC531257, IC543428.

4.3.2 Evaluation of wheat germplasm for terminal heat stress tolerance

A set of 25 wheat accessions (previously selected from 100 accessions based on phenotypic data) including six checks (HD-2967, C-306, Raj-3765, WR-544, HI-1531, HD-2932) was evaluated at NBPGR Experimental farm New Delhi in 5 X 5 double lattice design with two replications during *Rabi* 2020-21. These accessions were grown under normal and late sown conditions. Data were recorded for 12 morpho-physiological traits. Superior accessions identified over the best check (Raj3765) based on Heat Susceptibility Index for grain yield were IC589300, IC627711, IC615010, IC393880, EC577626, EC425335, IC619435, IC621221, IC615006, IC75246, IC531257, IC543428.

4.3.3 Evaluation of *dicoccum* wheat against terminal heat stress under NICRA project

Under NICRA project, 248 accessions of *dicoccum* wheat germplasm were grown for evaluation against terminal heat stress at ICAR-NBPGR Farm, New Delhi in Augmented Block Design under normal sown and late sown conditions using five checks, DDK1025, DDK1029, C306, IC531969, MACS2925. Observations were recorded for twelve agro-morphological and physiological traits. Promising germplasm were identified under terminal heat stress condition for traits namely, Days to spike emergence: IC35079, IC118765, IC28603, IC118763, IC28596, IC35093, IC35097, IC35119, EC577406, EC6839(<75 days); grain yield: EC590345, IC535099, IC535081, IC35174, IC212168, IC551396, IC603587, EC577406, IC47040, IC402045 (>218g); thousand grain weight: IC28603, IC28604, IC443708, IC603615, IC593663, IC551397, IC138455, EC08572, IC534621, EC577399 (>51.76g); EC577399, EC577398, EC577904, IC535152, IC417391, EC06910, EC11389, IC402018, EC08572, IC47035 (>47.07).

4.3.4 Evaluation of Barley core set for terminal heat tolerance:

Barley core set (678 accessions) was grown for evaluation against terminal heat stress at farm of ICAR-NBPGR, Issapur in Augmented Block Design under normal sown and late sown conditions. 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, IC0138110, IC0138115, IC0138116, EC0578946 (<65 days); days to maturity: IC0064171, IC0082714, IC0138010, IC0138016, IC0138023, IC0138110, IC0138115, IC0138116 (<105 days); plant height: EC0578447, IC0138016, IC0041585, IC0047346 (>90 cm); Tillers/plant: EC0177263, EC0492140, EC0667587, IC0137795, IC0108093 (>20); grain yield/plant: IC0108093, IC0057631, IC0356291 (>15 g).

4.3.5 Evaluation of barley germplasm for salt stress tolerance

A set of 27 barley accessions consisting of high salt tolerant, moderate and susceptible was constituted for pot evaluation after screening 112 accessions (including Barley Minicore) under 200 mM NaCl at seedling stage. This set was further evaluated for salt stress in pots (18- 20dS/m) based on physiological traits (RWC, MSI, Chlorophyll fluorescence, Chlorophyll concentration index, Canopy temperature, Na^+/K^+ uptake) and yield related traits. A panel of 7 salt tolerant EC0578359, EC0123148, EC0578251, IC0547723, EC0177250, IC0247671, EC0299361 and 6 salt sensitive EC0578761, RD2794, EC0177257, IC0533161, EC0578517, IC0355879 was identified for sequence variation analysis to identify potential SNP haplotypes of abiotic stress responsive genes associated with salt tolerance in barley.

4.3.6 Evaluation of lentil germplasm for drought stress and quality traits

A set of 20 lentil accessions (P3211, IC560037, IC398019, P8110, L5126, IC278791, IC559845, IG129185, IG334, IC282863, IC201678, IC361417, IC559829, IC279627, IC201676, IC208327, EC78391, P8114, FLIP-96-51, JL3) was assessed for their yield and quality response to drought stress in field conditions during 2019-20 and 2020-21. To estimate the effect of stress, seed yield and test weight of different genotypes was recorded from control and drought stressed plants. Harvested seeds were also studied for morphometric traits, seed protein content and Fe, Zn, and phytic acid (Table 4.16).

Table 4.16: Summary Statistics for seed morphometric, quality and yield traits of lentil genotypes

	Trt.	Fe	Zn	PRT	PA	PA:Zn	DPPH	AREA	LEN	BRD	SY	TW
Mean	Control	52.79	50.63	23.26	8.50	0.17	6.81	9.69	3.79	3.22	5.17	2.57
	Drought	40.02	34.90	17.37	11.25	0.34	3.75	12.94	4.51	3.79	3.16	2.26
Max	Control	84.05	66.80	25.81	13.30	0.28	8.40	29.32	6.28	6.15	6.92	3.57
	Drought	52.65	49.60	22.50	13.90	0.66	5.60	18.37	6.88	4.55	4.34	3.37
Min	Control	31.30	36.60	17.84	5.10	0.08	4.20	6.37	3.15	2.58	3.13	2.21
	Drought	27.30	20.40	12.66	9.70	0.19	1.40	8.90	3.68	3.13	2.17	1.47
SD	Control	12.61	8.62	2.02	1.98	0.05	1.25	4.77	0.63	0.73	0.82	0.35
	Drought	6.74	8.98	2.26	1.36	0.12	0.87	2.61	0.68	0.42	0.52	0.36
CV (%)	Control	4.17	5.87	11.51	4.29	3.40	5.45	2.03	6.32	4.41	6.30	7.34
	Drought	5.93	3.89	7.67	8.27	2.83	4.31	4.96	6.63	9.02	6.07	6.28

Lentil genotypes were evaluated for 11 traits viz., Fe, Zn, PRT, PA, PA:Zn, DPPH, AREA, LEN, BRD, SY and TW under control and drought conditions. Highly significant variations were observed among the experimental genotypes for studied traits under both conditions. The descriptive statistics of the investigated traits is displayed in Table 4.16. The mean values of the traits Fe, Zn, PRT, DPPH, SY and TW were found to be significantly higher in control compared to drought conditions. However, traits like PA, PA:Zn, AREA, LEN and BRD showed significantly higher values under the drought condition. The coefficient of variation ranged from 2.03-11.51 and 2.86-9.02 in control and drought conditions respectively, which showed that there was a significant variability across the accessions in terms of the traits in consideration.

Mean: Average value, SD: standard deviation, Min: minimum value, Max: maximum value, Fe: Iron, Zn:Zinc, PRT:protein, PA: phytic acid, DPPH: Total antioxidant activity, AREA:area, LEN:length, BRD:breadth, SY:seed yield, TW:test weight, Trt.: treatment, C:control, D:drought.

4.3.7 Field validation of previously identified black gram lines for waterlogging tolerance

Waterlogging tolerant black gram lines (IC530491 and IC559933) identified during evaluation under controlled conditions were subjected to waterlogging stress under field conditions at IARI, New Delhi and IIPR, Kanpur during *Kharif* 2021. Both the lines were found tolerant to waterlogging stress imposed 30 days after sowing for 10 days (Fig 4.19).

Fig 4.19: Field validation of black gram lines (IC530491 and IC559933) for waterlogging tolerance

4.3.8 Screening of lentil lines for heavy metal toxicity

This study assessed the effect of Cd stress in two lentil (*Lens culinaris* Medik.) varieties differing in seed Fe concentration [L4717 (Fe-biofortified) and JL3] under controlled conditions. Six biochemical traits, five growth parameters, and Cd uptake were recorded at the seedling stage (21 days after sowing) in the studied genotypes grown under controlled conditions at two levels (100 µM and 200 µM) of cadmium chloride ($CdCl_2$). The studied traits revealed significant genotype, treatment, and genotype × treatment interactions. Cd-induced oxidative damage led to the accumulation of hydrogen peroxide (H_2O_2) and malondialdehyde in both genotypes. JL3 accumulated 77.1% more H_2O_2 and 75% more lipid peroxidation products than L4717 at the high Cd level. Antioxidant enzyme activities increased in response to Cd stress, with significant genotype, treatment, and genotype × treatment interactions ($p<0.01$). L4717 had remarkably higher catalase (40.5%), peroxidase (43.9%), superoxide dismutase (31.7%), and glutathione reductase (47.3%) activities than JL3 under high Cd conditions. In addition, L4717 sustained better growth in terms of fresh weight and dry weight than JL3 under stress. JL3 exhibited high Cd uptake (14.87 mg g^{-1} fresh weight) compared to L4717 (7.32 mg g^{-1} fresh weight). The study concluded that the Fe-biofortified lentil genotype L4717 exhibited Cd tolerance by inciting an efficient antioxidative response to Cd toxicity.

4.3.9 Evaluation of diverse panel of linseed germplasm under PEG mediated osmotic stress:

A diverse panel of 122 accessions of linseed germplasm accessions was screened under Polyethylene glycol 6000 (PEG 18%); water deficit at -0.407 Ys at 25°C external water potential) using hydroponics technique. The data was recorded for the study of germination parameters, biomass and root system architecture (RSA). Based on principal component analysis done on relative growth under stress and optimum conditions, a panel of selected most tolerant and sensitive accessions was identified for analysis of structural variants in the candidate genes associated with drought tolerance by allele mining. The accessions IC0096648, IC0096611, IC0096738, IC0525977, IC0385336, IC0498744, IC0499135, IC0002372, IC0499170, IC0498706 were selected as most tolerant and accessions IC0096490, IC0499061, IC0499027, IC0526030, IC623723, JLS-95 as most sensitive under PEG stress. Five accessions IC523799, IC0249015, IC0096587, EC0041481, IC0526017 were found tolerant, while one accession IC0054949 was sensitive after stress as well as a recovery period of seven days.

4.3.10 Screening of linseed germplasm for moisture stress tolerance:

The entire collection of linseed germplasm (2657 accessions) conserved at National Genebank was screened under rainfed conditions to identify germplasm accessions tolerant to moisture scarcity under DBT- Linseed Network Project (Fig 4.20). Promising accessions were identified for various traits such as Days to 50% flowering: IC0118906, IC0499042, EC0022866, IC0096648, IC0118906, IC0499042 (<55); Early Plant Vigour: IC0526017, IC0305055, IC0597275 (>0.50); Normalized difference vegetation index (NDVI): IC0118867, IC0096567, EC0001550-B, IC0096634, IC0525923, EC0006160 (>0.69); Chlorophyll content (mg/m^2): EC0001459, IC0498705, EC0001395, IC0498880 (>400).

4.4 Biochemical and phytochemical evaluation

4.4.1 A total of 3,231 germplasm accessions of different field crops were analyzed for various quality traits. These includes 453 accessions of Brown rice (protein, starch, amylase, fat, dietary fibre, total phenol and phytate content), 292 accessions of polished Rice (protein, starch, amylase, fat and total phenol), 192 accessions of maize (Protein, oil, sugar, phenol, antioxidant, and specific gravity), 133 accessions of wheat (protein content), 36 accessions of *T. sphaerococcum* (lysine content), 102 accessions of amaranth (oil and protein content), and 10 accessions each of *C. quinoa* and *C. album* for fatty acid profile; 1545 accessions of linseed (oil and protein) and 190 accessions of sesame (oil, protein and phytic acid), 101 accessions of niger (*Guizotica abyssinica* L.) (oil content); 120 accessions of cowpea (moisture, ash, protein, starch, sugar, dietary fibre,

Fig 4.20: Field view of screening of linseed germplasm under irrigated and rainfed conditions at NBPGR farm, New Delhi

phenol and phytate contents). The details of number of accessions analysed, range, mean and superior accessions are given in Table 4.17. Further, four *C. quinoa* accessions found superior for protein content were grown along with complete set i.e. 13 accessions in *Rabi* 2020-21 at ICAR-NBPGR farm, IARI, New Delhi and seed was harvested and validated for protein content. The protein content of these accessions followed the order EC507741 (16.08%), EC507744 (15.96%), IC411825 (15.93%) and EC507749 (15.20%).

4.4.2 Evaluation for vicine-convicine content in faba bean selections

Table 4.17 Variability parameters and superior accessions for biochemical traits

Crop (No. of Accs.)	Traits (unit)	Range	Average ± St. Dev.	Superior Accessions
		Cereals		
Brown rice (453)	Total Protein%	9.66-12.3	10.7 ±0.48	(>11%) 10092, 6777, 46, 4, 10423, 6807
	Total Starch %	71.3-76.8	73.8 ± 0.88	(<73%) RL-2753, 4019, 10092, 6777, 6807
	Amylose %	14.7-32.5	26.1 ±3.12	(>28%) RL-10595, 3966, 2813, 10595, 4222
	Total Oil %	2.92-6.56	4.58 ±0.99	(>6%) RL- 61, 62, 68, 69
	Total dietary %Fibre	4.21-5.32	4.72 ±0.23	(>5%) RL-46, 18, 5
	Total Phenols%	0.133-1.05	0.542 ±0.22	(>0.9%) RL- 225, 351, 10377
	Phytate%	0.07-0.234	0.134 ±0.34	(<0.1%) RL-9998, 10194, 351, 361
Polished Rice (292)	Amylose%	4.89-32.7	24.6±4.07	RL-7128, 7003, 7221,
	Total Starch%	72.9-83.7	75.8±1.04	RL- 7286, 7367, 7103
	Total Phenols%	0.01-0.90	0.55±0.57	RL- 7127, 7054
	Total Oil%	1.56-4.63	3.01±0.26	RL-7003, 7127
	Total Protein%	6.43-11.7	9.23±1.03	RL-7324, 7062, 7247
Maize (192)	Protein Content (%)	8.21-15.10	10.56±1.80	IC77463 (14.1), IC98131 (15), IC98133 (14.4) IC338450 (14.1), IC568238 (14.5), IC200226 (15.1), IC200232 (15.1)
	Oil Content (%)	3.23-6.4	5.11±1.02	IC77390 (6.4), IC77463(6.32), IC200171(6.01)
	Sugar (%)	1.07-1.94	1.15±0.43	IC326557 (1.94), IC97936(1.76), IC556396(1.79), IC281540(1.81)
	Specific gravity (g/cm3)	0.9-3	1.98±0.43	IC0625597(3), IC0625598(2.5), IC617877(2.5)
	Phenol (%)	0.001-0.040	0.01±0.36	IC0624913(0.027), IC338450(0.028), IC556406(0.031), IC130762(0.036), IC0624910(0.040)
	Antioxidant (% GAE)	0.03-0.25	0.11±0.058	IC469894(0.23), IC97918(0.24), IC411752(0.24), IC77089(0.25), IC538939(0.25)
Wheat (133)	Protein content (%)	7.98 to >14.00	12.12 + 1.93	IC128620, IC104538, IC279060, IC138595, IC28749, IC138600, IC28872, IC138435, IC252568, IC279878, IC28649, IC347884, IC584159 (>14 %)
T. sphaerococcum (36)	Lysine content (%)	0.04-0.29	0.15 ± 0.07	EC10492 (0.29%), EC187176 (0.28%) and EC182945 (0.26%)

Crop (No. of Accs.)	Traits (unit)	Range	Average ± St. Dev.	Superior Accessions
Pseudocereals				
Amaranth (102 accs.)	Oil Content (%)	7.23-9.40	8.43± 0.52	IC506514 (9.40), IC506605 (9.4), IC268885 (9.36), IC255428 (9.31), IC362257 (9.30), IC506611 (9.29), IC279567 (9.24), IC506535 (9.23) in comparison to Best check BGA-2 (8.94)
	Protein content (%)	10.77-15.32%	13.0 ±1.11	IC506545 (15.32), IC556604 (15.16), IC279631 (15.16), IC444188 (15.05), IC506612 (15.00), IC444099 (15.00) in comparison to best check BGA-2 (12.85)
C. quinoa (10 accessions)	Fatty acid profile	Palmitic Acid (8.62-12.76)	11.2 ±1.33	EC507744 (8.62), EC507742 (9.73)
		Stearic acid (0.99-2.44)	1.42 ± 0.43	
		Oleic acid (22.74-29.03)	25.01 ±1.84	EC507742 (29.03), EC507744 (27.36)
		Linoleic acid (52.08-56.73)	54.76 ±1.52	EC507738 (56.73), EC507741 (56.14), EC507748 (55.97)
		Linolenic acid (6.80-9.09)	7.59 ±0.72	
C. album (10 accessions)	Fatty acid profile	Palmitic Acid (11.95-15.59)	13.52 ±1.09	NIC22503 (11.95)
		Stearic acid (0.34-1.67)	1.18 ±0.35	
		Oleic acid (19.94-29.11)	23.71 ±3.63	IC341703 (29.11), IC109235 (29.10), IC108819 (27.18)
		Linoleic acid (49.19-61.03)	55.7 ±3.99	IC341705 (61.03), IC415405 (59.94), IC415477 (58.87)
		Linolenic acid (3.25-7.90)	5.88 ±1.38	
Oilseeds				
Linseed (1545 Accs.)	Oil Content (%)	30.14-50.9	41.78±3.21	IC0054952(50.90%), IC0525973(50.87%), IC0498740(50.39%), IC0096498(50.16%)
	Protein Content (%)	14.11-25.72	18.54±1.26	IC0498590 (25.72%), IC0096746 (24.89%), IC0096770 (24.78%) EC0041720 (23.86%), IC0499111(23.10%)
Sesame (190 accs.)	Oil Content (%)	33.20-54.79	48.97±5.05	IC204253 (52.07%), EC346597(50.12%), IC0145469(51.04%), EC346376(53.97%), EC346321(54.37%), EC346326(54.09%), EC347108(54.79%)
	Protein Content (%)	11.88-26.98	20.94±2.83	IC127354(26.79%), IC0500856(26.74%), EC346577(26.67%), EC358990(26.98)
	Phytic Acid	0.008-2.02)	1.03±0.63	EC370536, EC346213, EC370500, IC0511064, IC0511090
Niger (101 accessions)	Oil Content (%)	29.29 to 47.14	36.81 ± 1.94	IC564781 (47.14)

Crop (No. of Accs.)	Traits (unit)	Range	Average ± St. Dev.	Superior Accessions
Pulses				
Cowpea (120)	Moisture%	9.1 – 12.2	10.0 ± 0.76	
	Ash%	1.2-4.2	3.5 ± 0.44	
	Protein%	19.4-27.9	24.1 ± 1.49	EC 390248, IC214752, EC 390263 >26%
	Starch%	24-40.2	32.7 ± 3.21	EC724321, EC724681, EC149314 >40% IC214751, IC214752, IC202813 <25%
	Sugar%	1.29-9.17	5.48 ± 1.51	EC240665, EC101913 >9% EC724385 <2%
	D fiber%	13.3 – 21.1	17.2 ± 1.72	EC244138, EC101970, EC257453 >20%
	Phenol%	0.078-0.831	0.26 ± 0.139	EC723744, EC109112 >0.8% EC240908, EC101987, EC724556 <0.08
	Phytate%	0.434 – 1.62	1.12 ± 0.22	EC390278 EC723824 <0.5%

Phenotypic marker i.e. white flower colour assisted selections were made in the nurseries received from ICARDA to select low anti-nutritional (vicine-convicine) content genotypes and the seeds were subjected to biochemical analysis. Twenty-four single plant selections were effected and progenies were raised in the net house for multiplication and to avoid cross-pollination. The vicine-convicine content ranged from 0.26 to 0.50%as against 0.60% in check (Table 4.18). These progenies will be raised again in the field during next crop season for confirmation of the results.

Table 4.18 : Vicine-convicine content in the selected progenies

S. No.	Nursery	ET No.	Vicine-Convicine (%)
1	FBIF5N	ET226534	0.38
2	FBIHTN	ET226412-1	0.39
3	Rebaya 40	ET226483	0.36
4	FBIF4-SAEA	ET226558	0.42
5	FBIF4-SAEA	ET226559-1	0.35
6	FBICSN	ET226466	0.31
7	FBIF4-SAEA	ET226569	0.47
8	FBIF4-SAEA	ET226560-1	0.31
9	FBIABN	ET226489-1	0.42
10	FBICSN	ET226462-1	0.35
11	FBIABN	ET226498	0.35
12	FBIF5N	ET226509	0.37
13	FBICSN	ET226468	0.41
14	FBIF4-SAEA	ET226557	0.36
15	FBIF5N	ET226520	0.38
16	FBIF4-SAEA	ET226574	0.26
17	FBIHTN	ET226408	0.39
18	FBIHTN	ET226412-2	0.30
19	FBIF4-SAEA	ET226559-2	0.33
20	FBIF4-SAEA	ET226560-2	0.32
21	FBICSN	ET226462-2	0.28
22	FBIF5NIB	ET226546	0.50
23	Check	Vikrant	0.57
24	Check	HFB-1	0.60

4.4.3 Comparison of kalingda seeds and cashew nuts quality characteristics

Three samples each of kalingda seeds and cashew nuts were analysed and compared for quality characteristics. Kalingda seed samples had higher average protein content (27.77%) than cashew nuts (18.55%). Similarly, average higher oil content i.e. 58.88% was obtained in kalingda seeds in comparison to cashew nuts (54.13%). In case of fatty acids, Kalingda seeds had higher average saturated fat content (29.41 %) in comparison to cashew nuts (21.64%). Kalingda seeds also had higher average PUFA content (56.57%) while cashew nuts had higher content of MUFA (average value 62.78%). Essential minerals viz. Fe and Zn content were also estimated in these samples. Both, average iron as well as Zn contents were higher in Cashew nut samples (5.65 and 3.28 mg/100g) in comparison to kalingda seeds (3.12 and 2.46 mg/100g).

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

To study the effect of different nitrogen treatments on protein content of these four *C. quinoa* accessions *viz.* IC411825, EC507741, EC507744 and EC507749, a separate trial was conducted 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 seeds were harvested for protein analysis.

4.4.5 NIRS prediction models validation statistics for nutritional traits in cowpea

NIRS prediction models for various nutritional traits in cowpea and wheat were validated. Crop-wise traits and the validation statistics are given in the Tables 4.19 and 4.20.

4.4.6 Phytochemical Evaluation of Medicinal and Aromatic Plants

Table 4.19: NIRS prediction models validation statistics for nutritional traits in cowpea

Trait	SEP	SD	RPD	RSQ	Validation range
Protein %	0.610	2.41	3.04	0.882	20.0-27.8
Dietary fiber %	0.467	1.499	3.18	0.901	12.2 -22.4
Starch %	0.188	2.812	14.95	0.996	26.7-38.7
Phenols %	0.06	0.111	1.85	0.717	0.026-.496
Phytate %	0.034	0.147	4.32	0.955	0.583-1.62

Table 4.20: NIRS prediction models validation statistics for nutritional traits in wheat

Trait	SEP	SD	RPD	RSQ	Validation range
Protein%	0.624	1.85	2.98	0.886	8.71-20.7
Starch%	3.123	5.223	1.67	0.668	54.4-77.8
Sugar%	0.356	0.882	2.48	0.835	0.509-4.03
Phytate%	0.047	0.092	1.96	0.748	0.398-0.908

Quality evaluation of 120 accessions of medicinal and aromatic plants germplasm of *Bacopa monierri* (Brahmi), *Fagopyrum* species (Buckwheat), *Zingiber zerumbet* (Wild ginger), *Abelmoschus moschatus* (Muskdana, ambrette), *Costus speciosus* (crepe ginger or spiral ginger), and *Hedychium* species was performed during this period and the range and superior accessions are given in Table 4.21.

4.4.7 Essential Oil Profiling of Rhizomatous Plant of Zingiberaceae Family

Rhizomes of three *Hedychium* species (*H. flavescens, H. coronarium, H. coccineum*) and *Zingiber zerumbet* of Zingiberaceae family collected from Eastern parts of India were analyzed for essential oil content and oil composition by GC-FID and GC-MS and details are presented in Table 4.22.

4.5 Interspecific hybridization for genetic base enhancement

4.5.1 Wide hybridization in *Brassica*

Generation advancement was done for the F_1 interspecific hybrids obtained by crossing between previously identified rust resistant accession of *Brassica carrinata* (BBCC) (IC 555891) and one of the *Brassica napus* (AACC) variety GSL1 to generate interspecific genetic variability. The hybrids were rust resistant under field conditions and showed

Table 4.21 Phytochemical Evaluation parameters in selected Medicinal and Aromatic Plants

Crop (No. of accs.)	Plant part analysed	Traits	Range (units)	Superior/Promising accessions
Chemical evaluation				
Bacopa monnieri (30 accs.) from twelve different Indian states	dry herb	total extractive yield	27.41 – 31.39 %	-
		total phenol content	13.13 – 27.19 mg GAE/g	-
		total flavonoid content	14.28 – 47.84 mg QE/g	-
		tannic acid	3.19-5.73%	-
		bacoside content	1.02 – 3.59%	IC554588, IC554586, IC353204 and IC342108 Validation: IC554586 (3.59%) and IC554588 (3.36%) were validated for high bacoside (> 3%) in dry herb consequently from last two years.
Quality evaluation				
F. tataricum (48) from six different Himalayan states of India along with exotic collections	seeds	total phenols	16.26 – 29.24 mg/g GAE	-
		total flavonoids	15.89 – 49.21 mg/g QE	-
		fixed oil	1.82 – 3.52%	-
		rutin	1.29 – 3.28%	IC258233, EC9879, IC49668, IC204084 and IC46160 (> 3%)

Table 4.22 Chemical Composition of Aromatic Plants of Zingiberaceae Family

Plant Name (Common Name)	Essential Oil (%) (DWB)	Refractive Index of oil	Major Aromatic Compounds Identified
Hedychium flavescens (Yellow Ginger lily)	0.87 ± 0.14%	1.478	Linalool (25.76%), β-pinene (19.29%), *p*-cymene (12.52%), 1,8-Cineole (10.75%), α-pinene (7.02%)
Hedychium coronarium (White Ginger Lily)	0.71 ± 0.07%	1.372	1,8-Cineole (47.73%), β-pinene (20.83%), terpinene -4-ol (5.09%), α-terpineol (8.38%)
Hedychium coccineum (Orange Ginger Lily)	0.89 ± 0.03%	1.378	(*E*)-Nerolidol (40.20%), Caryophyllene Oxide (24.76%)
Zingiber zerumbet (Wild/Shampoo Ginger)	1.27 ± 0.57%	1.464	Zerumbone (70.60%), α-Humulene (5.65%), Humulene epoxide I (5.22%), Humulene epoxide II (5.71%), Camphor (1.90%), Camphene(3.47%), Caryophyllene oxide (2.52%)

morphological characters that were intermediate between the two parents. The F_1 hybrid also showed partial sterility. The selfed seeds did not produce any seeds. Thus, seeds obtained by natural crossing from the F_1 plants were harvested and sowed for generation of F_2 population. Large variability was obtained for plant morphotypes, maturity duration, leaf shape and leaf waxiness, plant height (Fig 4.21&4.22). The height for plants in this population ranged from 60cm to 260cm. Most of the plants also showed partial sterility to complete fertility in terms of siliqua formation. A few plants were completely free from occurrence of rust infestation. Progeny from such plants may further be investigated for identification of rust resistance genetic resources created through wide hybridization between these two species.

4.5.2 Population development for rust and *Sclerotinia* rot resistance in identified potential genotypes:

Crosses were attempted for the development of population in potential rust resistant/tolerant accessions. Some of the accessions were also found tolerant to *Sclerotinia* rot when artificially inoculated in the field. Such accessions could be potential donor for simultaneous resistance against rust and *Sclerotinia* rot. The Number of flowers attempted in each combination are presented in Table 4.23.

4.5.3 Generation advancement of interspecific hybrids in *Linum*

Interspecific hybridization with wild linseed species viz., *L. grandiflorum* and *L. bienne* was attempted. Embryo rescue was done at different days after pollination for *L. grandiflorum*. Interspecific hybrid between *Linum usitatissimum* and its wild relative *Linum bienne* could successfully be grown in the field conditions. Three wild accessions of *Linum bienne* viz., EC993387, EC993389 and EC993391

Fig 4.21 : Variation in A) siliqua; B) Inflorescence type of F_2 population of interspecific hybrid; C & D) Range of variation in plant height (small to tall plants)

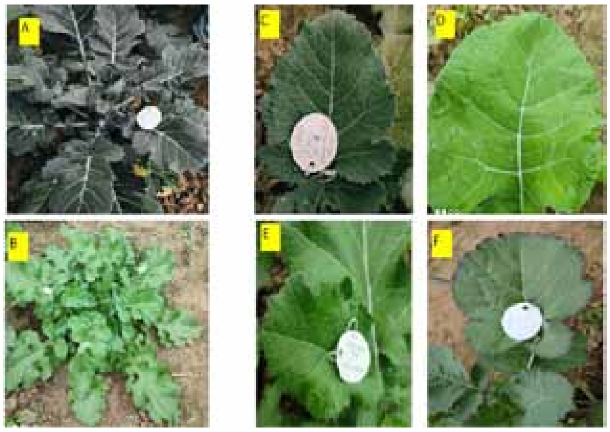


Fig 4.22: Variation in A &B) Leaf color and waxiness; C,D, E&F) Leaf color, leaf serration, presence of spines and pigmentation on F_2 population of interspecific hybrid

Table 4.23: Number of flowers attempted in each combination for *Sclerotina* rot/ Rust resistance accessions

Number of crosses attempted in each combination						
S. No.	Resistant Accessions	Pusa jai kisan	Pusa vijay	RLM 198	*Sclerotina* resistance	Rust resistance
1	IC20167	-	24	62	P	P
2	EC766313	-	39	34	P	P
3	IC546947	23	-	57	-	P
4	EC766402	-	56	38	P	P
5	EC766144	-	25	-	P	P
6	EC766191	39	34	-	P	P
7	EC76134	90	47	-	-	P
8	IC697932	19	-	52	-	P
9	IC766315	42	-	35	-	P
10	EC766148	50	38	-	-	P
11	EC766192	-	-	-	-	P
12	EC766193	27	64	-	-	P
13	IC265495	-	-	93	-	P

*P indicates the presence/occurrence of resistance/tolerance against particular disease were used in making interspecific hybrids in both ways. Since these *Linum bienne* accessions are having high number of branches, they may be used as donor parents for increasing the fibre yield in flax improvement programmes. Further, the F_1 and F_2 generations that were produced in the preceding year were advanced to next generation (Table 4.24) with the objective of creation of new variability by utilizing wild progenitor as one of their parents.

Table 4.24: Pedigree description (*L. usitatissimum* X x *L. bienne*)

Generation	Pedigree description (*L. usitatissimum* x *L. bienne*)
F_1 generation	T397 X EC993387 and its reciprocal
	T397 X EC993389 and its reciprocal
	T397 X EC993391 and its reciprocal
F_2 generation	T397 X EC993389
	T397 X EC993391

4.5.4 Pre-breeding and genetic enhancement of Chilli

Interspecific crosses involving different *Capsicum* species such as *C. annuum, C. frutescens, C. baccatum, C. baccatum var. pendulum, C. chinense, C. chacoense*, and *C. tovari* were generated to develop pre-breeding and trait specific genetic materials. Interspecific F1 cross combination between *C. chinense x C. annuum, C. tovari x C. annuum, C. frutescens x C. chinense, C. frutescens x C. tovari, C. tovari x Chinense and C. chacoense x C. baccatum var. pendulum* were found promising combinations with desirable erect plant type profuse branching, small size green and highly pungent fruits and resistance to ChiLCD, mites and thrips (Fig 4.23). Amongst interspecific cross combinations, *C. tovari x Chinense* was found earliest to mature. F2 seed of all interspecific crosses was harvested for identification of desirable and trait specific genetic materials in F2 population.

4.5.5 Pre-breeding and genetic enhancement in brinjal

The F_2 Populations of four crosses namely Pusa Shyamla x IC253952, Pusa Shyamla x IC539855, PPL x IC253952 and PPL x IC539855 were grown and the infestation % in the fruit and shoot borer. Based on the infestation, the immune (0% infestation) plants from each crosses were selected and selfed. The details of the infestation range, Mean of F2 population of cross combinations are given in Table 4.25.

Fig 4.23: High yielding and ChiLCD resistant F1 hybrids a) Pusa Jwala x IC570408 b) *C. Chinense* x *C. annuum*

Table 4.25: Infestation (%) range, Mean of F_2 population of cross combinations

Crosses (F_2)	Plants	Infestation (%) Range	Infestation (%) Mean
Pusa Shyamla x IC253952	109	0.0-66.7	Immune (33), Resistant (68), Moderately Resistant (7), Susceptible (0) Highly Susceptible (1)
Pusa Shyamla x IC539855	101	0.0-40.0	Immune (55), Resistant (42), Moderately Resistant (3), Susceptible (1) Highly Susceptible (0)
PPL x IC253952	101	0.0-30.0	Immune (50), Resistant (42), Moderately Resistant (9), Susceptible (0) Highly Susceptible (0)
PPL x IC539855	101	0.0-40.0	Immune (55), Resistant (42), Moderately Resistant (3), Susceptible (1) Highly Susceptible (0)

4.6 Achievements under CRP-Agrobiodiversity

4.6.1 Evaluation of wheat germplasm

A total of 324 wheat accessions were evaluated during *Rabi* 2020-21 for biotic stress traits, yellow rust, brown rust and Karnal bunt (PAU, Ludhiana), powdery mildew (IARI, RS, Wellington), loose smut (VPKAS, Almora), salinity tolerance (CSSRI, Karnal). Also, promising accessions over the locations and years were validated for respective traits.

Biochemical analysis of grain samples (338 acc.) from NBPGR, Delhi was carried out at IIWBR, Karnal for protein content and sedimentation value. Identified promising accessions are given in following table.

4.6.2 Validation of okra germplasm

Out of 85 accessions of *A. moschatus ssp. moschatus* screened for OYVMD & OELCD in *Kharif* 2021, 4 accessions namely EC360830, EC360586, EC360794 and EC361171 were found highly resistant to OYVMD and resistant to OELCD. The validation of 60 accessions comprising 19 accessions at 2nd year and 41 accessions at 1st year validation were grown in Randomized Block Design in *Kharif*-2021 at NBPGR, New Delhi for resistance to Okra Yellow Vein Mosaic Disease (OYVMD). Fourteen out of 19 accessions and 22 out of 41

Table 4.26. Promising wheat accessions identified for multiple traits under CRP-AB

Traits	Locations	Promising accessions
Karnal bunt	PAU, Ludhiana IIWBR, Karrnal	IC0313159, IC0382720, IC0582720, IC0582725, IC329348 (based on 2018-19 and 2019-20, 2020-21)
Powdery Mildew	IARI-RS, Wellington & CSKHPKV, Palampur	IC0589292, EC217803, IC0362113, IC539162, IC542112, IC547647 IC547642 (Validated for stem rust, leaf rust and powdery mildew) IC0406702, EC187159, IC0279880 (Resistance to powdery mildew at seedling as well as adult stage and against yellow rust)
Loose smut	VPKAS, Almora	Confirmed Sources (IC0591044, EC 0597830, EC0597886, EC0635739, IC078836-A, IC0595233, IC0538731, EC 0635708, EC0597885, IC0599914, IC 0591045, IC0339627, EC575981, IC449061, IC535217, EC576159, EC573974, IC252954, EC577050, IC531524)
Spot blotch	BHU, Varanasi	Validated entries (Three years) EC577693, IC0397821, IC0279885, IC0328890, IC0322032, IC0381168, EC0675842, EC0529888, IC529943, IC529373, EC575732 were found highly resistant (11 acc., DD Score at 3 stages <13)
Salinity tolerance	CSSRI, Karnal	IC0262780, EC0603237, EC0530190, EC0595296, EC0582389, EC0529967 and EC0530163 Validated entries (Four years): EC-11071, IC-598581, IC-596504, IC-445343
Quality traits Protein content > 15% and hectolitre weight >75 ml	IIWBR, Karnal	IC252459, IC415887, IC470825, IC539166, IC574482, EC276687, EC276695, EC178071-339, EC577693, EC530037, IC128381, IC128383, IC277738, IC277739, IC617424, IC138446 Validated entries (Five years): EC405359, EC217843, IC547637, IC296727 (Protein content > 15% and hectolitre weight >70 ml)

Years	Accs	Disease Reaction (OYVMD)	Promising Accessions For OYVMD
2021-22	41 (1st Year)	Highly resistant: 22 accs Resistant: 8 accs Moderately resistant: 7 accs Moderately susceptible: 3 accs	Highly resistant (22 accs): EC169309, EC169461, EC280751, EC284324, EC762071, EC762072, EC773522, EC777156, EC777159, IC043369, IC089726, IC094848, IC099745, IC111244, IC116989, IC257217, IC264834, IC325745, IC343414, IC347819, IC372198, IC602400 Resistant (8 accs): EC937359, IC013893, IC042484-SP, IC169410, IC268365, IC278934, IC305620, IC383132
2021-22	19 (2nd Year)	Highly resistant: 14 accs Resistant: 3 accs Moderately resistant: 1 accs Moderately susceptible: 1 accs	Highly resistant (14 accs): IC598240, IC598457, IC598737, IC598738, IC598747, IC620568, IC620570, IC620571, IC620573, IC620574, IC620575, IC622454, JBS/17-87-A, JBS/17-88 Resistant (3 accs): IC598739, IC600578, IC611595

IC620571 IC622454

Fig 4.24: Highly resistant okra accessions for OYVMD and OELCD.

accessions were found highly resistant against OYVMD.

At BCKV, Kalyani, three accessions namely IC598240, IC620573 and IC620574 showed resistance (PDI <10%) to YMVD whereas susceptible check Pusa Sawani showed PDI>80% whereas at AAU, Anand 5 accessions namely IC620570 (0%), IC620571 (5%), IC620568 (10%), IC620573 (10%) and IC621452 (10%) showed 0-10% PDI values whereas susceptible check Pusa Sawani showed PDI>90% (Fig 4.24).

At PAU, seventy accessions of *Abelmoschus moschatus*, one each of *A. angulosus* and *A. manihot* subsp. *manihot* and three varieties of cultivated okra species were screened against OYVMD during rainy season of 2021-2022. Fifteen accessions of *Abelmoschus moschatus* namely EC316073, EC329390, EC359878, EC360332, EC360377, EC360484, EC360787, EC360819, EC360913, EC360949, EC360964, EC361007, EC361014, EC361284, IC141068 and *A. agulosus* were found resistant to OYVMD disease. Interspecitic crosses were made between cultivated okra variety Punjab Padmini (susceptible to YVMV disease) and wild species namely, *Abelmoschus angulosus*, *Abelmoschus manihot* subsp *manihot* and 15 accessions of *Abelmoschus moschatus*. Only very few F_1 seeds were harvested from the four crosses namely (1) Punjab Padmini X A. manihot subsp. manihot, (2) PP X *A. angulosus*, (3) PP X *A. moschatus* acc. EC316073 and PP X *A. moschatus* acc. EC329390.

At IIVR, Varanasi out of 88 *A moschatus* ssp *moschatus* accessions 79 accessions identified as highly resistant against OYVMD and OELCD diseases under field condition. To confirm the resistance and to eliminate the symptomless carrier, sample of 4 accessions namely, IC333272, IC141055, EC359836 and EC361022 of *A moschatus* ssp *moschatus***,** along with susceptible check sample were screened using begomovirus specific primers for OYVMD and OELCD. There was no amplification reported in all the 4 accessions from the sample which showed resistance against OYVMD and OELCD under field condition and negate the possibility of symptomless carrier.

Interspectic crosses were made with *A esculentus* (Pusa Sawani and VRO-6) and *A moschatus* ssp *moschatus* accession IC333272, *A angulosus* (RCM/PK-65) and *A manihot* ssp *manihot* (VRmanihot-1) in all combinations. Seed set was served when Pusa Sawani and VRO-6 was used as female parents.

New Initiatives

Chip-based technology for real-time and RFID-passive monitoring of tree germplasm in field genebanks

Germplasm of woody perennials are maintained in NAG sites at various locations of the country. These trees are manually labeled. However, tree germplasm labelling has been one of the greatest challenges for any field worker in breeding, maintenance, and evaluation of woody plants. Long life cycle or gestation period makes the problem all the more difficult as the plastic lables or paints disintegrate or become illegible over time. The GPS geo-tagged trees are often difficult to judge if the tree in a place is the original one or a replacement. In the process, many a times the individual trees get wrongly labelled if any accessions are missing in between. This causes a setback to the conservation efforts. Therefore, a new initiative (Pilot study) was taken up in collaboration with ICRAF, IIHR and CAFRI to use Internet of Thing (IoT) based centralized remote monitoring system coupled with real-time sensor and RFID tagging technology for precisely labelling and tagging the tree germplasm in the field genebanks. The system uses web interface and mobile app to track tree status (Fig 4.25). The pilot testing of RFID and Real time sensors is now being tested and validated in the field. Eighty trees covering 6 species (*Ziziphus mauritiana*, *Aegle marmelos*, *Phylanthus emblica*, *Moringa oleifera*, *Morus sp*, *Cordia myxa*) have been tagged with 80 microchip tags. The real time sensors are giving daily check report on the health of the trees. The technology holds promise for maintenance, digitization of the gene bank and securing them from any kind of loss.

2) Establishment of field genebank of tree genetic resources

An attempt was made to establish a field genebank in a 30 acre plot in B-Block of Issapur farm. It included enrichment and augmentation of some of the already established species and plantation of new species of the semi-arid region. Fifty two (52) multi-purpose tree species such as *Salvadora persica, Madhuca latifolia, Oroxylum indicum, Punica granatum, Santalum albubum,* *Sapindus mukorossi, Saraca asoca, Syzygium jambos, Terminalia balerica, Terminalia chebula, Trewia nudiflora, Boehmeria rugulosa, Bosellia serrate, Cinnamomum tamala, Citrus maxima, Comiphera mukul, Dalbergia latifolia, Hardwikia binate, Holarrhena antidysenterica, Litsia glutinosa,*

Fixing of RFID tags in *Moringa oleifera*

Tag on the Tree Trunk

Scanner to record data

Fig 4.25: RFID tagging of tree germplasm at Issapur farm, New Delhi

Acacia catechu etc were established in one block. In another block germplasm of 9 species of Morus were established in July 2021 (Fig 4.26&27). Some of them were requisitioned from CSGCRC, Hossur and TCCU of NBPGR. In case of Morus species, 3 replications per accession were planted in the field.

Germplasm supply and seed multiplication

Seed supply

- A total 3738 accessions of pulse germplasm including chickpea, mungbean, urdbean and ricebean supplied to 27 indentors.
- During the period, 778 germplasm accessions of barley and 83 accessions of linseed were supplied to the indenters during the year.

Fig 4.26: Establishment of *Morus* germplasm in field no 23 of B-Block at Issapur

Fig 4.27: Field preparation and plantation of MPTs in Field no 27

- 385 accessions of Brassica germplasm and 310 accessions of sesame were supplied to indenters.
- A total of 275 accessions of wheat accessions were supplied to 4 indenters. In addition, 1005 accessions were sent for evaluation of wheat germplasm under CRP on Agro-biodiversity PGR management-component II.
- Supplied 19 promising accessions of okra germplasm each for multi-location evaluation for okra yellow vein mosaic disease to BCKV, Kalyani and AAU, Anand under CRP-AB.
- A total of 311 samples comprising 281 sample of brinjal germplasm and 30 samples of okra *Abelmoschus moschatus* were supplied to 10 indenters.

Seed multiplication

- A total of 678 accessions of barley germplasm and 2657 accessions of linseed were multiplied and conserved in medium term storage. A total of 210 accessions of tomato germplasm were multiplied.

Seed Deposition at NGB

- A total 298 accessions comprising linseed (180 accessions), tomato (101 accessions) and brinjal (17 accessions) including 8 accessions from Tripura were deposited in NGB.

Germplasm augmentation

Augmentation of linseed wild species and germplasm from diversity rich areas in India. Successful exploration was undertaken for the collection of *Linum mysorense* from Ratnagiri, Kolhapur and Sindhudurg (Western ghats) of Maharashtra) (Fig 4.28). It was found as a small herbaceous plant growing in the scattered patches on rocky and grassy lands, with very short stature and small yellow flowers. The plants of *L. mysorense* that were found at lower plateaus had shorter stature (5cm to 17cm height) than the ones (30-35 cm height) found at higher plateau. This is worth mentioning that the occurrence of this wild linseed was noted to be quite rare and scarce and construction of buildings for development of tourist areas were found to be destroying its habitat. This is a great matter of concern for the conservation of such rare and indigenous wild relative of flax. Apart from this 3 accessions of *L. perenne* (Indigenous) obtained from NGB and four cultivated flax accessions explored from Bihar and adjoining areas were also multiplied.

A total of 113 wild accessions belonging to 19 different species of wild linseed were introduce from USDA, ARS, United States of America and Iowa State University Regional Plant Introduction Station (Fig 4.29). These include *L. catharticum* (3), *L. flavum*

Fig 4.28: Collection of *L. mysorense* from western ghats from rocky elevations and grassy-lands

(7), *L. austriacum* (16), *L. perenne* (11), *L. hirsutum* (8), *L. bienne* (12), *L. lewisii* (33), *L. tenuifolium* (3), *L. strictum* (2), *L. pallescens* (1), *L. corymbiferum* (1), *L. marginale* (2), *L. grandiflorum* (1), *L .campanulatum* (1), *L. aristatum* (5), *L. hudsonioides* (2), *L. altaicum* (2), *L. maritimum* (1), *L. sulcatum* (1). Out of these 19 wild species (Fig 2), 10 species could produce seeds. Also, 123 *L. usitatissimum* accessions were successfully introduced from Plant Genetic Resources, Canada. Among the wild *Linum* germplasm, *Linum hudsoniodes* was found a potential source for lowering down the ALA content in flax in which ALA content ranged from 2.16 to 3.05% only.

Establishment of Spine gourd at New Delhi

Spine gourd is a nutritious cucurbitaceous vegetable having medicinal properties. Its propagation through seeds is not desirable due to very low germination and segregation resulting in reduced fruit yield. Therefore, experiments were conducted to standardise the mass multiplication through tissue culture. Accordingly, tubers of twelve genotypes were procured from RMD College of Agriculture and Research Station, IGKV, Ambikapur, Chhattisgarh and SDAU, SK Nagar, Gujarat. These tubers were planted in the earthen pots in net house. The sprouts were used as explants to standardise the tissue culture protocols for rapid multiplication of disease free planting material.

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. Rooting of the multiplied shoots was optimum on half-strength MS medium containing 4.9µM indole-3-butyric acid (IBA); (Fig 4.30).

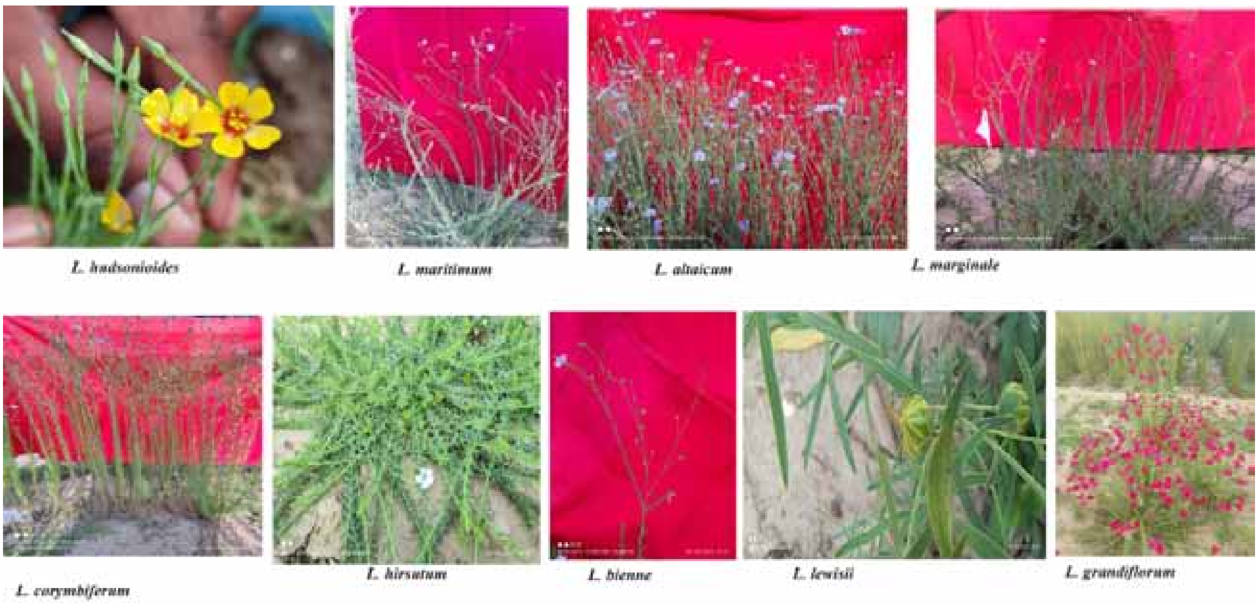


Fig 4.29: Multiplicatron of different wild species of *Linum*

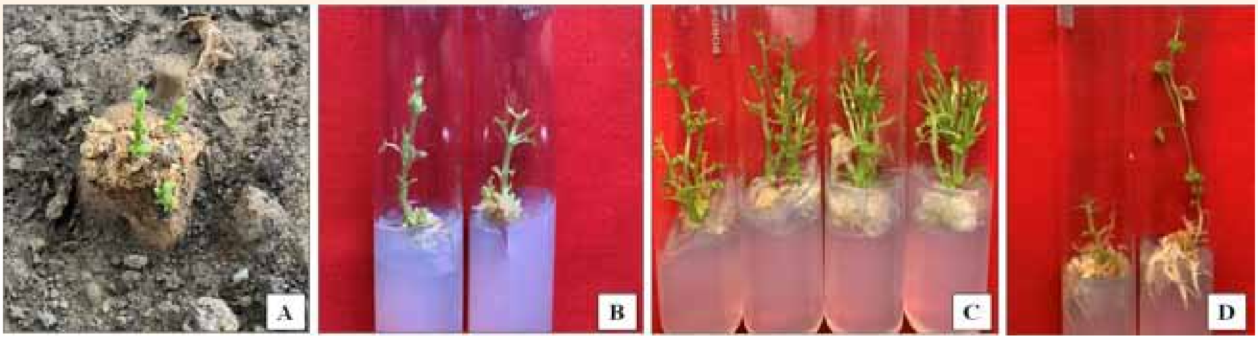


Fig 4.30: *In vitro* propagation of spine gourd (*M. dioica*) **A.** Apical shoots emerging from the tubers used as explants; **B.** *In vitro* shoot induction; **C.** *In vitro* multiplication of shoots; D. Rooting induced in the multiplied shoots.

List of Institute Programme and Projects (Institute Research Projects (Title, PI, Co-PIs and Associates)

ProgrammePGR/DGE-BUR-DEL01.00: Characterization, evaluation and documentation of genetic resources of agri-horticultural crops (Ashok Kumar)

Research Programme (Programme Code: Title, Leader)

PGR/DGE-BUR-DEL-01.01: Characterization, evaluation and documentation of wheat, barley and triticale germplasm

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

Jyoti Kumari, Sandeep Kumar, Sundeep Kumar, Vikender Kaur, Ruchi Bansal, SK Kaushik and Pardeep Kumar and *YS Rathi*

PGR/DGE-BUR-DEL-01.02: Characterization, evaluation and documentation of maize germplasm **Ashok Kumar**, Jyoti Kumari, Vinay Mahajan, Ishwar Singh, K S Hooda and *RK Sharma*

PGR/DGE-BUR-DEL-01.03: Characterization, evaluation and documentation of pulses germplasm **Gayacharan**, Kuldeep Tirpathi, Rakesh Bhardwaj, Ruchi Bansal, Z Khan, Jameel Akhtar, T Boopathi, Nand Lal Meena, Soma Marla, Mamta Singh and *Babu Ram*

PGR/DGE-BUR-DEL-01.04 : Characterization, evaluation and documentation of oil seeds germplasm **Rashmi Yadav**, Sandeep Kumar, RK Gautam, Vijay Singh Meena, Vikender Kaur, Mamta Singh, Jameel Akhtar, Sapna and *BL Meena*

PGR/DGE-BUR-DEL-01.05: Characterization, evaluation and documentation of vegetable, fruits and ornamental crops germplasm **KK Gangopadhyay,** Rakesh Srivastava, Vinod Kumar, SK Yadav, Pragya, Vijay Singh Meena, Raj Kiran, T Boopathi, Bharat Gawade, Nand Lal Meena and Pooja Kumari

PGR/DGE-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/DGE-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 (w.e.f. 05.08.2020) and *BS Panwar*

PGR/DGE-BUR-DEL-01.08: Evaluation for abiotic stress tolerance in field crops germplasm **Ruchi Bansal,** Vikender Kaur, Rashmi Yadav, Jyoti Kumari, Gayacharan, Kuldeep Tripathi, MC Yadav, Mamta Singh and Nand Lal Meena

PGR/DGE-BUR-DEL-01.09: Characterization of wild species and pre-breeding in selected crops **Vinod Kumar,** KK Gangopadhyay, Gayacharan, Kuldeep Tripathi, Mohar Singh, KS Hooda, MK Rana, M Latha, and R Gowthami, Celia Chalam (w.e.f. 08.08.2020) and Era V Malhotra (w.e.f. 08.08.2020)

PGR/DGE-BUR-DEL-01.10 : Characterization, evaluation and documentation of potential crops germplasm **SK Kaushik**, KK Gangopadhyay, Vinay Mahajan, SK Yadav, Hanuman Lal, Archana P. Raina, Rakesh Srivastava and Ishwar Singh

PGR/DGE-BUR-DEL-01.11: Application of statistical techniques in management of information on plant genetic resources HL Raiger

DBT: Minor Oilseeds of Indian Origin: Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Rashmi Yadav, SC Dubey, Celia Chalam, R Parimalan, Kartar Singh, Sapna, Sunil Gomase, K. Pradheep

DBT: Minor Oilseeds of Indian Origin: Leveraging genetic resources for accelerated genetic improvement of linseed using comprehensive genomics and phenotyping approaches Vikender Kaur, DP Wankhede, Sapna, Kavita Gupta, Mamta Singh

DBT: Characterization of Chickpea Germplasm Resource to Accelerate Genomics-assisted Crop Improvement Gayacharan, Z Khan, Neeta Singh, Mohar Singh, S Rajkumar, Amit Singh, Ruchi Bansal

Kuldeep Tripathi Vinod K Sharma

DBT: Characterization of Chickpea Germplasm Resource to Accelerate Genomics-assisted Crop Improvement Gayacharan, Z Khan, Neeta Singh, Mohar Singh, S Rajkumar, Amit Singh, Ruchi Bansal Kuldeep Tripathi

ICARDA: Discovery of Trait-Specific Germplasm to Address the Current and Future Needs of Indian Lentil Breeding Programs Kuldeep Tripathi, Rakesh Bhardwaj and Amit Singh

PPVFRA: DUS test of fababean S K Kaushik and S B Chaudhary

Alliance of Bioversity-CIAT: Mainstreaming underutilized multipurpose tree species and fodder crops in semi-arid region of India K P Mohapatra

CIFOR-ICRAF: Pilot the solutions of chip-based technology for real time and RFID passive monitoring of field genebank and agroforestry species for scaling up K P Mohapatra

DST, GoI: National Mission for Sustaining the Himalayan Ecosystem: Agriculture K P Mohapatra

Alliance of Bioversity-CIAT: Pre-breeding for genetic enhancement of chilli, beans & peas using crop wild relatives

DIVISION OF GENOMIC RESOURCES 5

Summary: DNA fingerprinting service was provided for one hundred and six (106) samples of 19 agri-horticultural crops. Novel genomic resources were developed in crops such as browntop millet, sesamum etc. Genetic diversity studies were undertaken in crops such as sesamum, browntop millet, little millet, in a finger millet using SSR markers. A total of 57 little top millet accessions were purified and also characterized for agro-morphological traits. In order to accelerate genomic studies in Amaranth, a SNP genotyping chip containing approximately 67k SNP markers was developed and tested in 192 accessions of grain amaranth. Moreover, a Genomic Resources Database of Amaranth has also been developed that contains information on SNPs, SSRs, transcription factors, transporters, microRNA and genes annotated from the publicly available resources. The chloroplast genomes of three species namely *Piper nigrum*, *Sesamum indicum* (cv. Swetha) and *S. indicum* subsp. *malabaricum* have been assembled. The transcriptomic studies of leaf and non-foliar photosynthetic tissues in wheat and rice have led to a model supporting evolution of the weak C_4 pathway in the BOP clade of Poaceae family, prior to the strong C_4 photosynthesis pathway in the PACMAD clade. Transcriptomic analysis of wheat genotype KRL3-4 identified key genes and pathways associated with sodicity stress tolerance. Cytological and DNA barcoding studies of *Allium* accessions have provid edevidence for a morphologically distinct unknown *Allium* taxon, closely related to *A. przewalskianum*.Cross-species transferability of SSR markers was analysed in wild relatives of safflower. Scanning electron microscopy (SEM) images of the starch granules in wheat genotypes having variable levels of susceptibility to heat stress were developed that could shed some light on the mechanism behind high levels of heat tolerance in some genotypes. SEM images of the seed surface characteristic features were found useful in distinguishing crop wild relatives of sesamum.

5.1 DNA Fingerprinting

One hundred and six (106) samples of 19 agri-horticultural crops, namely, barley, black gram, buckwheat, *Chenopodium*, cotton, cowpea, *Dolichos*, fababean, horse gram, linseed, mung bean, mustard, oats, pearl millet, sesame, soybean, taramira, toria, and walnut 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 below. By rendering DNA fingerprinting services, resources to the tune of Rs. 853260-00 were also generated.

Table 5.1: Details of samples DNA finger printed during 2021

S. No.	Crop	Scientific Name	Number of Samples
01	Barley	*Hordeum vulgare*	1
02	Black gram	*Vigna radiata*	14
03	Buckwheat	*Fagopyron esculentus*	1
04	Chenopodium	*Chenopodium album.*	1
05	Cotton	*Gossypium hirsutum*	41
06	Cowpea	*Vigna unguiculata*	3
07	Dolichos	*Lablab purpureus*	1

5.2 Development of 67K SNP Chip for characterization of grain amaranth

S. No.	Crop	Scientific Name	Number of Samples
08	Fababean	*Vicia faba*	1
09	Green gram	*Vigna mungo*	12
10	Horse gram	*Macrotyloma uniflorum*	4
11	Linseed	*Linumusitatissimum*	1
12	Mustard	*Brassica oleracea*	7
13	Oats	*Avena sativa*	4
14	Pearl millet	*Pennisetum glaucum*	4
15	Sesame	*Sesamum indicum*	1
16	Soybean	*Glycine max*	2
17	Taramira	*Eruca vesicaria ssp. sativa*	1
18	Toria	*Brassica campestris L. var. toria*	5
19	Walnut	*Juglans regia*	2
		Total	106

germplasm

Approximately 8.50 lakh SNP were identified and tested for the development of high-density chip for the characterization of total collection of Amaranth. Finally, the 402 bp feature molecule from each filtered SNPs were generated and used for high-density SNP genotyping chip development. All sixteen chromosomes (scaffolds) were used and 67K SNP makers were finally used for the SNP chip development. During chip development some markers probes were used from both strands therefore the number of probes increased to 70K. The maximum SNP probes from scaffolds 2 (7765) and minimum probes from scaffold 12 (760) were selected for Chip development. The distribution of SNP markers was also analyzed according to their presence in genic (exon, intron, 5' UTR and 3' UTR) and intergenic regions. A 67K SNP chip-based preliminary analysis on 92 accessions of grain amaranth shows that accessions collected from six states Uttarakhand, Himachal Pradesh, Madhya Pradesh, Gujarat, Arunachal Pradesh and Maharashtra have good genetic diversity (Fig.1).

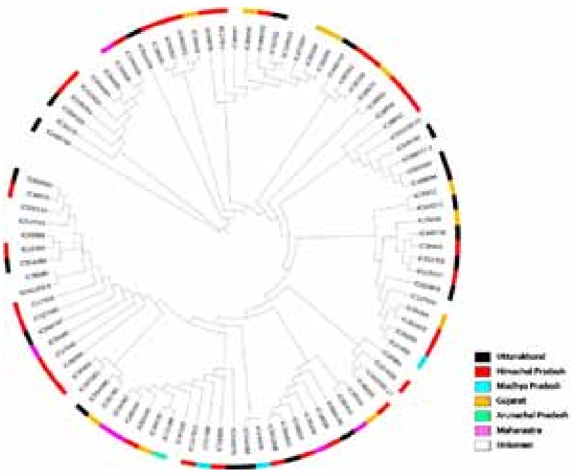


Fig. 5.1. NJ tree of 92 accessions of Grain amaranth based on 70K SNP genotyping data.

5.3 Development of SSR markers in browntop millet and their application in molecular characterization of brown millet germplasm of Indian National Genebank

In continuation with earlier work, 470 genic markers from little millet were tested for amplification and generation of genomic resources in browntop millet. One hundred twenty- nine genic markers showed double or single bands, 187 did not amplify and the rest of the markers showed multiple or smeary bands. Further, 75 in-house developed markers (transferred/developed from little millet and *Brachiaria* spp.) with a polymorphism rate of 76% were utilized for molecular characterization of 57 browntop millet germplasm available at ICAR-NBPGR **(Fig. 5.2).** The pair-wise genetic distances among the accessions were estimated based on 26 *Brachiaria* spp. SSR loci using DARwin 6.0 software and the dissimilarity matrix was used to construct a phenogram with the neighbor-joining algorithm

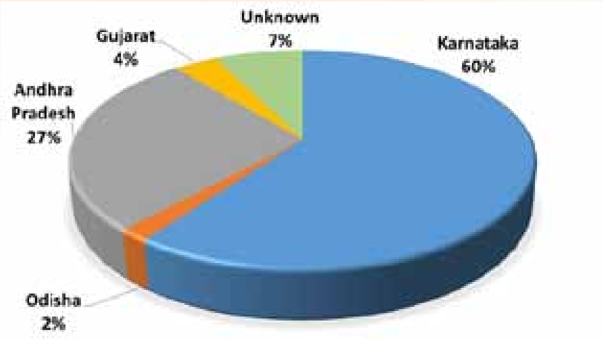


Fig. 5.2. Geographical distribution of 57 browntop millet genotypes used for characterization

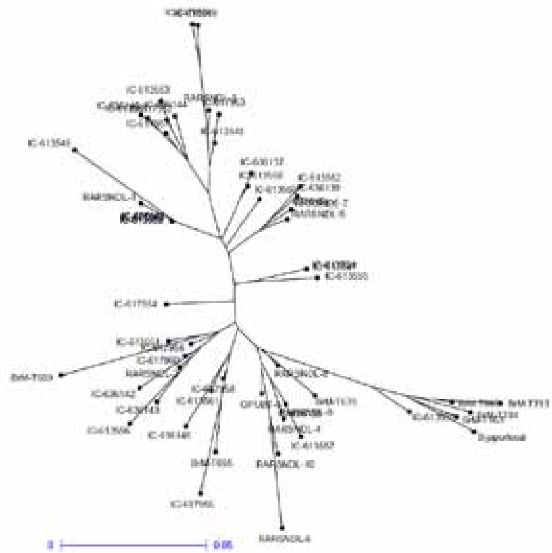


Fig. 5.3. Genetic relationships among 57 genotypes of browntop millet geermplasm linesusing 26 SSR markers derived from 26 Brachiaria spp.

(Fig.5.3). Based on this study, diverse genotypes and also the regions to be explored for collecting the substantial number of germplasm for conservation and utilization were identified.

5.4 Genotyping of 96 little millet accessions with fourteen additional genic SSRs to study level of polymorphism and allelic variation

Ninety-six accessions of little millet having wide variation with respect to different phenotypic traits viz. days to 50% flowering (39 to 118 days), thousand grain weight (1.12 to 3.487g) etc. and representing nine states of India were genotyped using fourteen additional genic SSR loci. A total of 24 primer pairs were used for the analysis, out of that 19 primer pairs were polymorphic (79.16% polymorphism). The number of polymorphic alleles ranged from 2 to 7 with an average of 3.3 alleles per locus. A representative amplification profile of 96 little millet accessions with LM90 primer is presented in **Fig. 5.4.**

5.5 Genomic SSR marker development and validation from whole genome sequence data of finger millet for DNA profiling

Multiple hybrid *de novo* genome assembly scaffolds (1897) data of finger millet variety PR 202 developed by Hatakeyama et al. (2018) was downloaded for genomic SSR marker development. A total of 1760, 513 and 253 primer pairs (including redundant primers) having tetra, penta and hexa repeats respectively were designed with minimum repeat size five. Out of this, fifty non-redundant primer pairs were synthesized for testing amplification in four varieties/five accessions of finger millet. Out of 50 primer pairs tested, one primer pair showed multiple bands, one showed

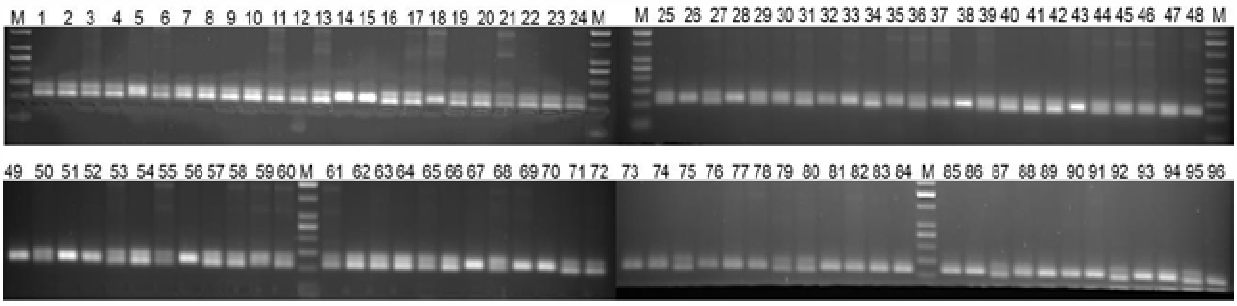


Fig. 5.4. Molecular profile of 96 accessions of little millet with genic SSR locus LM90

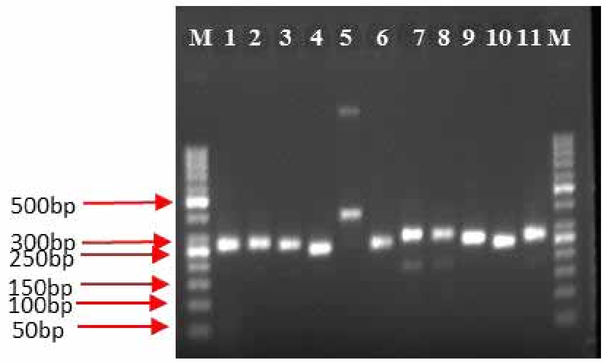


Fig. 5.5 Molecular profile of 106 accessions of finger millet minicore with SSR locus fmgssr12

faint multiple bands, five primer pairs did not show amplification and 43 primer pairs showed amplification in the desired size range. Out of 43 selected, 21 primer pairs were used to profile finger millet mini-core. A representative amplification profile of 96 little millet accessions withfmgssr12 primer is presented in **Fig.5.5**. Further, data analysis is in progress.

5.6. Cross-species transferability of SSR markers in *Sesamum*:

A total of 43 SSR primer pairs were tested for its cross-species transferability among the species of the genus *Sesamum*. Our results identified the set of eight polymorphic SSR markers, *Si*18, *Si*25, *Si*33, *Si*35, *Si*38, *Si*39, *Si*40, and *Si*42; and the set of

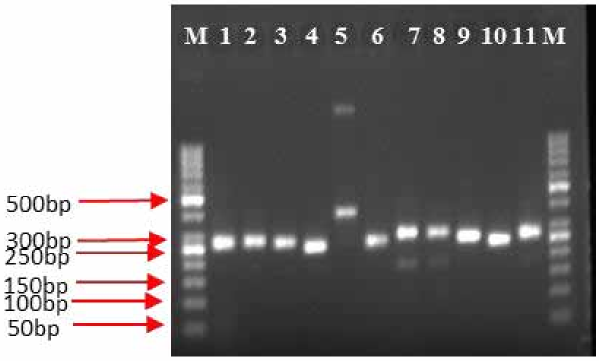


Fig. 5.6: Representative SSR profile (primer *Si*25) exhibiting the cross-species transferability. M: 50bp marker; **1:** *indicum*; **2:** *laciniatum*; **3:** *mulayanum*; **4:** *radiatum*; **5:** *alatum*; **6:** *mulayanum* x *indicum*; **7:** *prostratum*; **8 and 9:** *malabaricum*; **10:** *mulayanum*; and **11:***Sesamum* sp.

11 SSR markers, *Si*08, *Si*09, *Si*12, *Si*13, *Si*16, *Si*23, *Si*27, *Si*29, *Si*31, *Si*41, and *Si*43 that are transferrable for most of the species studied or monomorphic in nature across species. A representative profile for the primer *Si*25 is provided herewith **(Fig. 5.6)**.

5.7 Molecular diversity and population structure in sesame germplasm

Sesame germplasm (2496 accessions) were subjected to molecular diversity analysis using seven highly polymorphic SSR markers. The study revealed six major clusters and they are not associated with geographical regions and thereby underscoring the presence of the alleles across broader geographical regions and their often-cross pollinated nature. Population structure analysis revealed the presence of three major population of which, only cluster 6

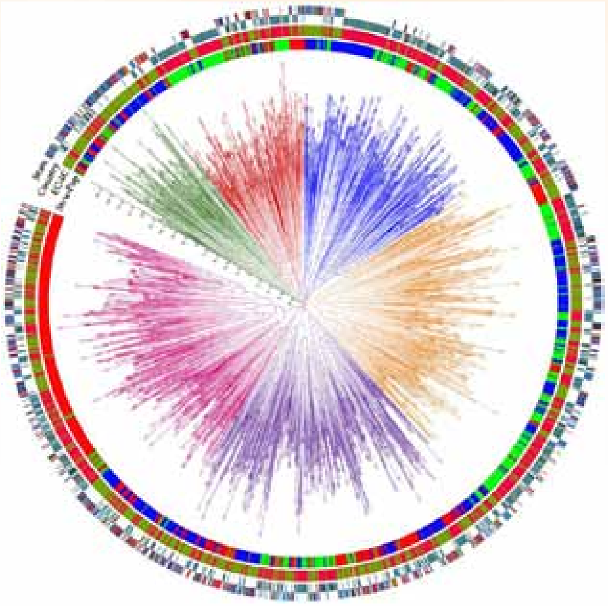


Fig. 5.7: Molecular diversity and population structure analyses among the 2496 sesame genotypes studied using seven SSR markers.

grouped into the single population (population 1); otherwise, shuffle between molecular diversity cluster pattern and the population structure pattern is observed. In Fig. 5.7, innermost of the concentric circles represents the three population (differentiated with different color strip) based on structure, next circle represents the indigenous or exotic collection (differentiated with two different color strip), and the next two circle of color-coded strips represent the country or state for the exotic or indigenous collection, respectively. Development of a core set of the sesame germplasm using molecular profiling data is in progress.

5.8 Evaluation of cross species transferability of SSR markers in wild relatives of Safflower

The major species closely associated with cultivated safflower were *Carthamus lanatus*, *Carthamus oxycantha* and *Carthamus palestianaus*. Among the three, two of them were grown in higher reach of the western Himalayan region. The collected accession along with imported accession is conserved in National genebank. These wild relatives possess important traits which can be used to improve safflower. These traits are aphid resistance and moisture stress.

In order to study the genetic diversity of these wild species available in the gene bank, genomic SSR markers developed in *Carthamus tinctorius* an cultivated species was used. Total 71 accessions belongs to two species viz. *C. lanatus* (23 accessions) and *C. oxycantha* (48 accessions) available in the gene bank were used to study the genetic diversity exist in these species. The genetic diversity parameters of these SSR markers in *C. lanatus* and *C. oxycantha* accessions is presented in Table 5.3 and 5.3, respectively. Principal co-ordinate analyses showed clustering of the accessions based on their geographic grouping **(Fig 5.8 and 5.9)**. Further, total 50 genomic SSR markers from *C. tinctorius* were used to evaluate the transferability to both *C. lanatus*and *C. oxycantha*. Out of these markers, 10 (20%) markers in *C. lanatus* and 14 (28%) in *C. oxycantha* displayed clear and reliable amplicon. The remaining markers were either not amplified or multiband amplification. This showed a low level of transferability of markers in wild safflower species.

No rare alleles were found and all the

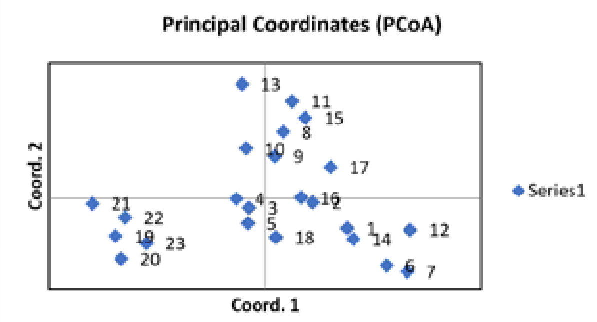


Fig. 5.8. The principal co-ordinate analysis showing grouping of *C. oxycantha* accessions based on their geographical distribution. The Indigenous accessions formed separate group compare to exotic collections.

Table 5.2: Genetic diversity of *C. lanatus* expressed in terms of Number of allele (Na) effective number of allele (Ne) Shanon diversity index (I), Observed Heterozygosity (Ho), Expected Heterozygosity (He) and Fixation Index (F).

SSR markers	N	Na	Ne	I	Ho	He	uHe	F
CAT 3	20	11.000	8.247	2.229	0.900	0.879	0.901	-0.024
CAT 5	23	14.000	11.626	2.532	0.826	0.914	0.934	0.096
CAT 29	23	9.000	6.298	1.968	0.087	0.841	0.860	0.897
CAT 46	23	7.000	4.766	1.726	0.087	0.790	0.808	0.890
CAT 48	23	9.000	8.138	2.140	0.000	0.877	0.897	1.000
CAT 58	22	5.000	3.143	1.310	0.000	0.682	0.698	1.000
CAT65	21	9.000	5.919	1.947	0.048	0.831	0.851	0.943
CAT 68	22	7.000	4.588	1.682	0.045	0.782	0.800	0.942
CAT 91	22	7.000	6.541	1.909	0.000	0.847	0.867	1.000
CAT 96	23	11.000	7.399	2.189	0.130	0.865	0.884	0.849

Table 5.3: Genetic diversity of *C. oxycantha* **expressed interms of Number of allele (Na) effective number of allele (Ne) Shanon diversity index (I), Observed Heterozygosity(Ho), Expected Heterozygosity (He) and Fixation Index (F).**

SSR markers	N	Na	Ne	I	Ho	He	uHe	F
CAT 3	44	9.000	7.014	2.047	0.000	0.857	0.867	1.000
CAT 5	36	14.000	11.571	2.526	0.528	0.914	0.926	0.422
CAT 6	46	8.000	6.298	1.934	0.000	0.841	0.850	1.000
CAT 23	45	13.000	10.176	2.422	0.000	0.902	0.912	1.000
CAT 29	48	13.000	7.361	2.172	0.125	0.864	0.873	0.855
CAT 46	46	8.000	5.186	1.821	0.000	0.807	0.816	1.000

SSR markers	N	Na	Ne	I	Ho	He	uHe	F
CAT 48	46	18.000	14.444	2.768	0.022	0.931	0.941	0.977
CAT 52	42	8.000	5.128	1.788	0.000	0.805	0.815	1.000
CAT 58	48	8.000	5.969	1.906	0.000	0.832	0.841	1.000
CAT 64	44	11.000	9.308	2.295	0.000	0.893	0.903	1.000
CAT 65	38	7.000	5.870	1.836	0.000	0.830	0.841	1.000
CAT 68	44	17.000	11.988	2.626	0.750	0.917	0.927	0.182
CAT 91	42	8.000	7.056	2.008	0.000	0.858	0.869	1.000
CAT 96	48	11.000	7.629	2.205	0.000	0.869	0.878	1.000

primers generated private alleles. The observed heterozygosity ranged from 0 to 0.9 with the average heterozygosity of 0.21 and the expected Heterozygosity (gene diversity) in this species showed range from 0.68 to 0.91 with the average expected Heterozygosity of 0.83 which is considered higher gene diversity.

No rare alleles were found and all the

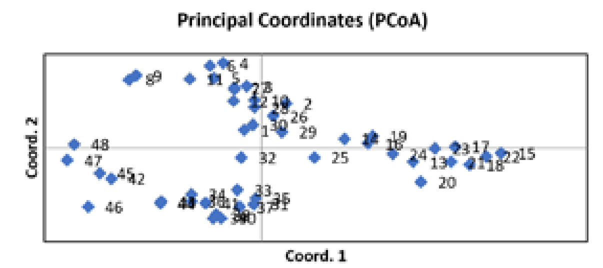


Fig. 5.9. The component plot showed grouping ofC. *oxycantha* accession based on the geographical distribution and temporal variation in collections.

primers generated private alleles. The observed heterozygosity ranged from 0 to 0.75 with the average heterozygosity of 0.10 and the expected Heterozygosity (gene diversity) in this species showed range from 0.80 to 0.93 with the average expected Heterozygosity of 0.86 which is considered higher gene diversity.

5.9. Cytological and DNA barcoding evidence in supporting morphologically distinct unknown *Allium* taxon and its relationship with allied species

The DNA sequence data set of nuclear Internal Transcribed Spacers (ITS) region used for phylogenetic analysis were generated from morphologically distinct *Allium* taxon and other species which are found in the same geographical region. The generated ITS sequences were used in construct the maximum likelihood tree. The tree with the highest log likelihood is shown **(Fig. 10)**. Based on the likelihood tree the new *Allium* taxon was observed to be closely related to *A. przewalskianum* and distantly related to other cultivated and wild *Allium* species used in the study. Among the taxa studied the minimum number of substitutions per site was between *A. cepa* and *A. cepa* var. *aggregatum* (0.005) followed by between *A. cepa* and *A. roylei* (0.010%). However, between *A. przewalskianum* and new *Allium* species the minimum number of substitution per site was 0.060. The genetic distance between *Allium* sp. nov. and *A. przewalskianum* is much higher than the species belonging to different section of the genus *Allium* i.e *A. cepa* and *A.roylei* .

The above findings indicated that the new taxon is a distinct species closely related to

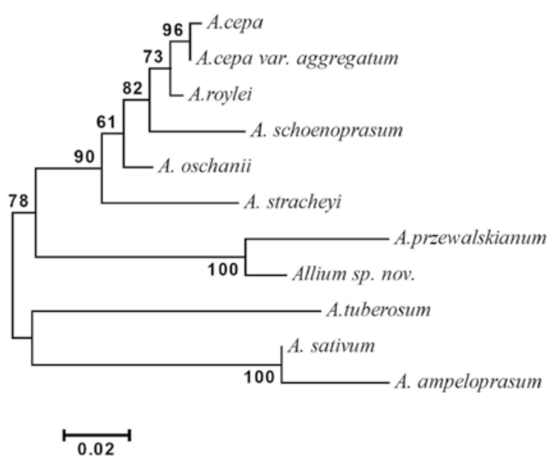


Fig. 5. 10. Maximum likelihood tree from nuclear ribosomal ITS sequence from 11 *Allium* taxa showing delineation of morphologically distinct *Allium* taxon

A. przewalskianum. These findings supported the observations recorded using morphology, particularly the floral characters were very distinct in the two species. The cytological observation also supports the above findings. The cytological studies are support the above finding as *A. przewalskianum* collected in the vicinity showed chromosome number 2n=32 whereas the unknown taxon showed chromosome number of 2n=16. The polyploidy nature is common in *A. przewalskianum* as it shows strong geographical distinction and this also attributes to the novelty of the unknown taxa.

5.10 Chloroplast genome assembly of *P. Nigrum*

The chloroplast genome of *P. Nigrum* has been assembled from the whole genome. The plastid genome was observed to be 161,522bp in size (**Fig. 5.11**), having quadripartite structure with a large single copy (LSC) region of 89,153bp and a small single copy (SSC) region of 18,255bp separated by a copy of inverted repeats (IRs), each 27,057bp in length. A total of 131 genes were observed, which included 81 protein coding genes, 37 tRNAs, 4 rRNAs and 1 pseudogene. Individually, LSC region consisted of 83 genes, SSC region had 13 genes and 18 genes were present in each IR region. Additionally, 216 SSRs were also detected.

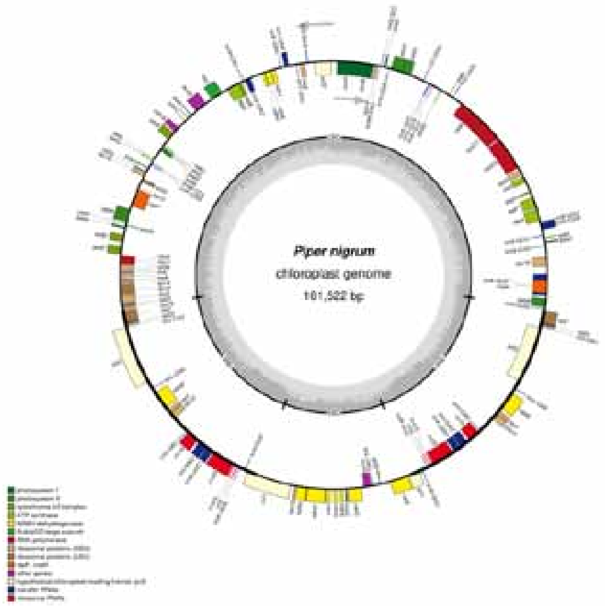


Fig. 5.11. Chloroplast assembly of *P. nigrum*

5.11 Chloroplast genome assembly of sesame spp.

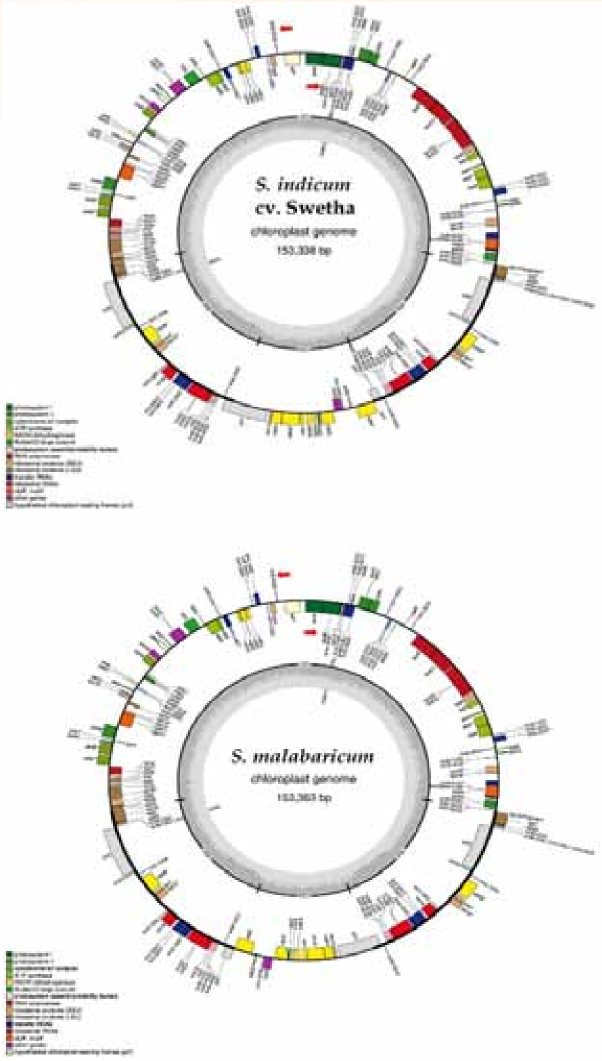


Fig. 5.12. Chloroplast assemblies for *S. indicum* subsp. *indicum* cv. Swetha (1,53,338 bp) and *S. indicum* subsp. *malabaricum* (1,53,363 bp) were made.

Single contig circular chloroplast assemblies for the sesame cultivar 'Swetha' and its wild relative *S. indicum* subsp. *malabaricum* were made,1,53,338 and 1,53,363 bp respectively (**Fig. 5.12**), and the raw data for the assembly is generated using short-reads of 2x150 bp paired-ends.

5.12 Development of Genomic Resource database on Grain Amaranth

A user-friendly genomic resource database has been developed for grain amaranth (**Fig. 5.13**) which comprises of SSR, SNP, miRNAs, Transcription factors, transporters and Genes module and hosted in ICAR-NBPGR website (http://www.nbpgr.ernet.in: 8080/AmaranthGRD/). The modules designed in such a way that user can use it very easily. For example, in case of SSR module user can search SSR markers based on type of SSR markers, according to their distribution to different scaffold, based on type of motif and sequence ID. SSR frequecy distribution showed that maximum di nucleotide repeats were present in the grain amaranth followed by tri, tetra, penta and hexa nucleotide repeats (**Fig. 5.14**). Similarly, in case of SNP module the SNP makers has been broadly categorised into genic and non geneic SNP markers and under genic category the user can search SNP based on Gene ID, SNP ID and Scaffold ID but in case of non genic SNPs facility has been provided to search SNPs based on their location in scaffold. The 78% SNPs were present in the nongenic regions whereas, 22% were present in the genic region (Figure 4). Out of 22% genic region SNPs 17% were present in the Exon, 3% in introns and 2% in the UTR regions. In transcription factor module all the 56 categorise of transcription factor has been provided with number of sequences

Fig 5.13. Amaranth Genomic Resource Database

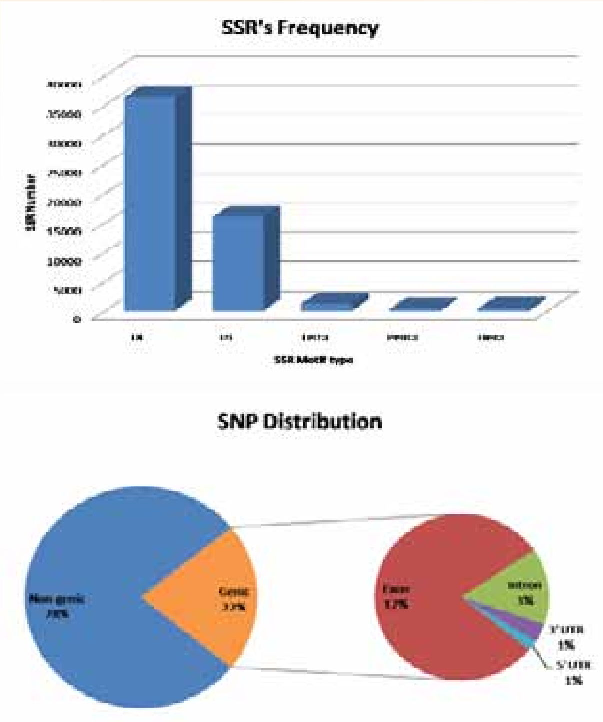


Fig 5.14 : SSRs frequency distribution and distribution of SNPs in genic and non genic region of Grain Amaranth

available in each category for Grain Amaranth and their sequences are dwonloadable. miRNA available in the grain amaranth can be searched according to their location in each scaffold. Diiferent transporters of grain amaranth can be searched by gene ID, scaffold, domains or by name of the gene.

5.13 Investigation of wild species of Luffa for nutraceutical value

Crop wild relatives of Luffa species (*L. grovelens, L. echinata* and *L. sylverstris)* were sown in net house in Delhi for evaluation of antioxidant activities and phenolic content. Quantification of *Luffa echinata* antioxidant activity, Total Saponin content (TSC), Total Flavonoid content (TFC), Total Phenolic content (TPC) was done in dry leaves and fruits extracted with different solvents on the polarity basis. In antioxidant assays, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity and ferric reducing antioxidant power (FRAP) was highest in methanol extract in leaves and fruits. Parameters like Total Flavonoid content (TFC) was highest in chloroform extract of fruit and leaf; chloroform and methanol extract of leaf and fruit showed good Total Saponin content (TSC), while chloroform and methanol leaf extract showed good Total Phenolic content (TPC) but in fruit petroleum ether extract showed high TPC along with chloroform. Gas chromatography-mass spectrometry (GC–MS) analysis of leaf and fruit revealed various bioactive molecules present belonging to various groups. Based on the present findings *Luffa echinata* consists of many bioactive compounds that need to be targeted for investigation of medicinal values.

5.14 Model for evolution of a weak C_4 pathway in non-foliar tissues of BOP clade:

Insights from transcriptomic studies (leaf and

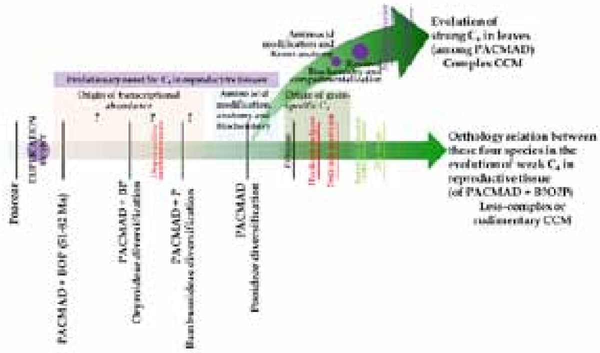


Fig. 5.15. A model for the evolution of a weak C_4 pathway in non-foliar tissues of the BOP clade.

non-foliar photosynthetic tissues) in wheat and rice had led to the proposal of the model for the evolution of the weak C_4 pathway in BOP clade of Poaceae family, prior to the strong C_4 photosynthesis pathway in the PACMAD clade **(Fig. 5.15)**.

5.15 Genetic dissection of maturity and plant height traits in *Linum usitatissimum* l. using multi-locus genome wide association study

Multi-Locus Genome Wide Association Study (ML-GWAS) was undertaken in an association mapping panel of 131 accessions of linseed, genotyped using 68,925 SNPs identified by genotyping by sequencing approach. Phenotypic evaluation data of five environments comprising three years and two locations was used. GWAS was performed for days to maturity and plant height by employing five ML-GWAS methods: FASTmrEMMA, FASTmrMLM, ISIS EM-BLASSO, mrMLM and pLARmEB.Using the five ML-GWAS methods, 30 and 27 stable QTNs have been identified for DM and PH, respectively. The LOD

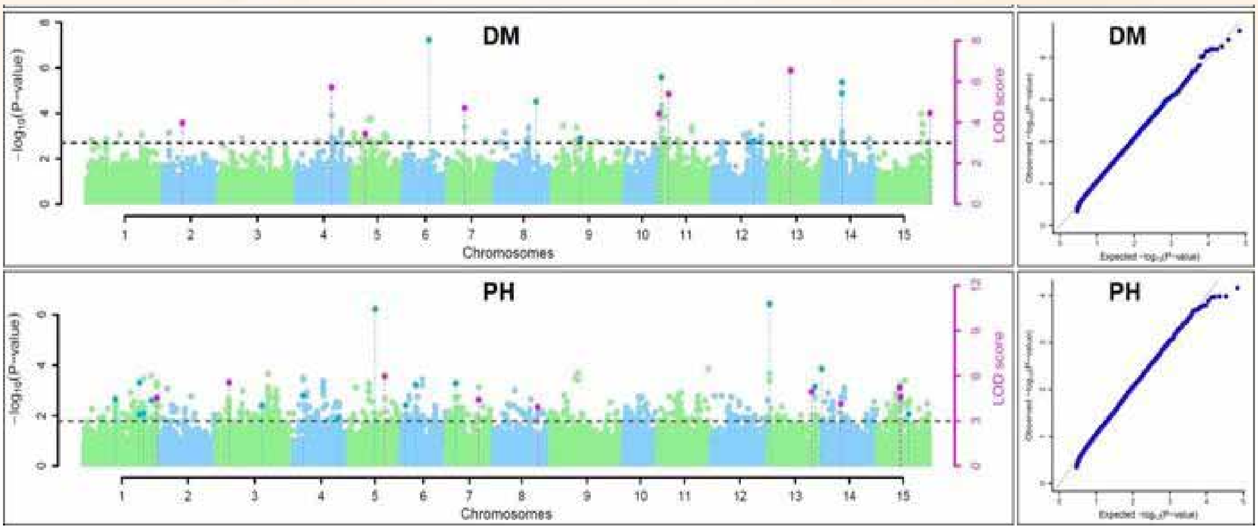


Fig 5.16. Manhattan plots and quantile-quantile plots for days to maturity (DM) and plant height (PH) using five ML-GWAS methods for environments DL 19-20. The dotted lines in Manhattan plots show threshold at LOD score of ≥3.0. The dots above the threshold depicts significant QTNs in respective chromosome. The pink dots depict significant QTNs for ≥ 2 methods.

and -log10(p) score of stable QTNs for DM were 3.03-9.17 and 3.73-10.09, respectively explaining up to 28.78% of variation in days to maturity. For PH, the LOD and -log10(p) values of stable QTNs were 3.06 to 12.15 and 3.76 to 13.13, respectively. The stable QTNs accounted phenotypic variation up to 36.6% for PH. Manhattan plots showing significant QTNs and respective QQ-plots of ML-GWAS for DM and PH traits are shown **(Fig. 5.16)**.

Genes around 30 kb region (up and downstream, total 60 kb) of the stable and unique QTNs were retrieved and putative candidate genes have been identified based on their function, homology with Arabidopsis ortholog and pathway analysis. For DM, important candidate genes identified included *Lus10037719 (Two-component response regulator ARR1), Lus10039906 (3-Ketoacyl-CoA synthase 19), Lus10010681 (Protein LURP-one-related 8), Lus10004130 (Bifunctional 3-dehydroquinate dehydratase/shikimate dehydrogenase), Lus10002133 (CSC1-like protein), Lus10002492 (AGAMOUS-like)*, and *Lus10004132 (FRIGIDA-like protein)*. For PH, the potential candidate genes included *Lus10021899 (LRR receptor-like serine/threonine-protein Kinase GSO2), Lus10005957 (Protein MAINTENANCE OF MERISTEMS), Lus10000613* and *Lus10014757 (lateral organ boundaries domain protein).*

5.16. Transcriptome analyses of wheat germplasm KRL3-4 under sodicity stress

The flag leaf transcriptome of a highly sodicity stress tolerant bread wheat germplasm (KRL 3–4) was analysed under high pH stress conditions. A total of 1,980 genes were differentially expressed in the flag leaf due to sodicity stress. Among these genes, 872 DEGs were upregulated and 1,108 were downregulated. furthermore, annotation of DEGs revealed that a total of 1,384 genes were assigned to 2,267 go terms corresponding to 502 (biological process), 638 (cellular component), and 1,127 (molecular function) **(Figure 5.17A)**. Go annotation also revealed the involvement of genes related to several transcription factors; the important ones are expansins, peroxidase, glutathione-s-transferase, and metal ion transporters in response to sodicity. additionally, from 127 KEGG pathways, only 40 were confidently enriched at a p-value <0.05 covering the five main KEGG categories of metabolism, i.e., environmental information processing, genetic information processing, organismal systems, and cellular processes (**Figure 5.17B**). Most enriched pathways were prioritized using Mapman software and revealed that lipid metabolism, nutrient uptake, and protein homeostasis were paramount.Finally, 19 important candidate genes contributing to sodicity tolerance in bread wheat were identified, and these genes might be helpful for better understanding and further improvement of sodicity tolerance in bread wheat.

5.17 Scanning electron microscopy (SEM)of

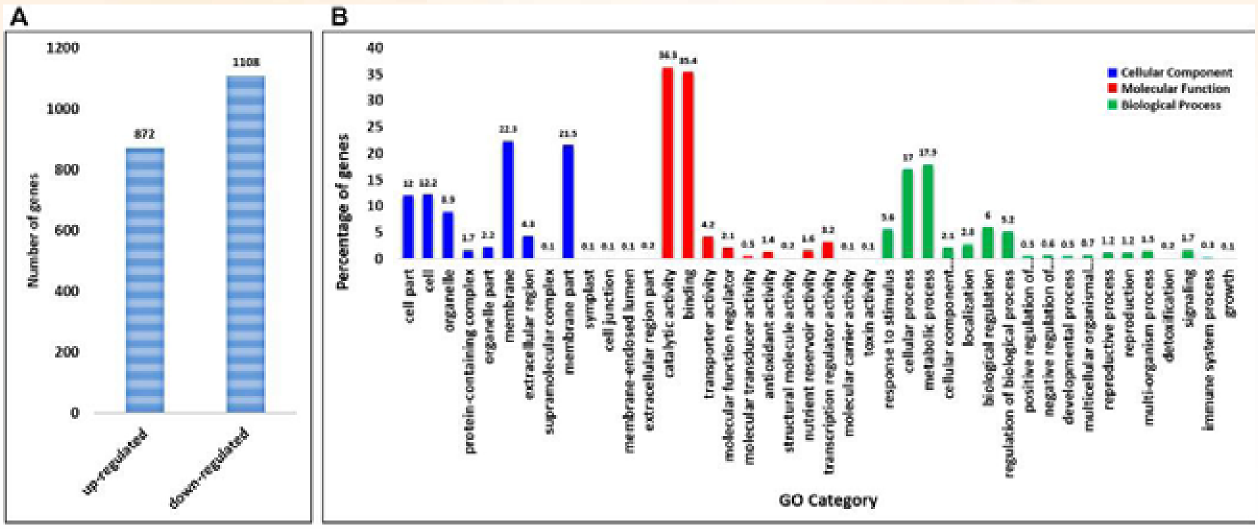


Fig. 5.17. (A) Significant up and downregulated differentially expressed genes (DEGs) identified under sodicity stress. (B) Gene Ontology (GO) annotation of DEGs in sodicity treated wheat flag leaves summarized in three main categories: biological process (BP), molecular function (MF), and cellular component (CC)

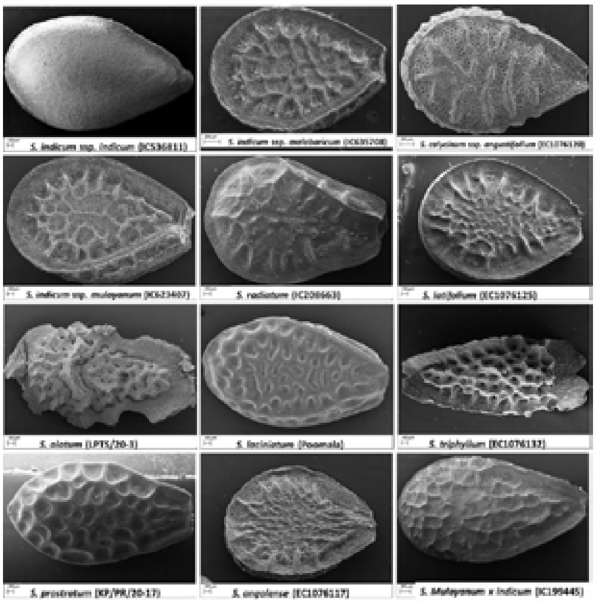


Fig. 5.18. SEM images exhibiting the differential micromorphological seed surface characteristics that could be used to distinguish the seeds of the sesame CWRs.

crop wild relatives of sesame:

The crop wild relatives (CWRs) of sesame are difficult to distinguish at taxon level using the seeds and is difficult to conserve or utilize till the establishment of the plants. So, to overcome this, we have developed the SEM images of the seed surface characteristic features to distinguish the taxa using their surface micromorphological features (**Fig. 5.18**).

5.18 Scanning electron microscopy (SEM) of wheat starch granules of heat stress:

The wheat genotypes variable for heat stress tolerance were subjected to heat stress during11-14 days post anthesis (dpa) and 27-30 dpa, both being mutually exclusive. After heat stress, they were studied for recovery and their grains harvested at

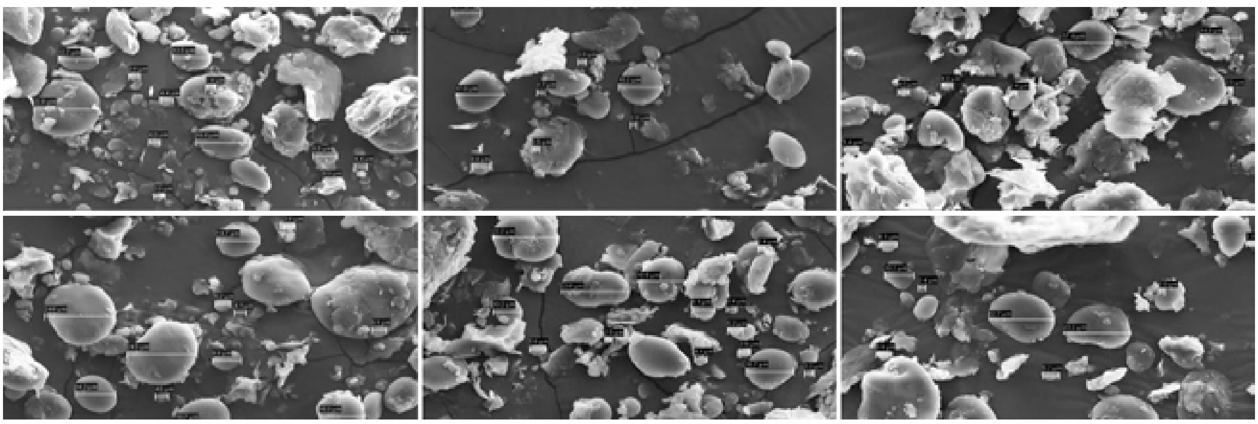


Fig. 5.19. Top row:SEM image of starch granules of heat susceptible genotype (EC1009521). **Left**: control (23 μm), **Middle**: heat stress at 11-14 days-post-anthesis (dpa) (10-15 μm), **Right**: heat stress at 27-30 dpa (only very few are of 10-15 μm); **Bottom row:**SEM images of starch granules of heat susceptible genotype (EC1009527). **Left:** control (24 **μm**), **Middle:** heat stress at 11-14 days-post-anthesis (dpa) (23 **μm**), **Right:** heat stress at 27-30 dpa (23 **μm**).

maturity and performed SEM **(Fig. 5.19)**.

5.19 Molecular testing of imported transgenics

Thirty seven (37) samples of imported transgenics including soybean - *Glycine max* (1 sample)and cotton - *Gossypium hirsutum* (36 samples) were received and tested for specific transgene elements using PCR/ real-time PCR. The presence of specific transgene (*cp4-epsps* gene) in soybean sample (IQ 46/21) was confirmed employing real-time PCR **(Fig. 20a)** and lateral flow strip (LFS) assays. Similarly, in cotton, the *Bt* samples were tested for presence of specific transgene *cry1D*. All 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 5.20b)**.

5.20 GMO matrix developed for 22 GM food crops approved globally and multiplex PCR-based GM diagnostics developed and validated for screening and detection of GM seeds/ food products:

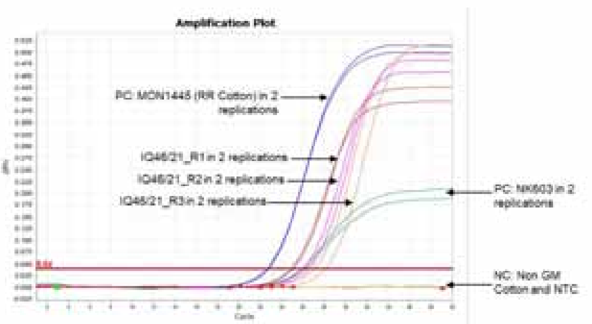
The screening targets for GM detection in 22 GM food crops including alfalfa, apple, brinjal, Argentina canola, common bean, chicory, cowpea, flax, melon, papaya, plum, Polish canola, potato, rice, safflower, soybean, squash, sugar beet, sugarcane, sweet pepper, tomato and wheat,were identified using GMO matrix developed for these 22 crops

Multiplex PCR assays were developed and validated for GM detection in food crops and products: (i) triplex PCR simultaneously targeting control elements [*Cauliflower Mosaic Virus* 35S (*P-35S*). *Figwort Mosaic Virus* promoter (*P-FMV*), *Agrobacterium tumefaciens* nopaline synthase terminator (*T-nos*)], (ii) triplex PCR targeting marker genes [aminoglycoside-3'-adenyltransferase (*aadA*), neomycin phosphotransferase (*nptII*), phosphinothricin-N-acetyltransferase (*pat*)] and (iii) duplex PCR targeting *Bt* genes (*cry1Ab/Ac* and *cry2Ab2*). These assays showed acceptable specificity (Fig. 5.21) and limit of detection (LOD) was established up to 0.5-0.05% depending on the target/ assay, which is in compliance with the labelling threshold of many countries or the tolerance limit of adventitious presence of GMOs permissible in the imported consignments.

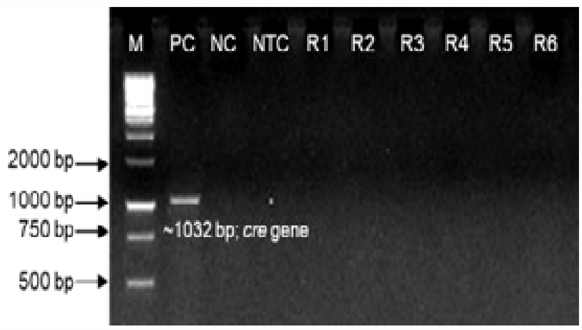
5.21 Loop-mediated isothermal amplification (LAMP)-based GM diagnostics developed and validated for rapid detection of pinII terminator sequence

So far, GM detection laboratory has developed and reported LAMP based GM detection technologies for more than 20 genetic elements (including promoters, marker genes, transgenes, construct regions, event-specific sequences) for GM detection.

Visual LAMP-based GM detection technology targeting *pinII* (protease inhibitor) terminator sequence was developed and validated using designed primers. Specificity was confirmed using a set of targets and non-targets **(Fig. 5.22)**. The developed LAMP assay showed acceptable specificity with limit of detection (LOD) up to



(a) Real-time PCR amplification profile forcp4-*epsps* gene in the imported GM soybean



(b) PCR amplification profile for ensuring absence of embryogenesis deactivator genein GM soybean IQ 46/21-R1-R6 in six replications (M-100 bp DNA Ladder; PC: Positive Control; NC: Negative Control; NTC: Non Template Control)

Fig. 5.20. Molecular testing of imported GM soybean (IQ 46/21)

0.01%.

Stability of LAMP reagents were assessed for the first time at our laboratory across a range of storage temperatures. Stability of assay was assessed by storing the reagents at different temperatures for a period of 15 days and no significant difference was found in the sensitivity of LAMP among the reagents stored at -20°C (recommended storage temperature), 4°C. 25°C, 30°C and 37°C.

5.22 Technical support provided for checking adventitious presence of transgenes in 123 linseed accessions imported from Plant Gene Resources of Canada (PGRC)

GM linseed CDC Triffid conferring tolerance to sulfonylurea herbicide has got approval in Canada in 1990s but deregistered in 2001. In spite of deregistration, the unexpected and unauthorized detection of traces of GM flax in the consignments imported from Canada to Europe has necessitated the stringent monitoring of flax shipments from Canada for suspected GM incidents.As GM linseed has not yet been approved in the country, testing of 123 linseed accessions imported from Plant Canada (by Division of Germplasm Evaluation) was done using PCR assays targeting *P-nos*, *T-nos*, *nptII*, *ALS* (herbicide tolerant – HT gene in GM linseed) and *cp4-epsps* (common HT gene in other crops). Amplifiability of samples was first confirmed using plant specific marker (*cp-tRNA* gene) and then GMO tests were conducted (**Fig. 5.23**). Based on the tests conducted, the samples did not show the adventitious presence of GM linseed.

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

One hundred and fifty (150) samples of 44 food products or derivatives or matrix including those derived from apple, maize, soybean, potato and tomato, and baby food, oils, frozen food products were tested in 2-3 replications with appropriate positive and negative controls using PCR/ real-time PCR tests as mentioned in Table 5.4.

DNA extraction protocols were optimized for frozen food products including ice cream, French fries, Pizza, Naan, Aloo parantha, Manchurian, Momos, Soya Chaap, Papaya Halwa, Spring rolls, Sabudana Tikki, Vada Pops, Mini Samosa, Veg Kebab, Paneer Tikka Wrap. Inhibition test was performed to ensure amplifiability of DNA extracts using real-time PCR and no inhibition was detected in the DNA extracts ranging from 0.1–1.0 to 100 ng dilution series depending on the type of processed food.

5.24 Utilization of GM diagnostics for GM testing of brinjal samples collected from Maharashtra:

Based on the news report shared by the Ministry of Environment, Forests and Climate Change regarding illegal cultivation of GM crops in Maharashtra [channelled through ADG (Seed), ICAR], a total of 103 samples (95 leaf and 8 fruit samples) of brinjal were collected from 14 villages

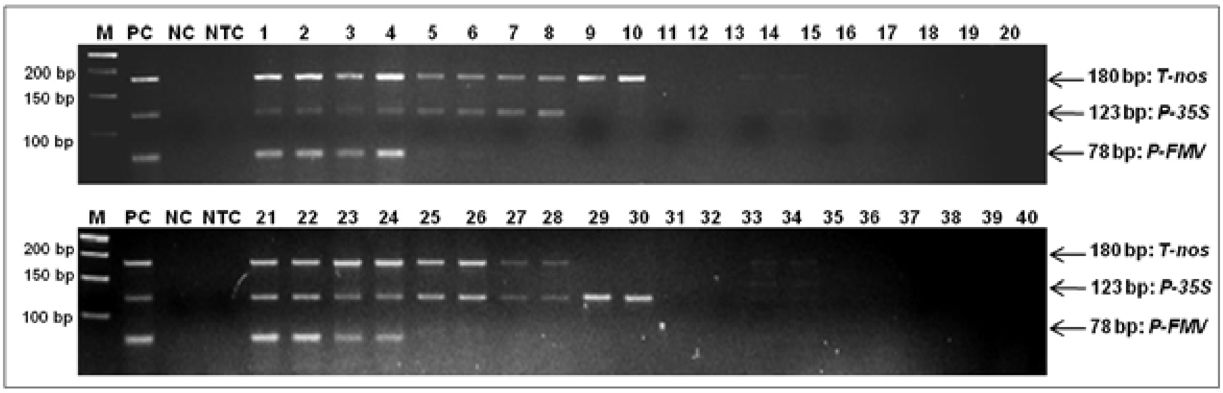


Fig. 5.21. PCR profile for specificity test of Triplex PCR targeting *P-35S, P-FMV, T-nos* (M: 50 bp DNA ladder; **1-2:** MON15985 x MON88913 x Cot102, **3-4:** MON15985 x MON 88913, **5-6:** NK 603, **7-8:** Bt11, **9-10:** GA 21, **11-12:** DP-98140, **13-14:** 356043, **15-16:** DAS 81419-2, **17-18:** Non-GM cotton, **19-20:** Non-GM maize, **21-22**: MON89034, **23-24**: MON15985 x MON88913 (repeated), **25-26**: MON863, **27-28**: 40-3-2, **29-30**: TC1507, **31-32**: DAS 68416-4 (Blank), **33-34**: 40278-9, **35-36:** 281-24-236 x 3006-210-23, **37-38:** Non-GM soybean; **39-40:** 305423, PC: Positive control; NC: Negative control, NTC: Non-template control)

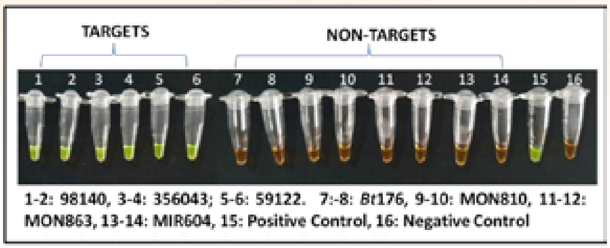


Fig. 5.22. Specificity testof Visual LAMP targeting*pinII terminator* sequence

of Shrigonda Taluka of Ahmednagar District, Maharashtra **(Fig. 5.24a)**. GMO testing of collected samples was done using PCR assays targeting *P-35S* promoter and *T-nos* and *T-ocs* terminators as these screening elements cover indigenously developed *Bt* brinjal events [EE1 with *cry1Ac* gene developed by Mahyco (event approved in Bangladesh), Event142 with *cry1Fa1* gene and *Bt* brinjal with *cry1Ab* gene developed by ICAR-National Institute for Plant Biotechnology, and *Bt* brinjal with *cry1Aa3* gene developed by ICAR-Indian Institute of Vegetable Research, Varanasi]. Based on the tests conducted, none of the samples were found positive for GM targets tested **(Fig. 5.24b)**.

5.25 Quality assurance for GM detection

a) Successfully participated in the International Proficiency Testing on real-time PCR-based GM detection organized by the United States Department of Agriculture, Agricultural Marketing Service, Federal Grain Inspection Service (USDA-AMS-FGIS):

- **Biotechnology Proficiency Program – April 2021** - Qualitative testing was conducted for three screening elements (P-35S, P-FMV, T-nos) and eleven GM maize events (T25, MON810, GA21, NK603, MON863, HerculexRW, MIR604, Event3272, MON88017, MON89034, MIR162) in one maize test (blind) sample.
- **Biotechnology Proficiency Program – October 2021** - Qualitative testing was conducted for three screening elements (*P-35S, P-FMV, T-nos*) and nine GM maize events (T25, MON810, GA21, MON863, MIR604, HerculexRW, Event3272, MON89034, MIR162) in one maize test (blind) sample.

b) Organized Inter-laboratory Comparison Programme (ILCP) on 'Qualitative GM testing in Oil (Canola/ cottonseed/ soybean/ Indian mustard)' in compliance with ISO/ IEC17015;2017:

- ILCP was organized by GM Detection Research Facility where eight national GM detection laboratories participated with the objective to determine the performance of individual national GM detection laboratories for qualitative detection of screening elements, i.e., *CaMV* 35S promoter (*P-35S*) and nos terminator (*T-nos*) in three blind samples of Oil using Real-time PCR, and to assess the performance of GM detection laboratories to extract amplifiable DNA from

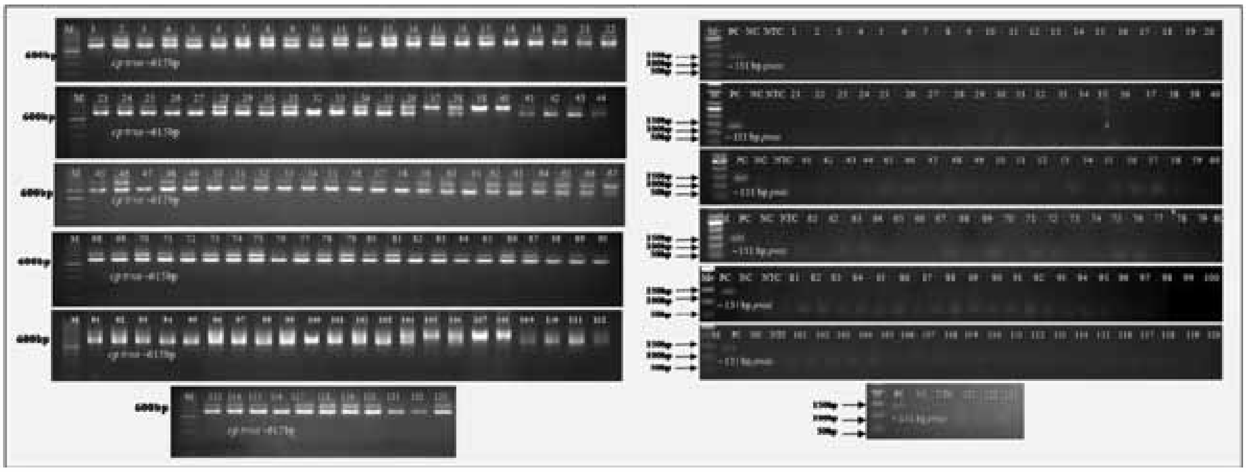


Fig. 5.23. PCR profiles for checking PCR inhibitors to ensure amplifiability of DNA samples using *cp-tRNA* (plant) gene specific assay (left) - 100 bp DNA ladder (b); 1-123: Flaxseed accessions (S. No. 1-123); and checking GM status targeting transgenic element, *P-nos* in 123 flaxseed accessions (right) - 50 bp DNA ladder (b); 1-123: Flaxseed accessions (S. No. 1-123), PC: Positive control, NC: Non-GM flaxseed, NTC: Non-template control

Table 5.4 : Summary of GMO testing of food products/ derivatives

S. No.	Food derivative	No. of samples	PCR/ Real-time PCR tests conducted	Results
		Maize products		
1.	Flour	4	P-35S, T-nos, pFMV, nptII, pat, aadA, cry1Ab/Ac, cry2Ab2, cp4-epsps	Absent
2.	Chips/ Puffs	6		Absent
3.	Soup	1		Absent
4.	Popcorn	10	P-35S, T-nos	Absent
5.	Cornflakes	10		Absent
		Soybean products		
6.	Soy milk	2	P-35S, T-nos	Absent
7.	Tofu	5		Absent
8.	Soy sticks	4		Absent
9.	Chunks	2		Absent
		Apple products		
10.	Fruits (Red)	5	P-35S, T-nos, pFMV, nptII, pat, aadA, cry1Ab/Ac, cry2Ab2, cp4-epsps	Absent
11.	Fruits (Green)	1		Absent
12.	Apple Pie Cookies	3		Absent
13.	Cereal Snacks	1		Absent
14.	Fruit Drink	2		Absent
15.	Juice	5	P-35S. T-nos	Absent
		Frozen food prodycts		
16.	SabudanaTikki	1	P-35S, T-nos	Absent
17.	Vegetable kebab	1		Absent
18.	Mini samosa	5		Absent
19.	Vada Pops	1		Absent
20.	Pizza	1		Absent
21.	Paneer tikka wrap	1		Absent
22.	Aaloo parantha	1		Absent
23.	Whole wheat naan	1		Absent
24.	Chop Stick	1		Absent
25.	Momos	1		Absent
26.	Papaya Halwa	1		Absent
27.	Vegetable Manchurin	1		Absent
28.	Vegetable Spring rolls	1		Absent
29.	French fries	5		Absent
30.	Ice cream	5		Absent
		Potato products		
31.	Potato chips	10	P-35S, T-nos	Absent

S. No.	Food derivative	No. of samples	PCR/ Real-time PCR tests conducted	Results
		Tomato products		
32.	Soup	10	P-35S, T-nos	Absent
33.	Sauce	2		Absent
		Baby food		
34.	Baby/ infant cereal	4	P-35S, T-nos	Absent
35.	Health and nutritional flavour powder for milk	5		Absent
36.	Child Nutrition Supplement	1		Absent
37.	Porridge	4		Absent
38.	Milk powder	2		Absent
39.	Teething sticks	2		Absent
40.	Pancake mix	5		Absent
41.	Biscuits	10		Absent
		Oils		
42.	Canola Oil	2	P-35S,T-nos, pFMV	Absent
43.	Soybean Oil	2		Absent
44.	Mustard Oil	3		Absent

Oil samples.

5.26 Conservation of the voucher samples of indigenously developed GM soybean developed by ICAR-Indian Agricultural Research Institute (IARI), New Delhi:

GM soybean seeds harboring the genetic constructs (four events of antisense myo-inositol-3-phosphate synthase (MIPS), two events of ihp-MIPS, two events of over expression of phytase) for low phytate content were received from ICAR-Indian Agricultural Research Institute (IARI), New Delhi for conservation as voucher samples (Fig. 5.25a). Prior to conservation, the samples were validated for *bar* selectable marker gene employing

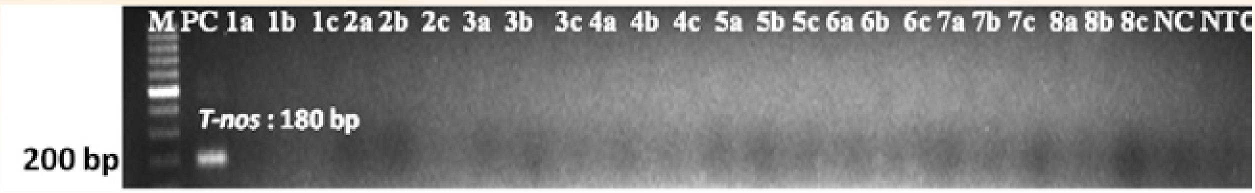
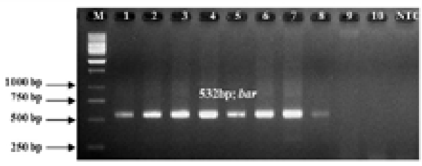


Fig. 5.24(a) Representative images of collection of brinjal samples from different regions of Shrigonda Taluka of Ahmednagar District, Maharashtra; (b) PCR profile of GMO testing of brinjal fruit samples using *T-nos* specific assay -M: 100 bp DNA ladder, 1a-8c: Brinjal fruit samples, PC: Positive control, NC: Non-GM brinjal Negative Control), NTC: Non-template control (Water control)

PCR using the protocol provided by the developer **(Fig. 5.25b)**.

5.27 Renewal of accreditation of GM Detection Research Facility as per ISO/IEC 17025:2017 with enhanced scope

Re-assessment for renewal of ISO17025 accreditation by the External NABL Assessors was successfully conducted from 5-6 June 2021 in the virtual mode and the quality and technical parameters were assessed in accordance with the ISO/IEC 17025:2017 standard. Validity of accreditation has been extended till 28 June 2023 with the enhanced scope covering GM testing of seeds of ten GM crops, namely, Apple, Brinjal, Cotton, Flax, Indian mustard/ Canola, Papaya, Maize, Rice, Soybean and Wheat, and oils of Canola, Cottonseed, Indian Mustard and Soybean. The nine targets covered under the scope include promoters (*P-35S, P-FMV*), terminator (*T-nos*), marker genes (*aadA, nptII, pat*), and genes (*cry1Ab/Ac, cry1Ac, cry2Ab2*) for GM detection using PCR or Real-time PCR.



M-1 kb DNA Ladder; 1- DS9712 MIPS (AS) T5a; 2- DS9712 MIPS (AS) T5b; 3- DS9712 MIPS (AS) T5c; 4- DS9712 MIPS (AS) T6d; 5- DS9712 MIPS *thp*T3a; 6- DS9712 MIPS *thp* T3b; 7- DS9712 Phytase T5b; 8- DS9712 Phytase T4a; 9- Round-up Ready Soy; 10- Non GM Soy; NTC- Non Template Control

Fig. 5.25: (a) Voucher samples of GM soybean received from ICAR-IARI and (b) PCR-based validation using herbicide resistant *bar* gene specific assay

5.28 GMO testing services to public and private sector

GMO testing services were provided for27 seed samples of 19 consignments of cotton and papaya were tested for checking the GM status in papaya or event confirmation in cotton (Table 5.5). (Resource generated; Rs 2.44 lakhs)

National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

GM DETECTION RESEARCH FACILITY, DIVISION OF GENOMIC RESOURCES

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

ICAR-NBPGR, NEW DELHI, DELHI, INDIA

in the field of

TESTING

Certificate Number: TC-7492

Issue Date: 29/06/2021 Valid Until: 28/06/2023

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Identity : ICAR-National Bureau of Plant Genetic Resources

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

Table 5.5: Details of consignments received for GMO testing during 2021

Crop	No. of Consignments (Samples)	Source
Papaya	06 (11)	Known-You Seed (India) Pvt. Ltd., Pune [Through Directorate of Plant Protection Quarantine and Storage (DPPQ&S), Plant Quarantine Station (PQS), Mumbai]
	02 (03)	East West Seeds India Pvt. Ltd., Aurangabad (Through PQS, Mumbai)
	01 (01)	Seeds India (Through PQS, Mumbai)
	04 (04)	DPPQ&S, Regional PQS, Rangpuri, New Delhi
	02 (02)	I&B Seeds Pvt. Ltd (Through PQS, Bengaluru)
	01 (01)	Greenzade Agriseed Pvt. Ltd., (Through PQS, Bengaluru)
	01 (01)	Bharat Agro Overseas India (Through PQS, Mumbai)
Cotton	02 (04)	Surya Seeds Ltd., Guntur

Programme (Programme Code: Title, Leader)

PGR/DGR-BUR-DEL-01.00: Development of genomic tools for identification, protection and enhanced utilization of PGRs Gurinderjit Randhawa

PGR/DGR-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 and oilseed crops Rajesh Kumar, S Marla, J Radhamani, Yasin JK, DP Wankhede, Rashmi Yadav, S Rajkumar, R Parimalan, Amit Kumar Singh, Vikender Kaur and SK Singh

PGR/DGR-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/DGR-BUR-DEL-01.03: Development of genomic tools for enhanced utilization of millets Lalit Arya, Monika Singh, Mamta Singh, Sunil Gomashe and Shashi Bhushan Choudhary

PGR/DGR-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/DGR-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 Radha Mani, DR Pani and M Latha

PGR/DGR-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 Raj Kumar, Rajesh Kumar, AK Singh, JK Yasin, R Parimalan, Sheel Yadav (on study leave w.e.f. 28 July 2018), DP Wankhede, Monika Singh, Sangita Bansal and SK Singh

PGR/DGR-BUR-DEL-01.07: Development and utilization of GM diagnostics for detection of genetically engineered plants and derivatives Monika Singh, Gurinderjit Randhawa

PGR/DGR-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, Manjusha Verma, Sundeep Kumar, Rajesh Kumar, S Rajkumar, R Parimalan, AK Singh, Sheel Yadav (on study leave w.e.f. 28 July 2018), DP Wankhede, Yasin JK and SK Singh

Externally Funded Projects :

April 2021: Rationalisation of rice collections originating from major areas of diversity and allele mining in selected unique set of accessions for biotic, abiotic and quality traits using molecular markers. ICAR Rakesh Singh

September 2020: National Programme for Quarantine and GM Diagnostics of Genetically Engineered Plant Material (Component-2) DBT Monika Singh

April 2021: Identification and validation of climate-smart germplasm and pre-breeding for abiotic stress tolerance in wheat and rice using crop wild relatives and related species ICAR Mahesh Chandra Yadav

October 2017: Genomics of black pepper, cardamom and fenugreek for relating genes to traits of economic importance

ICAR Ambika Gaikwad

October 2018: Genomics-led improvement of biotic and abiotic stress tolerance in mustard rape for economic and environmental sustainability DBT Rajesh Kumar

October 2018: Integrated genomics strategy for accelerating domestication of rice bean (Vigna umbellata) DBT Amit Kumar Singh

October 2018: Characterization, evaluation of genetic resources for genetic enhancement and improvement of minor pulses DBT DP Wankhede

March 2019: Development of amaranth core collection using SSR and SNP markers and evaluation of core set for nutritional, yield traits and abiotic stress tolerance DBT Rakesh Singh June 2019

June 2019: Candidate gene association analysis and transcriptome sequencing to identify novel allelic variants of grain size associated gene in wheat SERB Amit Kumar Singh

February 2020: Development of reference genome and core set using molecular markers: under network project 'Leveraging genetic resources for accelerated genetic improvement of linseed using comprehensive genomics and phenotyping approaches' DBT DP WankhedeFebruary 2020: Genotyping of sesame germplasm following high t

hroughput genomics DBT Parimalan R

February 2020: Germplasm characterization and trait discovery in wheat using genomics approaches and its integration for improving climate resilience, productivity and nutritional DBT Sundeep Kumar

February 2020: Germplasm genomics for trait discovery in wheat DBT Amit Kumar Singh & Sundeep Kumar

February 2020: Capacity building in the area of genomic selection and high throughput phenotyping and its integration in national breeding programs DBT Sundeep Kumar

February 2020: Evaluation of wheat germplasm for quality traits :DBT Sundeep Kumar

February 2020: Exploiting genetic diversity for improvement of safflower through genomics-assisted discovery of QTLs/ Genes associated with agronomic traits DBT S Rajkumar

March 2020: Mainstreaming rice landraces diversity in varietal development through genome- wide association studies: A model for large-scale utilization of gene bank collections of rice DBT Rakesh Singh

March 2020: Development of superior haplotype based near isogenic lines (Haplo-NILs) for enhanced genetic gain in rice DBT Rakesh Singh

April 2020 : Towards understanding the C3-C4 intermediate pathway in Poaceae and functionality of C4 genes in rice ICAR Parimalan R

April 2021: Identification of genes/genomic regions associated with Fusarium head blight resistance in wheat ICAR Sundeep Kumar A National Mission Mode Program on Nutritional improvement of digestible protein content and quality in rice.

February 2020: Exploiting genetic diversity for improvement of safflower through genomics-assisted discovery of QTLs/ Genes associated with agronomic traits DBT S Rajkumar

March 2020: Mainstreaming rice landraces diversity in varietal development through genome- wide association studies: A model for large-scale utilization of gene bank collections of rice DBT Rakesh Singh

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April 2020 : Towards understanding the C3-C4 intermediate pathway in Poaceae and functionality of C4 genes in rice ICAR Parimalan R

DIVISION OF GERMPLASM CONSERVATION

6

Summary: A total of 14649 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 14369 accessions of different agri-horticultural crops to the base collection, thereby raising the total germplasm holding to 458873. Of the conserved accessions, 10, 234 were new and 4,135 accessions were received after regeneration. Monitoring of viability and seed quantity in conserved germplasm (5060 accessions) and distribution (14,147) for characterization/evaluation/regeneration/research were the other priority activities.

Long-term storage (LTS) of seeds of various agri-horticultural crops in the National Genebank (LTS, at -18^{0}C) and medium-term storage (MTS, at +8^{0}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, were the other important activities to facilitate its use in crop improvement programmes.

6.1 Germplasm augmentation (*Relevant* Aichi Biodiversity Target 6,7,13)

A total of 14,649 germplasm accessions of various agri-horticultural crops were received for long-term conservation in the National Genebank, 14,369 accessions qualified for conservation as per the genebank standards and were conserved at -18 ± 2^0C as base collections. Of the conserved accessions, 10,234 were new and 4,135 accessions were received after regeneration. (Table 6.1). A total of 12,744 accessions were salvaged after 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.

Among the new accessions added to the genebank, cereals (5,549), legumes (337), vegetables (728), and oilseeds (2,014), comprised a major portion of germplasm followed by fibres (547), millets (274), medicinal aromatic plants (254), pseudo-cereals (184), forages (82) and spices & condiments (18). The total germlasm holdings in the National Genebank representing 2,065 species has increased to 4,58,873 (including 10,771 trial material and 10,235 accessions of lentil and pigeonpea as safety duplicates). Accessions received after regeneration (4,135) belonged to cereals (772), pulses (1052), millets (597), fibres (546), forages (467), oilseeds (484), vegetables (162), medicinal and aromatic plants (33), pseudo- cereals (11) and ornamentals (10) crop groups (Table 6.1).

In addition, 1,087 vouchers samples of exotic germplasm of agri-horticultural crops received from different parts of the world were stored in medium term storage by the respective crop curators for further multiplication and maintenance.

6.2 Monitoring of germplasm

Germplasm conserved in the long-term storage condition for $\geq$10 years (5060 accessions) 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.

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

Table 6.1: Status of germplasm holdings in the National Genebank (as on December 31, 2021)

Crop Groups/Crop Name	No. of Accessions conserved (1st January to 31st December 2021)			Total no. of Species	Present Status
	Regenerated Acc.	New Accessions	New Species Added		
Cereals	772	5549	7	146	1,71,891
Millets	597	274	2	31	60,013
Forages	467	82	18	221	7,398
Pseudocereals	11	184	2	57	8,017
Grain legumes	1052	337	0	111	67,837
Oilseeds	484	2014	1	88	62,961
Fibre	546	547	3	80	16,767
Vegetables	162	728	4	222	28,191
Fruits & Nuts	0	5	0	71	298
Medicinal & Aromatic plants	33	254	6	688	8,645
Ornamental	10	217	6	128	687
Spices, Condiments and Flavour	1	18	0	28	3,482
Agroforestry	0	25	2	194	1680
Duplicate safety samples	0	0	0	0	10,235
Trial Material (wheat, barley)	0	0	0	0	10,771
Total	**4,135**	**10,234**	**51**	**2,065**	**4,58,873***

* The figure includes germplasm to be released/ notified as varieties and genetic stocks

Crop	Numbers of accession tested for viability	Initial viability range (%)	Present viability range(%)	No. of accessions identified for regeneration
Wheat	487	90-100	84-100	-
Barley	328	85-100	80-90	5
Pea	250	85-100	85-100	-
Sesame	91	90-100	85-100	
Niger	69	90-100	85-100	
Finger millet	1,012	90-100	85-100	-
Sorghum	1,549	70-100	50-85	63
Foxtail millet	440	90-100	80-100	-
Round gourd	49	70-100	50-90	05
Ridge gourd	15	70-90	70-90	-
Cauliflower	18	70-100	70-100	-
KnolKhol	08	70-100	70-100	-
Sponge gourd	20	70-100	70-100	-
Okra	15	70-90	70-90	-

Crop	Numbers of accession tested for viability	Initial viability range (%)	Present viability range(%)	No. of accessions identified for regeneration
Muskmelon	25	70-100	70-100	-
Ash gourd	17	70-90	70-90	05
Radish	10	70-90	70-90	-
Medicinal crops	142	70-95	70-100	-
Pseudo-cereals	85	95-100	95-100	-
Spices	130	85-95	80-95	-
Cotton	300	65-100	20-100	12
Total	**5060**			

6.3 Distribution of germplasm for characterization, regeneration and utilization

A total of 14,147 accessions were supplied for utilization by different stakeholders. Most of the accessions were distributed for research, regeneration, characterization (including under CRP on Agro-biodiversity) and evaluation. The details are given in Table 6.3.

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

Crops (no. of accessions)	Purpose	No. of accessions cessions
Pigeonpea (1,122)	CRP (AB)	1122
Paddy (112), Lablab bean (1276), *Avena* sps (51)	Regeneration and/or evaluation	1439
Paddy (4754), Wheat (1138), Sorghum (1742), *Pennisetum* sp. (286), Cucumber (148), Bitter gourd (102), *Cucumis* species (53), Round gourd (20)	Multiplication / Characterization	8243
Paddy (550), maize (402), wheat (281), barley (7), guar (7), chickpea (82), faba bean (25), pigeonpea (10), lentil (9), mung (6), urd (14), coriander (25), fennel (25), *Andrographis paniculata* (63), medicinal plants (20), buckwheat (6), chenopods (6), coix (15), ajwain (1), sesbania (14), fenugreek (70) chilli (1091), radish (40), knolkhol (8) cauliflower (20) snakegourd (37), ash gourd (23), portulaca (10), muskmelon (52), ridge gourd (355), finger millet (60), foxtail millet (2), *Brachiaria* (7)	Research/ and Utilization	3343
Total		**14,147***

*Figure includes those characterized under CRP-AB.

6.4 Management of Information and National Germplasm Conservation Network

6.4.1 Upgradation/Modernisation of National Genebank

- The National Genebank, formally commissioned in 1996, has been renovated and upgraded to increase the efficiency and security systems. Its 12 long-term storage (LTS) modules and 4 medium term storage modules are now state-of-the-art, with AI enabled security systems. Central Management System (CMS) and Biometric System has been strengthened for central monitoring of temperature, suction pressure, discharge pressure, humidity.Calibration/ Testing work of all the upgraded MTS and LTS modules was completed by National Physical Laboratory, New Delhi.

- **Dedication of upgraded/refurbished National Genebank**: The upgraded/refurbished National Genebank was dedicated to the nation on 16 Aug 2021 by the Hon'ble Minister of Agriculture & Farmers' Welfare, Government of India, Shri Narendra Singh Tomar in the presence of Shri Kailash Choudhary (Union Minister of State for Agriculture and Farmers' Welfare) and Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR; Dr. Tilak Raj Sharma, DDG; Dr. Devendra Kumar Yadava, ADG (Seeds), ICAR, Dr. Kuldeep Singh, Former Director, ICAR-NBPGR; Dr. Ashok Kumar, Director, ICAR-NBPGR; and Dr. Veena Gupta, Head, DGC, ICAR-NBPGR, New Delhi (Fig 6.1).

A webinar executed by Conviron, Canada on "New Generation of Plant Growth Chambers and on complete Refrigeration System, controlling System including Central Management System of Long Term Storage (-20 °C) and Medium Term Storage (+4 °C)" on 17th June 2021 was attended by the entire genebank staff.

- **Barcoding:** To improve the operational efficiency by reducing human error during data entry and to speed up the routine genebank operations, barcoding of germplasm being conserved at the National genebank was started with the upgraded genebank. Barcodes are now used to track samples through many, if not all, genebank operations, from the field to storage, including during characterization/ evaluation activities and distribution. This has also made it possible to collect data electronically, even in the field: the barcode can be scanned and then the relevant data entered. This minimize the risk of wrong data entry. So far 3,541 accessions of earlier conserved germplasm and 10,234 fresh accession conserved during the 2021 were labeled with barcode.

6.4.2 Technical Support to NAGS, Agricultural Universities and Agricultural Institutes

- Technical know-how and detailed layout drawing and specifications of LTS and MTS were provided for establishment of Genebank at PPV&FR Authority Bhawan.
- Technical support for maintenance MTS and detail layout specifications for MTS provided to ICAR- NBPGR, Regional Station Thrissur, Kerala.
- Technical know-how for MTS and technical specifications of dehumidifier of MTS module was provided. One decommissioned dehumidifier and one dehumidifier motor of existing National Genebank, ICAR-NBPGR, New Delhi was transferred to ICAR-IGFRI, Jhansi, UP.

6.4.3 Management of MTS and LTS facilities

Operation and maintenance of 12 Long Term Storage (LTS) and 5 Medium Term Storage (MTS) modules, to maintain the temperature (-20°C)

Fig. 6.1: Hon'ble Minister of Agriculture & Farmers' Welfare, Government of India, Shri Narendra Singh Tomar dedicating the upgraded/refurbished National Genebank on August 16, 2021 to the nation

for LTS Modules and (+4°C) for MTS Modules, humidity, refrigeration system, seed dryers and other National Genebank facilities round the clock to ensure safety of National Germplasm collections kept under Storage in the MTS & LTS facilities.

6.5 Supportive research

6.5.1 Characterization of the conserved germplasm-(Relevant Aichi Biodiversity Target 2,6,7,14)

A two-decade analysis of germplasm footprints in Indian wheat belt (2000-2020)

The wheat germplasm foot-print analysis for the period 2000-2020 revealed that though there is commendable increase in the number of varieties getting notified by CVRC, there is decline in the number of wheat varieties present in the active seed production chain (Fig 2&3). Classical landraces/ varieties like Hard Red Calcutta, Khapli, Etawah, C-591 etc are prevalent in the background of almost all popular varieties.

6.5.2 Redundancy assessment for management of genebank collections- a case study in maize

A study was undertaken to assess the extent of redundancy in Maize Genebank collection, through use of passport data, morphological data and molecular characterization data, in a selected set of 24 maize populations collected from four northern districts of Mizoram. The experiments involved 30 morphological descriptors and 93 microsatellite markers for an extensive analysis of multiple parameters. The analysis could identify redundant sets within genetic clusters, through integration of geographic, morphological and molecular data and from within 24 accessions, 16 accessions were marked for bulking, which would bring down the conservation size from 24 accessions

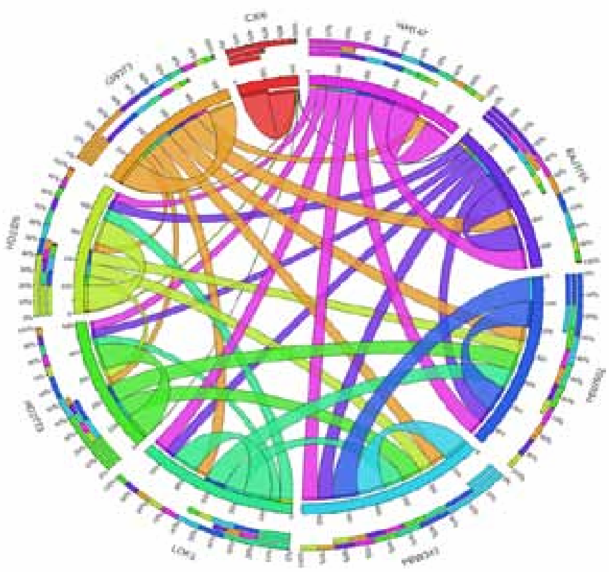


Fig 6.2: Pedigree analysis of prominent wheat varieties in seed production chain in 2009

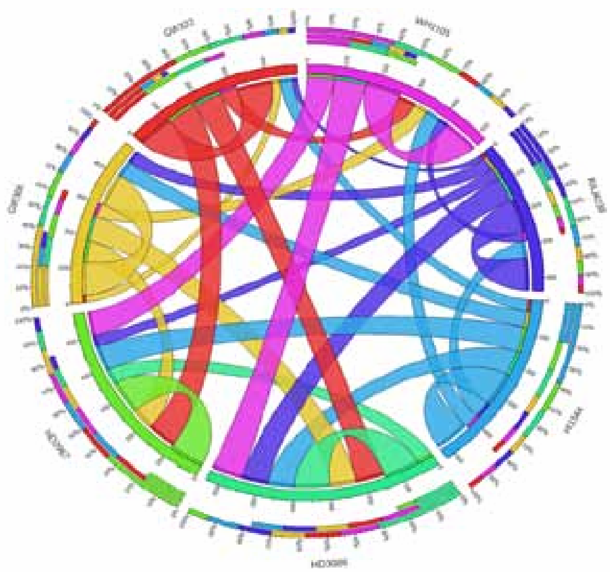


Fig 6.3: Pedigree analysis of prominent wheat varieties in seed production chain in 2017

to 14 accessions. This is the first such attempt in the germplasm collection conserved in NGB.

6.5.3 Development of seed germination protocols in indigenous medicinal plants

Standardization of germination in *Eclipta alba* L. (Bhringraj)

Seeds of *Eclipta alba* (80 lines; showing maximum filled seed per seed lot 60 to 70 %) were given six dormancy breaking treatments in three replications. Of the all treatments, Highest germination % observed in seeds with acid treatment followed by GA_3 soaking (64 %), followed by 48 hours soaking in water (Fig 6.5).

Standardization of germination in *Intisia bijuga* (Colebr.) Kuntze (Buglam)

Intisia bijuga seed collected from Andaman and Nicobar Islands showed hard seededness and nil germination was observed even when soaked in water for 1 week. Therefore, various seed coat scarification treatments were given, of which mechanical scarification of seed coat followed by water soaking for 24 hr. gave 100% germination (Fig 6.6).

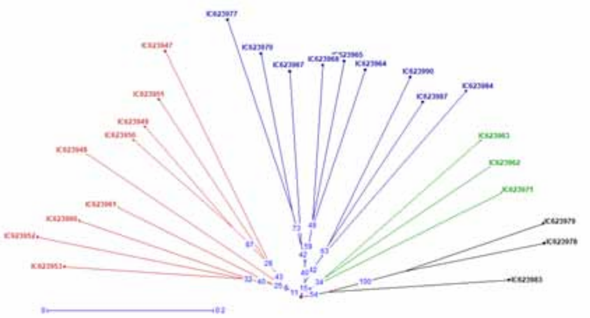


Fig 6.4: Cluster analysis for SSR data in maize

3.6 Plant germplasm registration

Four Plant Germplasm Registration Committee (PGRC) meetings were conducted online through GRIS (Germplasm Registration Information System). The meetings were held at ICAR-NBPGR, New Delhi on March 18, 2021, June 30, 2021, September 21, 2021 and December 21, 2021 respectively under the Chairmanship of Dr TR Sharma, DDG (CS) ICAR, New Delhi. Out of that 323 proposals submitted, 274 were considered for registration. Finally, 242 proposals belonging to 101 species were approved for registration.

Fig. 6.5: Enhanced germination in *Eclipta alba* (Bringraj)

Some notable registered germplasm were: Rice with high grain Zinc content 41.05 ppm; Wheat with high water use efficiency; Naked barley with resistant to stripe rust under artificial inoculation. Possessing seedling resistance against all the pathotypes of black rust except for race 117-6 (shows moderately resistant response); Maize with high beta carotene (9.248µg/g); Jute highly resistant to stem rot caused by *Macrophomina phaseolina*; Cotton with high ginning outturn percentage (43.9%); Oil palm with short stature (28.9 cm) and high FFB (243.91 kg); Finger Millet resistant

Fig. 6.6: Seed germination in *Intisia bijuga* after mechanical scarification + overnight soaking in water

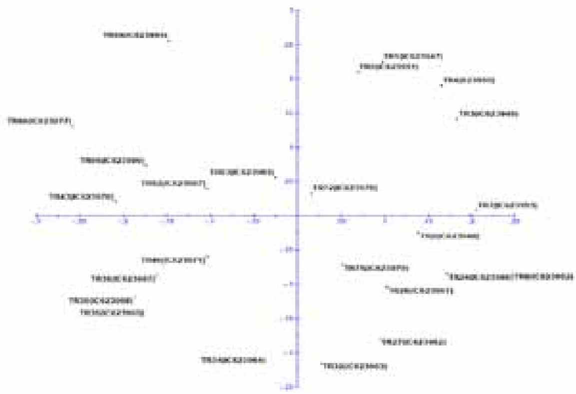


Fig. 5: Principal Coordinate Analysis for SSR data

to Neck Blast (3.71 score in 1-9 scale); Extra early (60-62 days) black gram resistant to Yellow Mosaic Disease; Chilli with non-persistent calyx in red ripened fruit; Groundnut with tolerance to salinity; Castor with resistance to leaf hopper; Sunflower with high oil content (41%); Sugarcane with high fibre (15.05%) in cane combining high sucrose (19.77%) content of commercial level; Apple with better fruit size (155g) and early maturity (114-117 days); *Carissa* with multiple flowering/fruiting in a year (Sadabahar); Chrysanthemum with spatulate florets. Long peduncle (8-12 cm); Betle leaf with wavy margin in leaves, Deep concave shape leaves, Dark green leaf colour and low eugenol (27.57%) content and Sun-cured chewing tobacco with high resistance to caterpillar.

Table 6.4: Crop-group and meeting wise germplasm registered

Crop group	Current status	No. of accession January 01, 2021-December 31, 2021	XXXXIIIrd PGRC, 18 March, 2021	XXXXIVth PGRC, 30 June, 2021	XXXXVth PGRC, 21 September, 2021	XXXXVth PGRC, 21 September, 2021
Cereals and pseudocereals	666	96	34	12	15	15
Millets	111	24	14	-	9	9
Fibre and forages	124	4	2	-	-	-
Grain legumes	185	22	5	2	9	9
Vegetables	121	26	5	2	11	11
Oilseeds	237	18	7	1	4	4
Commercial crops	114	1	1	-	-	-
M & AP & Spices and Masticatory	121	23	8	-	8	8
Fruits and nuts	53	4	1	-	1	1
Tubers	52	13	6	1	6	6
Ornamentals	85	8	4	3	1	1
Narcotic/beverages	8	3	3	-	-	-
Agro-forestry	8	0	-	-	-	-
Grand Total	**1,885**	**242**	**90**	**21**	**64**	**67**

Fig 6.6: Chilli (*Capsicum annuum*) (IC0631916; INGR21155), germplasm with non-persistent calyx in red ripened fruit and Pendent bearing habit

Fig 6.7: Groundnut (*Arachishypogaea*) (IC0640705; INGR21156), Germplasm with small, dark green leaves (stay green character). Resistant to stem rot, late leaf spot and rust.

Fig 6.8: Chrysanthemum (*Chrysanthemum morifolium*) (IC0638881; INGR21108) Florets spatulate in shape. Long peduncle (8-12 cm).

Fig 6.9: Potato (*Solanum tuberosum*) (IC0638884; INGR21111), Germplasm with better nitrogen use efficiency

Fig 6.10 : Apple (*Malus domestica*) (IC00638609; INGR21071), germplasm with resistance to Scab. High TSS and firmness.

Fig 6.11: Chewing Tobacco (*Nicotiana tabacum*) IC0638885; INGR21079), Germplasm with high seed yield.

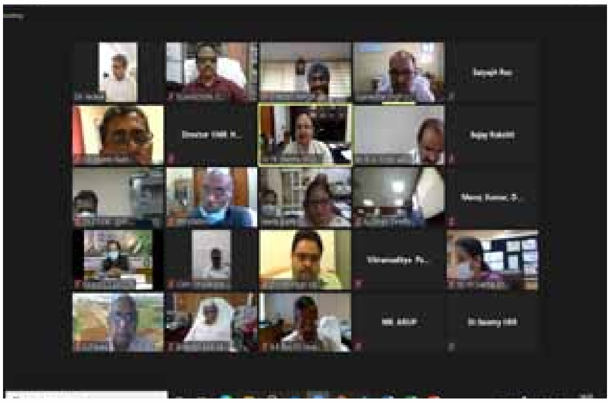


Fig 6.12: XXXXIIIrd PGRC Meeting (March 18, 2021)

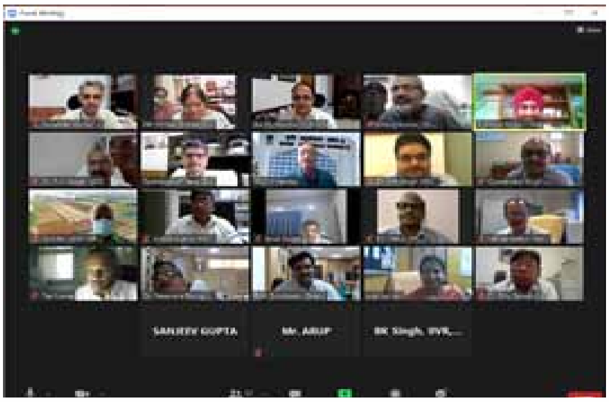


Fig 6.13: XXXXIVth PGRC Meeting (June 30, 2021)

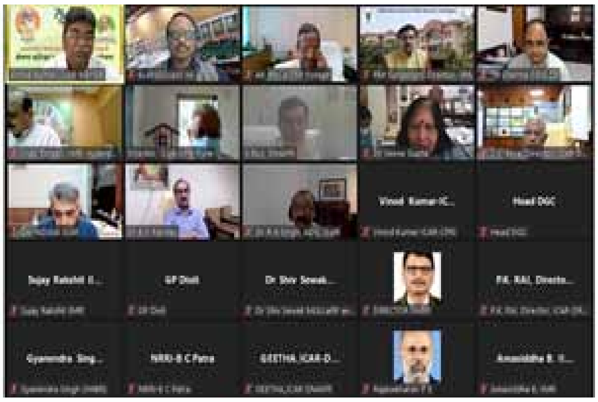


Fig 6.14: XXXXV PGRC Meeting (September 21, 2021)

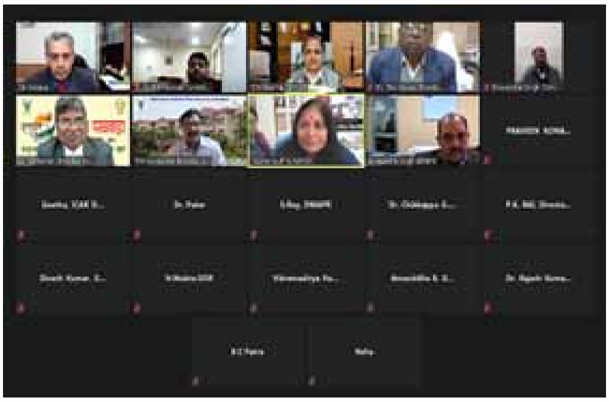


Fig 6.15: XXXXVI PGRC Meeting (December 24, 2021)

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**)

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 Koul,** Sunil Archak, J. Aravind (on study leave from Dec. 2019), Rajvir Singh, Smita Jain, Rajiv Gambhir, S.P Sharma and Nirmala Dabral)

PGR/GCN-BUR-DEL-01-02:Conservation of grain legume germplasm using conventional seed storage methods and associated research (**Neeta Singh**, Chithra Devi Pandey and Padmavati G. Gore)

PGR/GCN-BUR-DEL-01-03: Conservation of paddy germplasm using conventional seed storage methods and associated research (**S Vimala Devi** (till 31st May 2021), **Harish G.D.** (from1stSeptember 2021), J Aravind (on study leave from Dec. 2019), Sherry Rachel Jacob and AD Sharma)

PGR/GCN-BUR-DEL-01-04: Conservation of oilseed germplasm using conventional seed storage methods and associated research. (**J Radhamani** (till 31st November, 2021), **Badal Singh** (from 1st Oct.,2021), Neeta Singh, Sherry Rachel Jacob and J Aravind (on study leave from Dec. 2019).

PGR/GCN-BUR-DEL-01-05: Conservation of cereal germplasm excluding paddy, using conventional seed storage methods and associated research. (**Sherry Rachel Jacob**, J Radhamani (till 31st November, 2021), Badal Singh (from 1st Oct.,2021), and Padmavati G. 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 G. 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 S Vimala Devi(till 31st May2021),Harish G.D. (from1stSeptember,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)

Externally-funded projects

Implementation of PVP legislation: National Plant Variety Repository (**Sherry Jacob**)

TISSUE CULTURE AND CRYOPRESERVATION UNIT

7

Summary: *In vitro* cultures of 1,936 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 12,137 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 21 new accessions were added to the IVAG and 19 accessions were added to *In Vitro* Base Genebank (IVBG). *In vitro* establishment and multiplication protocols were developed in *Bunium persicum*, *Fritillaria cirrhosa, Piper longum*, *Sauropus androgynous*, *Smallanthus sonchifolius*, *Syzygium cumini*, *Xanthosoma sagittifolium*, *Zingiber neesanum* and *Z. whitianum.* Varying degrees of success was achieved in cryopresevation experiments using vitrification, droplet-vitrification, encapsulation-dehydration and V- and D-cryoplate techniques. A total of 231 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 12 species and protocols for breaking seed dormancy were optimized in three species. Maintenance of genetic integrity of cryopreserved plants was confirmed in *Vaccinium* spp. (using 49 ISSR) and *Colocasia esculenta* (using 38 ISSR markers) and revealed high similarity.

7.1 Conservation of Vegetatively Propagated Crops

7.1.1 Germplasm maintenance, augmentation and addition

A total of 1,936 accessions of the mandated crops (Fig. 7.1) were conserved *in vitro* in the form of 36,800 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±2ºC and 16 h photoperiod, and in some species at low temperature (5-10ºC, 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).

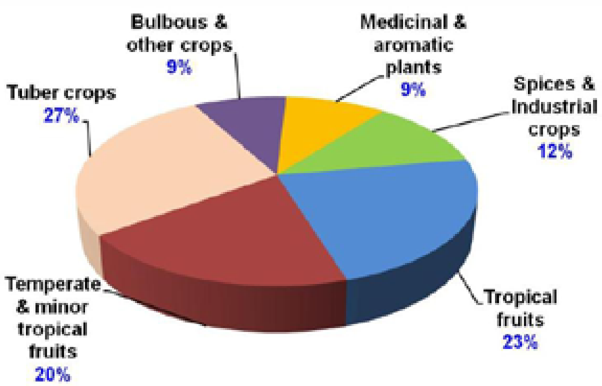


Fig. 7.1 Graphical representation of germplasm collections of major crop groups in the *In Vitro* Genebank (Dec. 31, 2021)

Germplasm augmented for its conservation in IVAG/IVBG during the year comprised accessions of *Allium negianum* (1), *A. przewalskianum* (1), *A. roylei* (1), *A. sativum* (26), *A. stracheyi* (1), *A. tuberosum* (1), *A. wallichii* (1), *Fragaria* sp. (8), *Actinidia* sp. (1) from ICAR-NBPGR RS, Bhowali, *Allium sativum* from ICAR-DOGR, Pune and Division of Plant Exploration and Germplasm Collection, *Curcuma* spp. (41) from ICAR-NBPGR RS, Shillong, wild *Curcuma* spp. (1) and *Curcuma longa* (1) from Bihar, *Fritillaria cirrhosa* (2) from ICAR-NBPGR RS, Shimla, *Gladiolus hybridus*, *Fragaria* x *ananassa* (1), *Prunus avium* (5) from Germplasm Exchange and Planning Unit (GEPU),

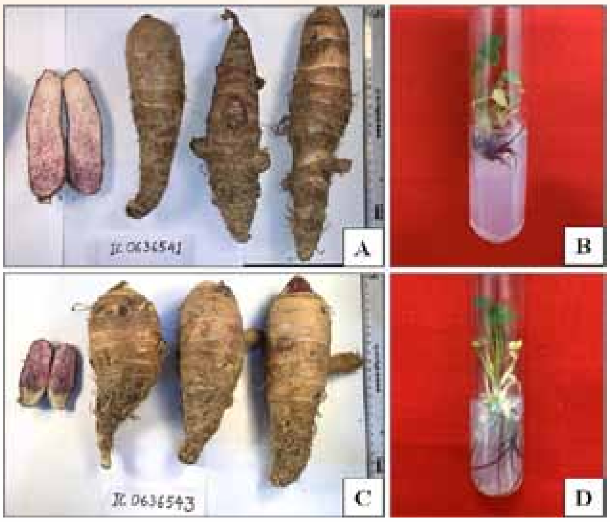


Fig. 7.2.: *In vitro* establishment of taro *(C. esculenta)* with purple coloured corm: A. Corms of accession IC0636541; B. *In vitro* culture establishment of IC0636541; C. Corms of accession IC0636543; D. *In vitro* culture establishment of IC0636543

Smallanthus sonchifolius (1) from Kinnaur, Himachal Pradesh. In addition scion sticks of *Prunus persica* (2), *P. corunuta* (4), *P. mira* (1), *P. salicina* (1), *Pyrus pashia* (1), *P. pyrifolia* (1), *Ribes* spp. (1), *Rubus* spp. (5), *Sorbus* spp. (3), *Vitis* spp (2) and *Ziziphus jujuba* (3) received from ICAR-NBPGR RS, Shimla were augmented for conservation. *Musa balbisiana* (3) in the form of seeds/infloresence were received from Valmiki Tiger Reserve, West Champaran Dt., Bihar (KP/PR/21-04 and KP/PR/21-50) and Karnataka (PPS/21-29) for its long-term conservation.

Based on the collections received, 21 accessions were added to the IVAG. These were *Colocasia esculenta,* purple colored corms (2) (Fig.7.2), *Garcinia gummi-gutta* (1), *Malus domestica* (2), *Prunus* spp. (12), *Pyrus communis* **(2),** *Smallanthus sonchifolius* (1) and *Zingiber whitianum* (1).

7.1.2 *In vitro* cryobanking

Based on protocols developed earlier, cryobanking was continued in 9 accessions of *Dioscorea deltoidea* (IC527296, IC527299, IC527300, IC527303, IC527304, IC527307, IC527310, IC527313 and IC582604). Cryobanking was initiated in one new accession of *Colocasia esculenta* (IC317643), *Dioscorea floribunda* (IC202365), *Fragaria* x *ananassa* (EC381255) and *Fragaria chiloensis* (EC560170), *Garcinia indica* (IC0638184) and two accessions of *A. sativum* (IC613375, IC627868) and *D. deltoidea* (IC527309, IC527312) using shoot tips. The status of germplasm cryobanked in the IVBG is given in Table 7.2.

In vitro germplasm supply and hardening

Thirty accessions of *Morus* spp. (hardened potted plants) including one accession of *Morus indica,* regenerated from cryopreserved shoot tip were supplied to Division of Germplasm Evaluation for establishment at field genebank at Issapur.

Table 7.1. Status of *in vitro* conserved germplasm in IVAG/IVBG (as on December 31, 2021)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)	No. of accs added during 2021	Major collections (no. of accessions)
Tropical fruits	2	16	9,000	**444**	1	*Musa* spp. (443), *Garcinia gummi-gutta*
Temperate and minor tropical fruits	10	42	8,500	**380**	16	*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)
Tuber crops	5	14	7,500	**526**	3	*Alocasia indica* (4), *Colocasia esculenta* (96), *Dioscorea* spp. (153), *Ipomoea batatas* (263), *Xanthosoma sagittifolium* (10)
Bulbous and other crops	4	13	4,000	**171**	0	*Allium* spp. (157), *Dahlia* sp. (6), *Gladiolus* sp. (7)
Medicinal and aromatic plants	30	40	4,000	**185**	0	*Coleus forskohlii* (14), *Plumbago zeylanica* (15), *Rauvolfia serpentina* (16), *Tylophora indica* (10), *Valeriana wallichii* (18)

Crop group	Genera (no.)	Species (no.)	Cultures (no.)	Accessions (no.)	No. of accs added during 2021	Major collections (no. of accessions)
Spices and industrial crops jojoba)	8	24	4,300	**228**	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	**59**	**149**	**36,800**	**1,936**	**21**	

Table 7.2. Status of germplasm cryobanked in the IVBG (as on December 31, 2021)

Crop/Species	Acc.added during 2021	Total no. of accessions	Technique(s)*	Explant (s)#
Allium sativum	2	134	V, DV	ST
A. albidum	0	1	V, DV	ST
A. chinense	1	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	0	6	V, DV	ST
Colocasia esculenta	1	2	DV	ST
Dioscorea bulbifera	0	2	V	ST
D. deltoidea	11	12	V	ST
D. floribunda	1	1	V	ST
Ensete glaucum	0	2	AD	ZE
Fragaria x ananassa	1	1	ED	ST
F. chiloensis	1	1	ED	ST
Garcinia indica	1	1	DV	ST
Gentiana kurroo	0	3	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
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

Crop/Species	Acc.added during 2021	Total no. of accessions	Technique(s)*	Explant (s)[#]
Rubus hybrid	0	6	ED	ST
Vaccinium ovatum	0	7	ED	ST
Total	**19**	**297**		

*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

Fragaria vesca (1) was supplied to PQD for research purpose. Hardened plants of *Rubus* (2) to ICAR-NBPGR, RS, Shimla, *Rubus* (24), *Fragaria* (2), *Pyrus* (1) to ICAR-NBPGR, RS, Srinagar for field genebank establishment and evaluation. Thirty eight exotic accessions of *Musa* were supplied as *in vitro* cultures to NRC for Banana, Trichy, for field evaluation and research work. In addition, 13 samples of seeded *Musa* and *Ensete* were supplied to Dept of Botany, University of Delhi for basic research.

Supportive Research

7.2.1. *In vitro* shoot multiplication/ micropropagation protocols

Somatic embryogenesis in *Bunium persicum:* Black cumin, commonly known as *Kala Jeera* is a member of family Apiaceae and native to the cold temperate regions of the Europe and Central Asia. Poor seed germination and long seed cycles make this plant species recalcitrant for germination under field conditions. Cotyledon segments excised from *in vitro* germinated seedlings were used as explants and callus induction was maximum on MS media fortified with 0.5 mg/L TDZ + 0.1 mg/L NAA, whereas, MS media fortified with 0.15 mg/L NAA was found to be the best for high frequency *in vitro* somatic embryogenesis in black cumin (Fig. 7.3).

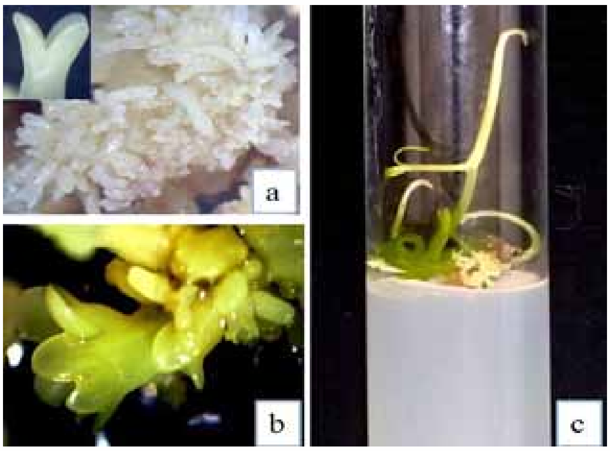


Figure 7.3. Somatic embryogenesis in *B. persicum*, a) embryogenic calli b) proliferating somatic embryos c) plantlet development

In vitro* initiation of *Fritillaria cirrhosa (Syn.: *F. roylei*)**:** Bulb scales (basal and distal scale of around 1.0 cm segments) of *F. cirrhosa* were inoculated on MS media supplemented with various concentration of BAP, NAA and 2iP. Small bulblets with single green shoot along with roots initiated 10 weeks on MS + 0.5 mg/L BAP + 0.1 mg/L NAA upon transfer of cultures from 25±2°C under 16h photoperiod and 8h dark to 22/5°C with 16h photoperiod and 8h dark. Experiments are continuing to induce multiple shoots.

In vitro* multiplication of *Piper longum (TCR 212): *In vitro* slow growth cultures were used as source of plant material for developing a protocol for rapid *in vitro* multiplication in *P. longum*. Nodal segments were used as explants and were cultured onto MS media combinations of different concentrations of BAP and Kn. Cultures were observed for induction of multiple shoots and shoot elongation. Best response for multiple shoot induction and longest shoots was recorded on medium supplemented with 6.97 µM Kn (Fig. 7.4).

Fig 7.4.: *In vitro* multiplied plants of *P. longum*

***In vitro* multiplication of *Sauropus androgynous* (IC636692):** Experiments were

Fig. 7.6. *In vitro* establishment of *X. sagittifolium*

initiated in *Sauropus androgynous* for *in vitro* multiplication/regeneration using nodal segments. Of the various media tested, in ~70% cultures multiple shoots (2-3 shoots) were developed on B5 medium supplemented with BAP (1.0 mg/L) and NAA (0.1 mg/L).

***In vitro* establishment of *Smallanthus sonchifolius* (IC644477):** The pot-grown tubers were washed under the tap-water to remove soil debris followed by suspending the pieces of tubers and shoot tips in a solution containing 1% cetrimide, 1% bavistin, 0.1% streptomycin with 4-6 drops of Tween-20 for 20 min. The explants were washed with distilled water 4-5 times followed by treatment with mercuric chloride (0.1%) for 5 min. followed by rinsing with sterile double distilled water. Initially all the cultures were streaked on nutrient agar medium to test for any bacterial contamination before establishment. Clean cultures which were showing no contamination were successfully established on MS medium supplemented with BAP and NAA (Fig. 7.5).

Fig. 7.5: *Smallanthus sonchifolius* (ground apple) A. Tubers; B. Sprouted tuber in the net house; C. Shoot tip collection from the cleaned tubers; *D. In vitro* establishment of aseptic cultures.

Shoot multiplication of *Syzygium cumini*: *Accession* IC0638187 was collected from Goa in the year 2018, seeds being highly recalcitrant, showed sensitivity to desiccation and freezing. Shoot multiplication medium was optimized for this species. Maximum shoot multiplication (13 ± 5 shoots/explant) was observed with 2.22 µM BAP. Shoot elongation was achieved by transferring the multiplied shoots to the MS medium containing 0.2% charcoal. These *in vitro* multiplied shoots will be used further for conducting long-term conservation experiments in this highly recalcitrant fruit crop.

***In vitro* establishment of *Xanthosoma sagittifolium*:** Commonly known as 'arrow elephant ear', 'cocoyam' or 'tania' is a herbaceous, perennial vegetatively propagated plant. It produces an edible, starchy corm and is rich in carbohydrates, vitamin B6, copper, iron and potassium. Shoot tip explants of accession IC582689 were cultured onto MS basal medium and MS medium supplemented with 32 different concentrations of plant growth regulators including BAP, TDZ, Kinetin and NAA. Overall, the media containing combinations of NAA and BAP gave best response (Fig.7.6).

***In vitro* establishment of *Zingiber neesanum* and *Z. whitianum*:** *In vitro* cultures of *Z. neesanum* (JP/20-1) and *Z. whitianum* (JP-20-18), collected from the Anamalai Hills of Western Ghats, Kerala, were established using embryos as explants. Seeds were surface sterilized using 2% bavistin for 30 min and 0.05% mercuric chloride for 10 min. Embryos were excised and cultured onto MS medium supplemented with 11.11 µM BAP. Plantlets were successfully established *in vitro* in both the species (Fig. 7.7).

Re-introduction and re-establishment of long-term *in vitro* conserved germplasm of *Curcuma* spp.: Long term *in vitro* conserved plants were transferred to the net house after hardening. Cultures were initiated from shoot tip explants of field growing plants (18 accessions). Explants were surface sterilized with 0.2% bavistin for 20 min followed by 0.5% mercuric chlorite for 30 min and cultured onto MS medium supplemented with 11.11 µM BAP. Established cultures are being routinely subcultured and conserved.

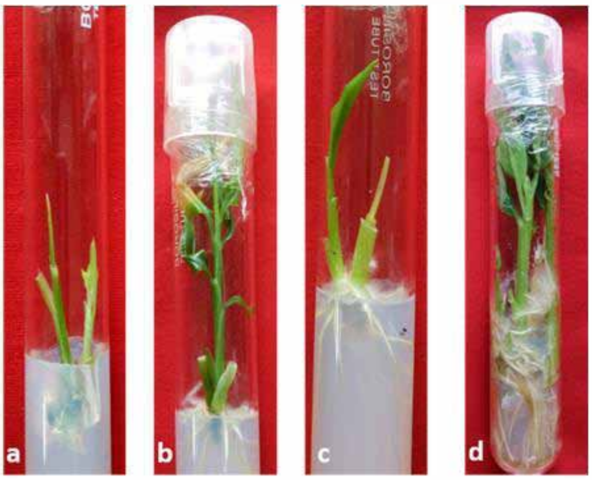


Fig. 7.7. *In vitro* establishment of *Z. neesanum* (a-b) and *Z. whitianum* (c-d)

7.2.2 *In vitro* slow growth conservation

***Fragaria* sp.:** To compare shelf life of cultures in two growing conditions (low temperature and room temperature), 23 accessions of *Fragaria* x *ananassa* were conserved for six months. Under normal growth condition (standard culture room), 11.32% cultures showed drying and 7.08% cultures were found contaminated with fungus. While 88.67% cultures showed survival but needed subculture as media was getting brown. At low temperature (8°C) 100% cultures were green and no contamination was observed. Experiment is continued for further optimization.

7.2.3 *In vitro* cryopreservation protocols

***Allium* spp.:** Cryopreservation experiments continued in *A. hookeri* (IC557018), shoot tips sourced from 4wk–old cultures on SM medium, precultured on SM medium with 0.3M sucrose at 5°C, treated with a loading solution for 30 min,

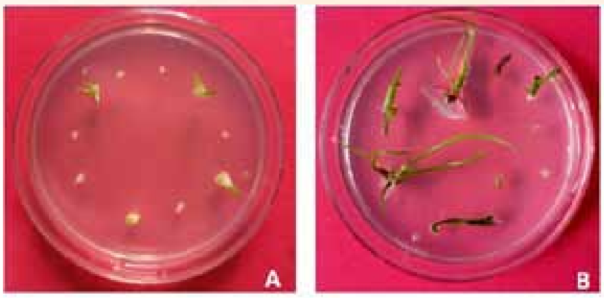


Fig. 7.8: Post-thaw regrowth (A) *A. hookeri* and (B) *A. schoenoprasum*

Fig 7.9. Post-thaw regrowth in D. deltoidea

dehydrated with plant vitrification solution (PVS2) for 17 min, improved post-thaw regrowth using droplet-vitrification (40 - 50 %) was obtained. Cryopreservation experiments were conducted in *A. schoenoprasum* using DV protocol. Following pre-growth of shoot tips on MS + 0.1 NAA + 0.5 BAP for 8 week (25 °C for 4 week and 22/5 °C for 4 week), pre-culture for three days on MS + 0.3 M sucrose, loading solution treatment for 30 min, PVS2 dehydration for 45 min, post-thaw regrowth of 40-50% was obtained (Fig.7.8). Cryopreservation experiments were done with 26 accessions of *A. sativum* using DV technique. Post-thaw survival of shoot tips (isolated from cloves), ranged from 0-100% and shoot regrowth varied from 0-70%.

***Artocarpus lakoocha*:** Experiments were initiated to standardize cryopreservation protocol for lakoocha using vitrification technique. About 40% survival and regrowth were obtained in PVS2 control (20 min exposure) and 20% regrowth of

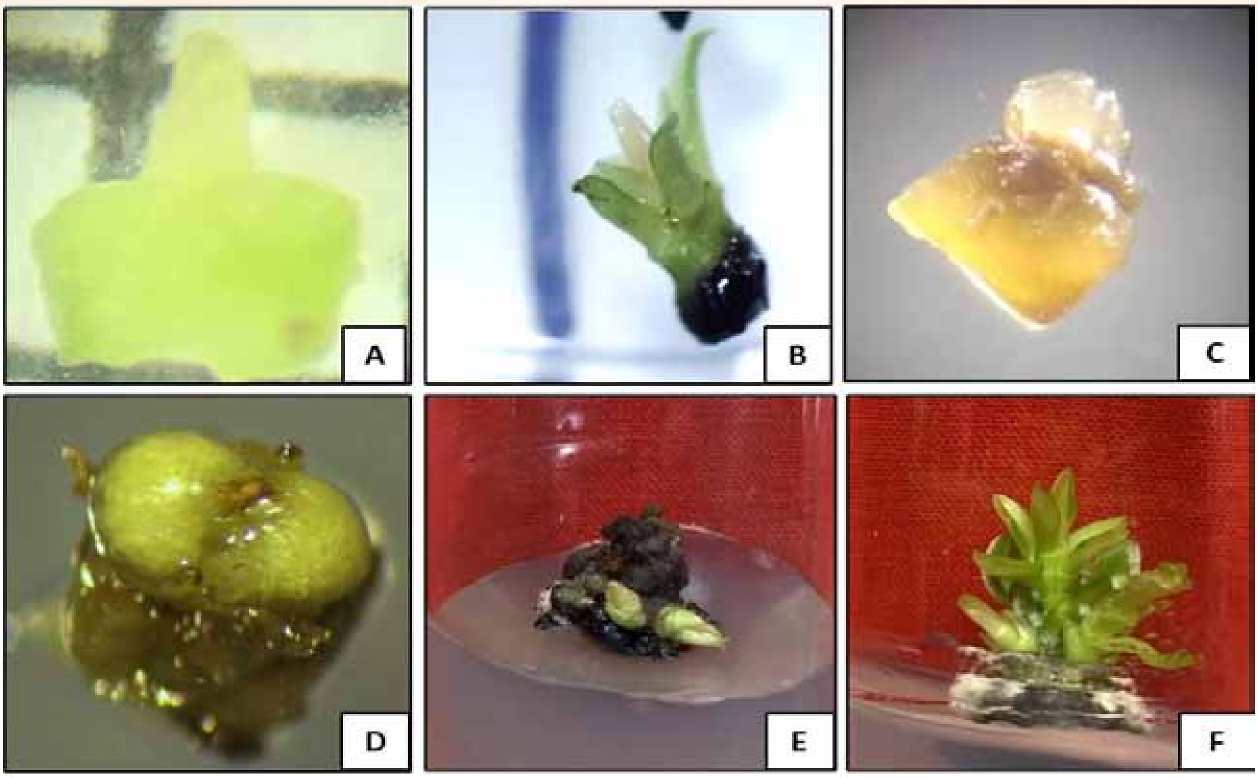


Fig. 7.10. Cryopreservation of *G. indica*. A. Apical shoot-tip; B. Shoot induction and survival at 40 min. PVS2 treatment; C. Surviving ST after LN exposure and thawing; D-F. Shoot regeneration and proliferation after droplet vitrification.

LN treated shoot tips using vitrification. However, no survival and regrowth were obtained in PVS2 control and LN treated shoot tips in 40- and 60-min of PVS2 exposure.

***Dioscorea deltoidea*:** Is a critically endangered high medicinal plant. Shoot meristems excised from 4-wk-old *in vitro* plantlets were precultured on MS medium containing 0.3 M sucrose for 16 h, treated with a loading solution for 20 min, dehydrated with plant vitrification solution (PVS2) for 90 min and cryopreserved using both vitrification and droplet-vitrification protocols. Genotype dependant variation in post-thaw regrowth ranging from 30% (Dd12) to 53.9% (Dd06) using V and 21.1% (Dd09) to 50.6% (Dd15) using DV was observed. The vitrification protocol has been implemented for long-term cryobanking of *D. deltoidea* germplasm **(Fig. 7.9).**

***Fragaria vesca*:** Cryopreservation experiments in *Fragaria vesca* (IC319113) were initiated using *in vitro* shoot tips. Post-thaw regrowth of 66% was obtained when 3-wk cold acclimatized shoot tips were cryopreserved using V-cryoplate method.

***Garcinia indica*:** Apical and axillary meristems of *G. indica* (IC638183) were cryopreserved using vitrification (V) and droplet-vitrification (DV) techniques. DV was found to significantly improve the survival of the cryo-retrieved shoot-tips as compared to the V technique. Highest survival (70-80%) of 2 mm long apical shoots collected from 24-wk-old explants was observed when exposed to loading solution at 0 °C for 20 min. followed by 40 min. PVS2 treatment at 20°C, exposure to liquid nitrogen by DV and thawing in recovery solution for 15 min. Shoots without any preculture treatment were found to respond well following this protocol, with regeneration rates of 40-60% on MS medium supplemented with 2.22 µM BAP followed by shoot multiplication at 8.88 µM BAP and 2.68 µM IAA **(Fig. 7.10).**

***Ipomoea batatas*:** Cryopreservation experiments of *Ipomoea batatas* (EC55040 and IC399226) were initiated using droplet vitrification protocol. Control plants showed 100% survival and regeneration whereas, vitrification control showed only 40% survival with callusing. No regeneration was observed in LN treated samples.

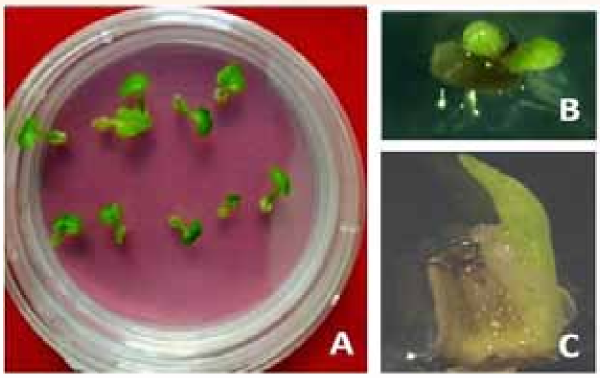


Fig. 7.11. Cryopreservation in *P. longum*. (A) Control (B-C) Post-thaw regrowth

***Morus indica*:** Experiments were initiated to standardize cryopreservation protocol for mulberry using vitrification. One-wk-cold acclimated cultures showed 50% recovery of PVS2 control (20 min. exposure) while no regrowth was observed after LN.

***Musa* AAA cv Williams:** Experiments were undertaken to assess the response of three cryopreservation techniques, Droplet Vitrification (DV), Vitrification cryo-plate (VCP) and Dehydration cryo-plate (DCP) for *in vitro* meristems in *Musa* AAA cv Williams (EC 493718) in different PVS2 dehydration exposure times (30, 60, 90, 120 and 150 min). The VCP method with mean shoot regrowth of 75.5% was found to be significantly better than that obtained from DV (63.1%) and DCP (64.8%). Taking into consideration practical aspects for each technique, any of the three cryopreservation approaches can be used for cryobanking of proliferation meristems of *Musa*, as DV offers cost-effectiveness, while VCP and DCP have ease of explant handling, and DCP avoids chemical toxicity of PVS2.

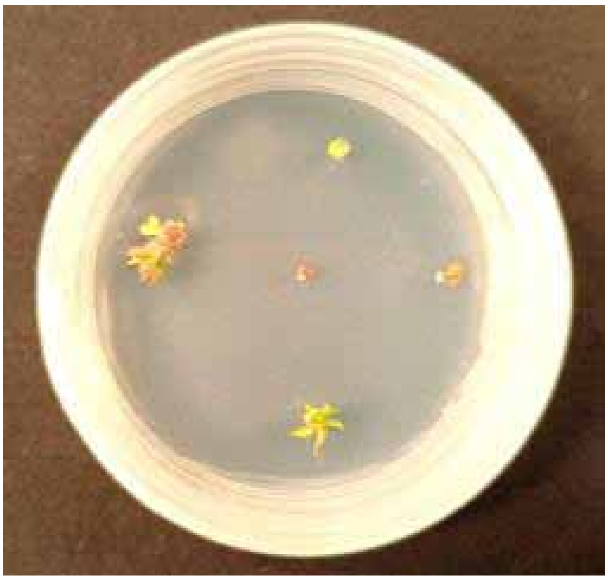


Fig. 7.12. Post-thaw regrowth in *Pyrus* spp.

***Piper longum*:** Cryopreservation of shoot tips of *P. longum* was attempted using the DV technique. Shoot tips (2 mm) isolated from one-month-old cultures were precultured for 16 h on medium containing 0.3 M sucrose. Osmotically dehydrated shoot tips were further desiccated with a loading solution for 20 min at room temperature and then treated with PVS2 for 10, 20, 30, 45 and 60 min to ascertain the optimal cryoprotectant dehydration regime. Control shoot tips showed 100% survival and regeneration while PVS2 exposure of 10 min was found to be optimal for post-thaw shoot tip survival (100%) and regeneration (20%) (Fig. 7.11).

***Pyrus communis*:** Cryopreservation experiments were conducted in *Pyrus communis* (EC560219) using DV technique. Following pre-growth of shoots on MS + 1.0 mg/L BAP + 2.0 mg/L thiamine for 10 wk (25°C for 5 wk and 22/5 °C for 5 wk) followed by pre-culture of shoot tips for three days on MS + 0.5 M sucrose medium, post-thaw regrowth of 40% with 60 min. of PVS2 dehydration **(Fig.7.12)** was achieved.

7.2.3 Genetic stability analysis of cryopreserved germplasm

Transcriptomic studies during *Musa* cryopreservation : *Musa* AAA cv Borjahaji (IC 250462) was selected for transcriptomic studies during four stages of cryoprotocol, using DV technique. Two bioreplicates [control (C), high sucrose (0.4 M) pre-culturing (T1), LS + 60 min PVS2 treatment (T2), LN treatment and thawing in RS (T3)] were selected for transcriptome analysis using RNA-seq. After mapping to the

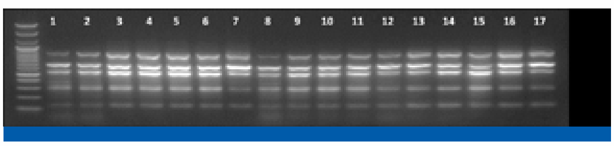


Fig. 7.13. Representative gel image of amplification of accession EC562093 with ISSR primer UBC-848; Lane L: 100bp DNA marker; 1-2 - Mother plants; 3-5 - 0.3M sucrose control; 6-8 –LN - encapsulation controls; 9-11 - 0.75 sucrose controls; 12-14 - air dehydration controls; 15-17 - cryo preserved plants using encapsulation-dehydration

banana reference genome, a total of 201 (T1 vs. C), 213 (T2 vs. C), 133 (T3 vs. C), 8 (T1 vs. T2), 13 (T2 vs. T3) and 17 (T1 vs. T3) were identified as differentially expressed genes (DEGs). Compared to control tissue (C), all the treatments (T1, T2, T3) showed 70 common DEGs, out of which 34 were up-regulated and 36 down-regulated. Thereafter, GO (gene ontology) enrichment analysis was done on three terms i.e. biological process (BP), cellular components (CC), molecular functions (MF) using UniProt database. Significantly enriched KEGG pathways were identified according to the P-value cut off (FDR) <0.05 from ShinyGO database. The activation of *EIN3* and members of the GRAS families transcription factors (role in response to oxidative stress) and very-long-chain 3-ketoacyl-CoA synthase (participate in enhancing the membrane integrity) were observed in T1 (high sucrose pretreatment). In T2, genes related to sugar-proton symporter (Putative polyol transporter 1) and stress reponses (Zinc finger A20 and AN1 domain & C3H1-type domain-containing protein) were involved and indicates their role in optimization of cellular metabolites and tolerance to severe desiccation, oxidative and chemical toxicity of PVS2 and they may be involved in recovery from stress-induced injuries. High fold expressed DEGs in T3 were involved in regulation of gene expression (factor Y subunit C-6-like protein), in fatty acid biosynthesis to control membrane stability (very-long-chain 3-oxoacyl-CoA synthase) and in regulation of signaling response (nucleolar GTP-binding protein 1-like). In pathway analysis, biosynthesis of secondary metabolites pathway was regulated in all treatments (T1, T2 and T3), five pathways of EIN 3-like 1 protein, biosynthesis of cofactors, MAPK signaling pathway, ascorbate and aldarate metabolism and fatty acid elongation were common in T1 and T3, and two pathways of 3-ketoacyl-CoA synthase 6-like and plant-pathogen interaction were common in T2 and T3. This is a first-of-its-kind study on higher plant cryopreservation and is expected to help in devising improved cryoprotocols in future.

Genetic stability analysis of cryopreserved *Vaccinium* germplasm

Three accessions (EC562093, EC562078, EC562091) of *Vaccinium* spp. cryopreserved using encapsulation-dehydration technique were compared to their respective mother plants for testing their genetic stability using 49 ISSR primers. No significant variation was observed between the banding profiles of *in vitro* multiplied material (tissue culture controls); plants used as cryopreservation

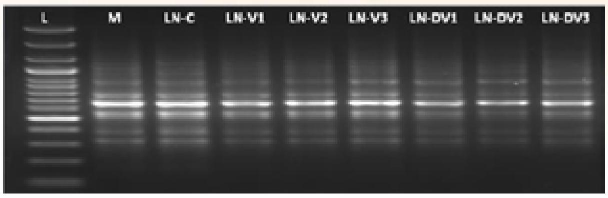


Fig. 7.14. Representative banding profiles of plants obtained by ISSR primer IS53. L-100bp DNA marker; M- in vitro mother plant; LN-C - PVS2 control; LN-V1-V3 – plants conserved by vitrification; LN-DV1-DV3 - plants conserved by droplet vitrification

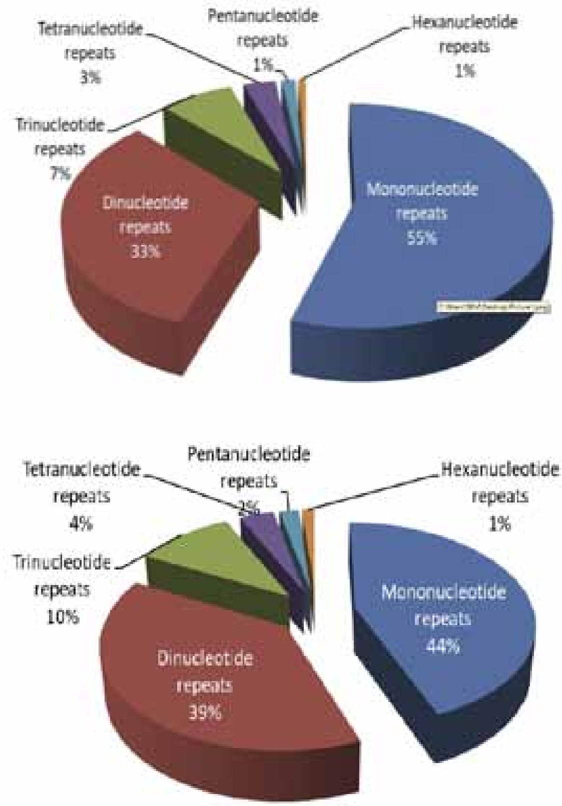


Fig. 7.15. SSR counts and length distribution for each type

controls; and cryopreserved plants. High levels of genetic similarity were observed between the plants of the same accession, indicating no loss of genetic stability of the plants at the tested loci (Fig. 7.13).

Genetic stability analysis of cryopreserved *Colocasia esculenta* plants using ISSR markers A total of 38 ISSR primers were used for analysis of genetic stability of *Colocasia esculenta* (IC317585) plants regrown post cryopreservation using two different techniques, namely, vitrification and droplet vitrification. The banding patterns of the cryopreserved plants were compared to the mother plants and the tissue culture controls and analysis revealed an overall similarity level ranging from 95-100%. No significant variation was detected at the tested loci among the analysed plants (Fig.7.14).

Development of genomic SSR markers for *B. persicum*

Sequencing of genome of *B. persicum* accession IC630572 was done on Illumina (Hiseq 3000). The assembled singleton sequences were used for mining of genomic SSRs using the Krait software. The search criteria for identifying SSRs was restricted to minimum 10 for Mono-, 6 for Di-, 5 for Tri, 4 for Tetra-, 4 for Penta-, 4 for Hexa-, nucleotide motif, respectively.

A total of 1,77,029 perfect SSR motifs were identified in 2,12,585 assembled sequences. SSRs were found to be with an average length of 15.04 bp and relative abundance of 299.41 loci/Mb. Mono-nucleotide repeats were most abundant followed by di-, tri, tetra-, penta- and hexa-nucleotide repeat motifs (Fig. 7.15). Primers were designed for the identified SSRs using the Primer3 script integrated within Krait. A total of 101,519 primers were designed for sequences containing repeat motifs and from these 88 primers were synthesized from di-, tri-nucleotide and hexa-nucleotide repeat motifs for validation. Genomic DNA was extracted from seeds of 25 accessions of *Bunium persicum* and PCR conditions were optimized for each primer pair. Out of these 88 primer pairs, 68 pairs gave scorable amplification (Fig. 7.16).

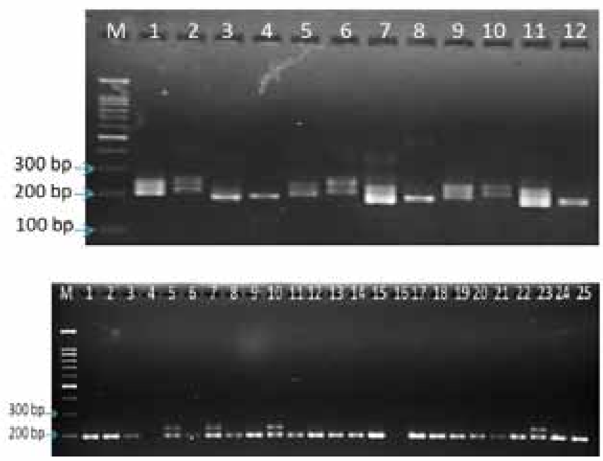


Fig 7.16. a) Gradient PCR for primers SSR2202, 3206, 4651, 16432 at annealing temperature 55.2 (Lane 1-4), 58.6 (Lane 5-8) and 59.8°C (Lane 9-12), respectively; b) Gel image of amplification profile of 25 accessions with primer pairs for SSR15244

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

7.3.1 Germplasm augmentation and cryostorage

Germplasm augmentation and cryostorage: A total of 12,137 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); (Fig.7.17). Germplasm was augmented in the form of fruits/seeds (12 mostly grown wild) from various exploration missions and dormant buds of walnut (8), almond (11), scion sticks of *Juglans regia* (4), *Corylus jacquemontii* (1), *Parthenocissus quinquefolia* (1), *P. tricuspidata* (1) and *Stauntonia latifolia* (1) from ICAR-NBPGR RS- Shimla for conducting long-term conservation studies. During the period, a total of 231 accessions of diverse germplasm comprising fruits and nuts, industrial crops, medicinal, 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.

Table 7.3 Status of cryopreserved germplasm (as on 31st December 2021)

Categories	No. of accessions added in 2021	Total Accessions (no.)
Recalcitrant & Intermediate		
Fruits & Nuts	146	3,818
Spices & Condiments	59	223
Plantation Crops	0	121

Categories	No. of accessions added in 2021	Total Accessions (no.)
Agroforestry & Forestry	0	1,645
Industrial crops	0	1,343
Medicinal & Aromatic Plants (incl. Orchid)	01	48
Total	206	7,198
Orthodox		
Cereals	0	289
Millets and Forages	0	293
Pseudo-cereals	0	76

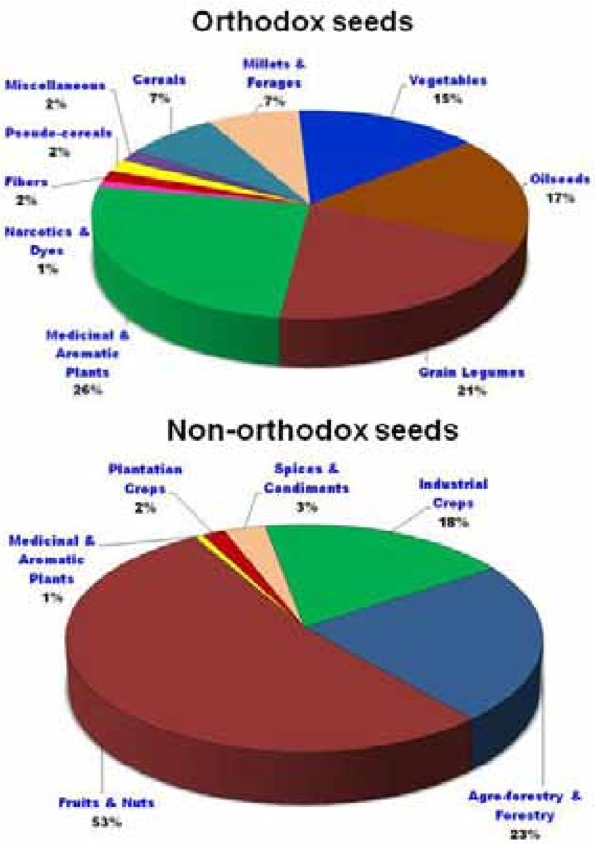


Fig 7.17. Graphical representation of germplasm collections of major crop groups in the Cryogenebank (Dec. 31, 2021)

Categories	No. of accessions added in 2021	Total Accessions (no.)
Grain Legumes	0	813
Oilseeds	0	682
Fibers	0	68
Vegetables	0	587
Medicinal & Aromatic Plants	0	1,013
Narcotics & Dyes	0	35
Miscellaneous	0	78
Total	0	3,934
Dormant buds	0	389
Pollen grains	25	616
Total	**25**	**12,137**
Genomic resources	**0**	**2194**

7.3.2 Basic Studies on germplasm

Studies on desiccation and freezing sensitivity of germplasm

Studies on seed viability, moisture content, desiccation and freezing sensitivity were conducted on different species *Aegle marmelos* (3), *Annona reticulata* (2), *Bunium persicum* (64), *Buchanania lanzan* (24), *Elaeis guineensis* (35), *Pithecellobium dulce* (2), *Ziziphus mauritiana* (7) and *Z. nummelaria* (4) including 12 new species *viz.,* *Catunaregam spinosa* (1), *Cotoneaster affinis* var. *bacillaris* (1), *Crataegus laevigata* (1), *C. pseudoheterophylla* (9), *C. songarica* (5), *Dillenia indica* (1), *Fritillaria roylei* (9), *Limonia acidissima* (1), *Prunus cerasifera* (3), *Spondias pinnata* (1), *Strychnos nux-vomica* (1) and *Tamilnadia uliginosa* (1). *Limonia acidissima* (7.5% MC; Fig. 7.18) and *Tamilnadia uliginosa* (7.9% MC) revealed non-orthodox seed storage behavior, as the viability of the seeds reduced drastically below the critical MC (shown in paranthesis). Seeds of

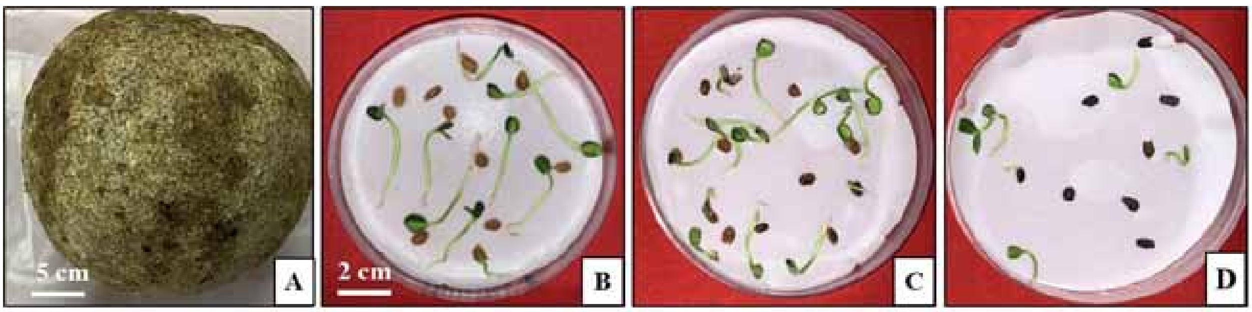


Fig. 7.18. Long-term storage studies in Limonia acidissima: A. Fruit; B. Germination in fresh seeds (53% MC; 90% viability); C. 12 h desiccated seeds (7.5% MC; 85% germination post LN); D. 24 h desiccated seeds (3% MC; 35% germination post LN)

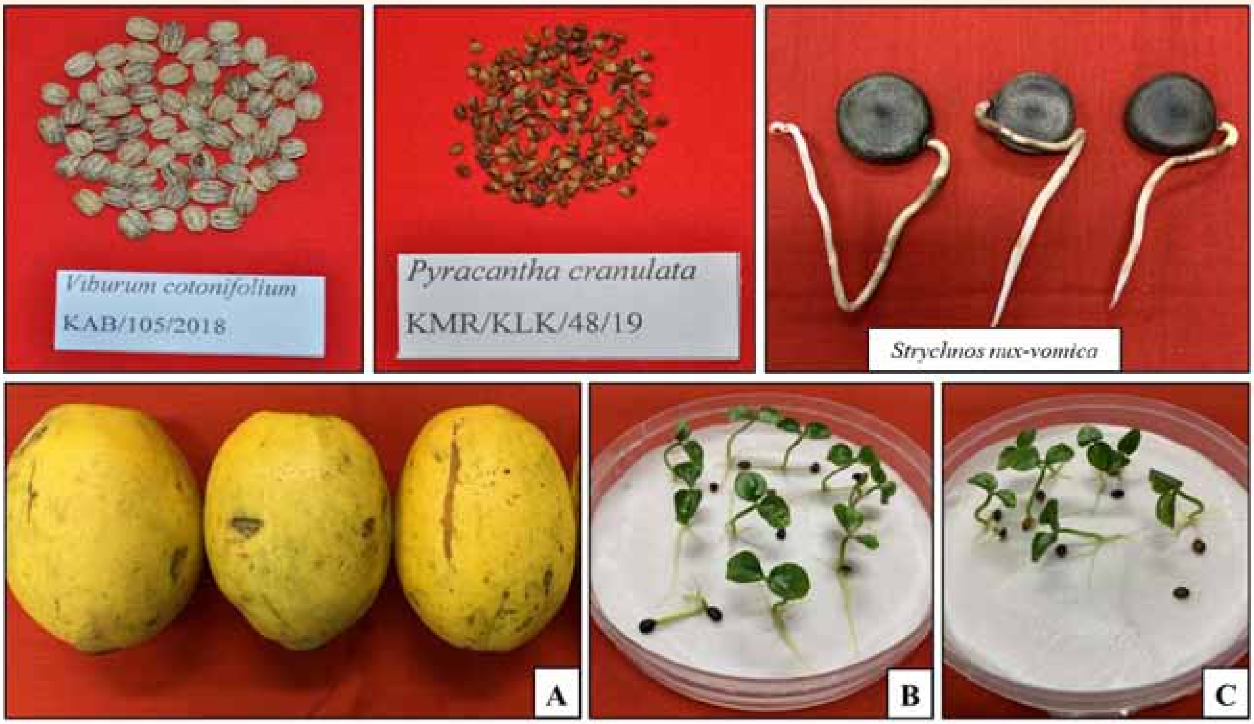


Fig 7.19: Long-term storage in *Tamilnadia uliginosa:* A. Fresh fruits (seeds with 24.23%MC; 90% germination); B. 12 h Desiccated seeds; C. 12 h desiccated seeds post LN treatment (7.9% MC; 70% germination).

these species showing good post-thaw viability were further cryobanked for LTS. *Strychnos nux-vomica*, *Dillenia indica* and *Catunaregam spinosa* seeds showed orthodox seed storage behaviour as they could be conserved for long-term in LN at a critical MC of 4%. Seeds of *Spondias pinnata* are covered with dense network of hard tissues posing difficulty in seed extraction and difficult for long-term conservation through cryobanking. Seeds of wild turmeric (*Curcuma* spp. – Collector No. KP/PR/21-03) collected from West Champaran Dist. of Bihar were studied for their tolerance to desiccation and freezing to explore the possibility of their conservation by cryopreservation. Fresh seeds had high moisture content (46.53%) and viability and retained their viability post LN storage when desiccated to 13.48% MC.

Fig. 7.20: Post-cryo viability of conserved germplasm of a) *Pithocellobium dulce* (freshly cryostored); b) *Capparis decidua* (after 5 yrs. of cryostorage)

Seed physiological studies

Seed dormancy breaking protocol was standardized in *Dillenia indica, Strychnos nux-vomica* and *Tamilnadia uliginosa*. Chemical scarification using 25% HCl for 10 min. was found to break the seed coat dormancy in *Tamilnadia uliginosa.* Seed germination in *Strychnos nux-vomica* was enhanced with incubation in GA_3 (100 ppm) for 5 hrs. In *Dillenia indica*, enhanced germination was recorded when seeds were soaked in GA_3 (100 ppm) for 5 min (Fig. 7.19).

Testing health status and regeneration of cryostored germplasm

Health status of 81 accessions of 31 diverse species was checked and two were found infected. Post-cryo viability testing done for 45 accessions of fresh non-orthodox seeds and 21 cryostored accessions revealed retention of viability after 5 years of their cryostorage (Fig. 7.20).

Awards/Honours/Prizes

Publications

Figure 7.21. (A) Fruits (*Citrus medica*) from Mizoram and (B) seeds (*C. indica*) from Nagaland

New initiative

DBT funded Project "Collection, Conservation and Morpho-Phenological Characterization of Citrus Germplasm of North East Region" was initiated where 11 partners representing all the states of NE of India are participating besides ICAR-NBPGR, New Delhi and ICAR-NBPGR Regional Station, Umiam. Under this mega-network project germplasm of citrus from all the states is being collected, characterized and conserved both in the field genebanks and in the cryogenebank. Besides being one of the partners, ICAR-NBPGR is the mentor institute in this project and providing all the guidance and coordination. In these efforts two online workshops were conducted to sensitize and brief the partners about objectives and activities of the project. The launch workshop was inaugurated by the Vice Chancellor of Assam Agricultural University, Jorhat. Under the project 36 accessions were collected from various parts of Sikkim. Overall, 165 accessions were received from the partners and germplasm was processed for cryobanking. IC numbers for all the germplasm were obtained and communicated to the partners.

08

AGRICULTURAL KNOWLEDGE MANAGEMENT

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, wasaccessed 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 fewbackend functional improvements were incorporated in the past year for stability improvement. The application is running 24X7 for past eight years. During 2021, PGR Portal had 73,258 page views, at par with previous year. Google Analytics data show that 3082 users clocked >200 page views per day across 5418 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.

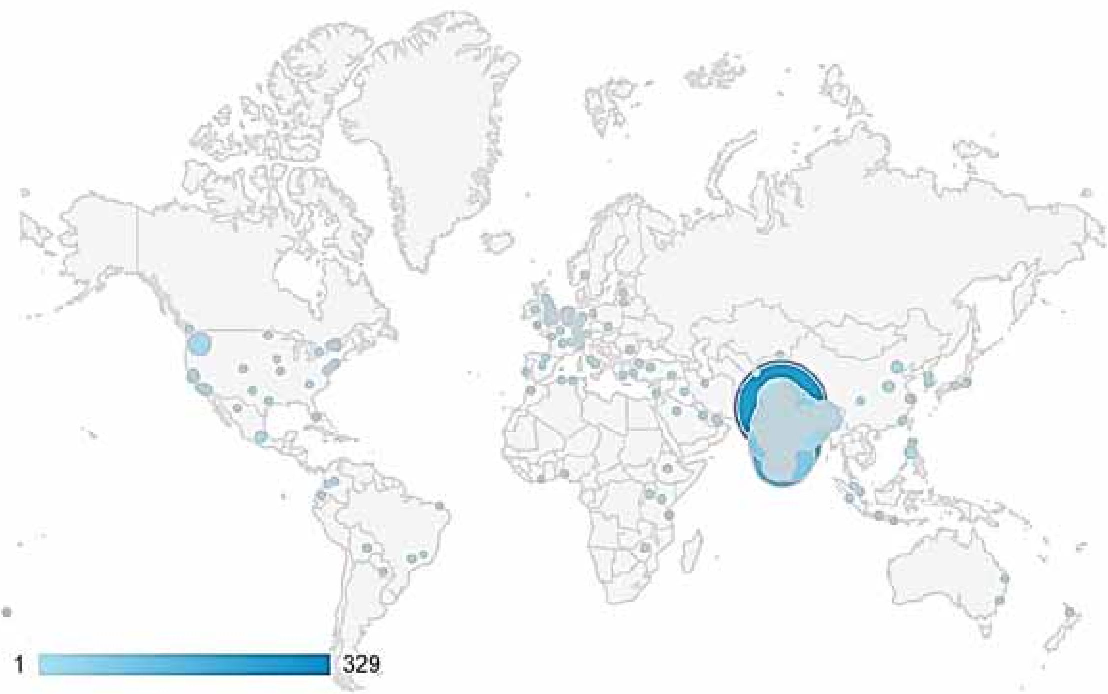
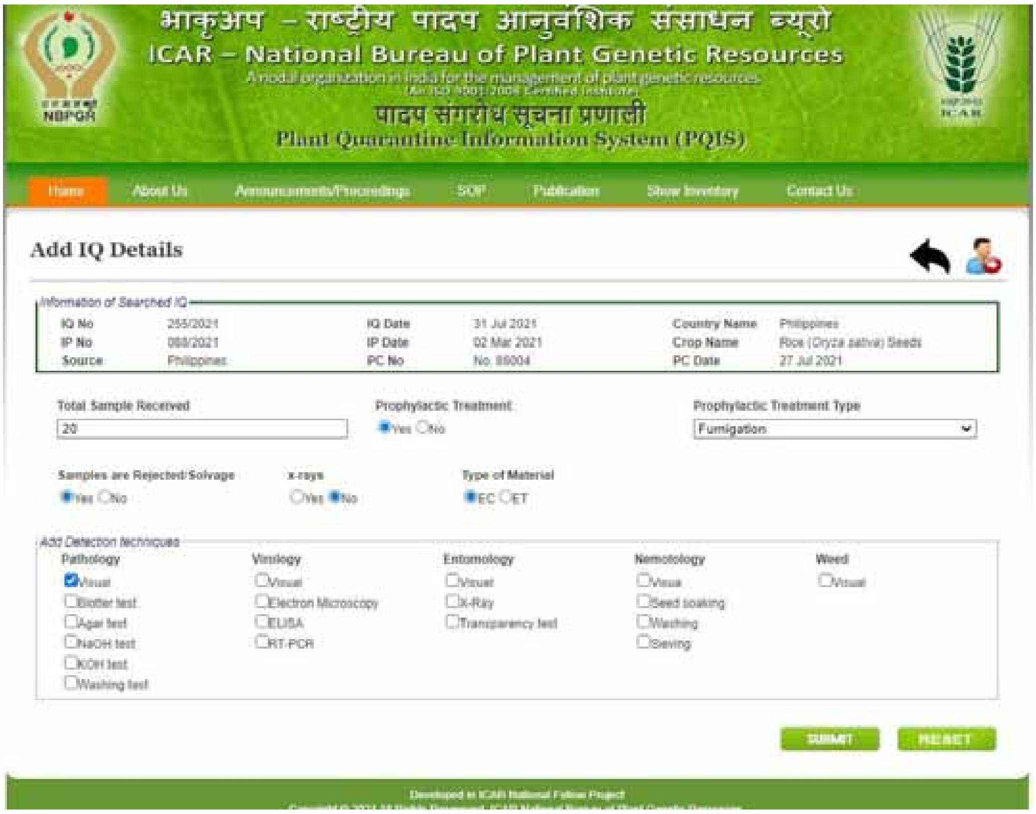
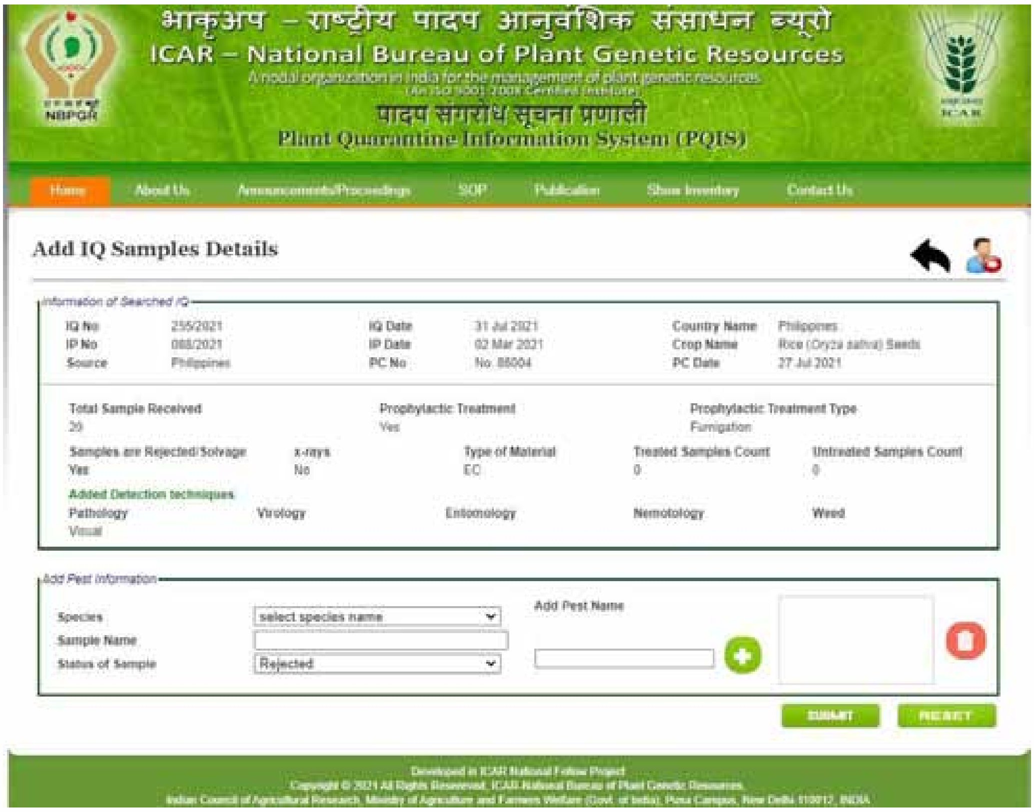


Figure 8.1. Access to PGR Portal was fromacross the world (top) and throughout 2020 (except Covid19 pandemic forced server shut-down period (bottom).*Source: Google Analytics*

8.2 Plant Quarantine Database and Web-based application

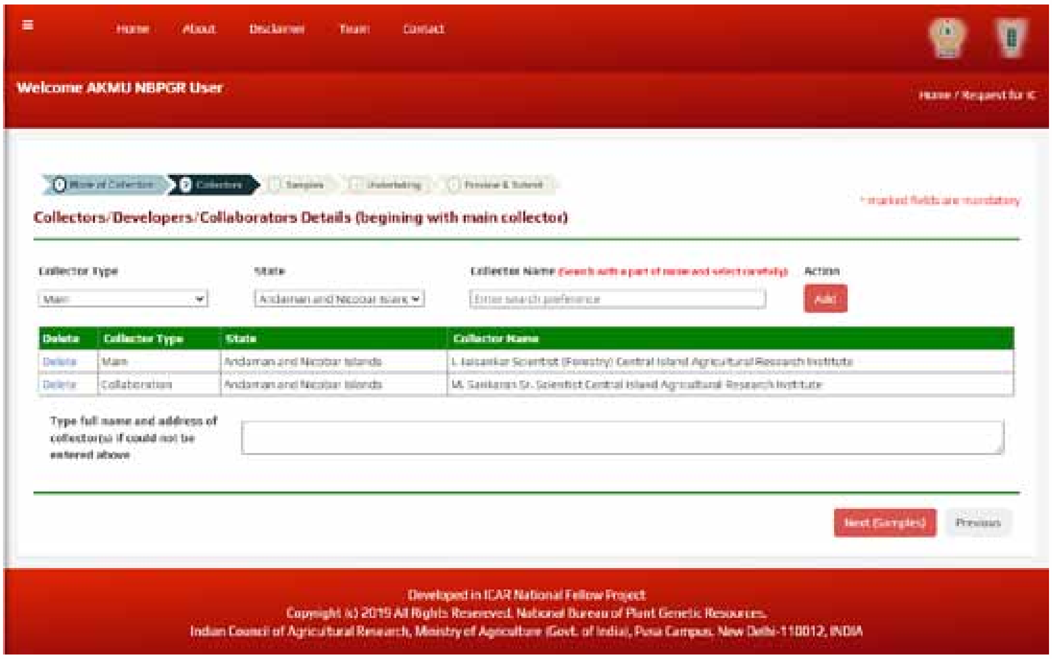
Did a feasibility-cum-system study for database development and mechanization of activities related to the Division of Plant Quarantine . Once the activity is completed, the same will be linked to the already operation web-application of Germplasm Exchange unit.

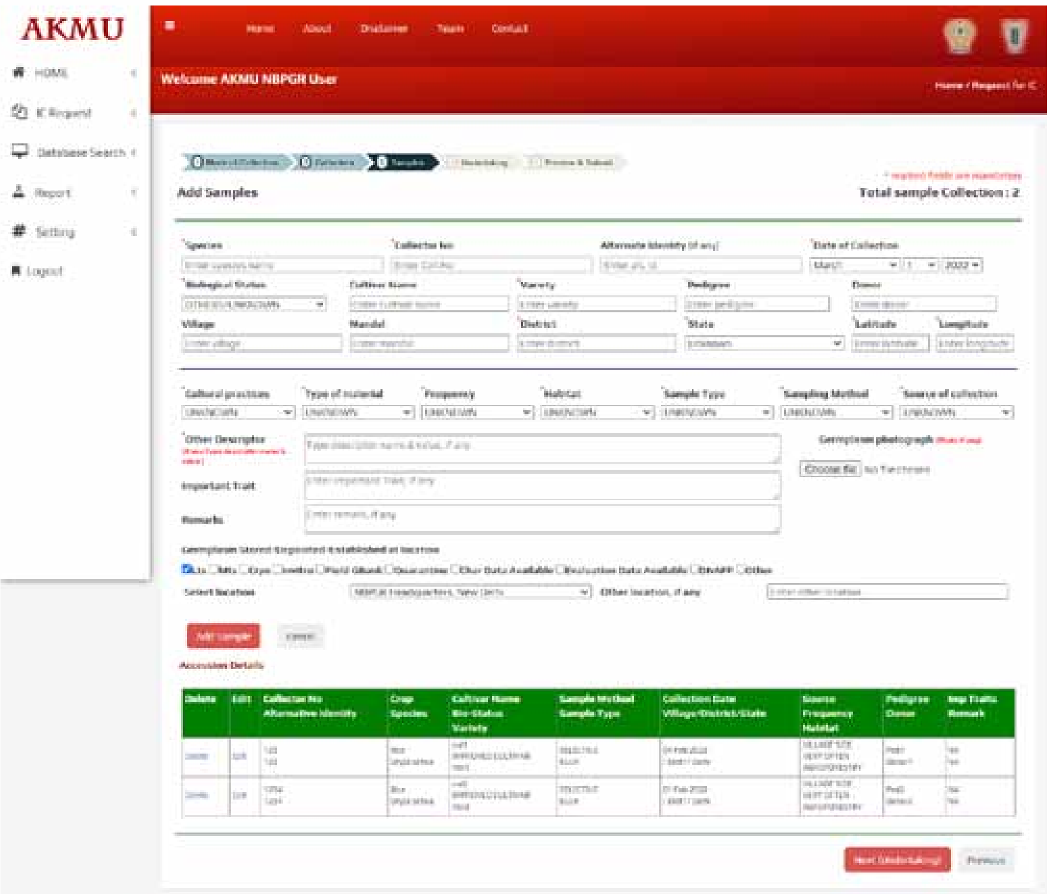




8.3 IC number allocation web-based application

Initiated work on development of a web-based software application for on-line submission of requests and allocation of IC numbers. Once completed, this activity will become totally paperless, shall provide an up-to-date running status of each IC number allocation request as well as collector/collaborator-wise reporting of germplasm collections. The application if likely to be fully tested and implemented by 31 May 2022.





8.4 Development of generalized data update pages in existing applications

With renovation of the National Gene Bank (NGB), a need was felt for bulk updates in the germplasm stored in the NGB. The activity was originally done on one accession at a time basis and was time-consuming and also needed direct support from AKMU experts. This activity has also been automated to seamlessly handle bulk changes/ updates of germplasm storage location as and when needed.

8.5 Picture Gallery in NBPGR Website

A provision exhibit multi-fold pictures pertaining to important official events in an easier slider mode was incorporated in www.nbpgr.ernet.in> Downloads >Photo Gallery Management System

8.6 NBPGR on social media: NBPGR maintains

a strong presence on the social media via the official twitter account @INbpgr. During 2021, NBPGR tweeted 523 information bits, which attracted as many as 4.3 lakh impressions. By the end of 2021, NBPGR had 1243 followers. NBPGR YouTube channel hoisted 17 events (10 live) in 2021.

8.7 Virtual Platform: AKMU managed virtual meetings, webinars, interviews, events, etc. as well as NBPGR social media. During 2021, a total of 342 virtual engagements (meetings, interviews, IRC, RAC, trainings, seminars, viva, classes, etc.) were facilitated accounting for a total of 16,559 participants.

8.8 Maintenance activities

a The unit managed and maintained NBPGR's webserver, database server, security firewall, and LAN in three series with ~400 nodes connecting computers, printers and servers at NBPGR headquarters. Antivirus software licenses (console-based with 250 users) managed to ensure data security and safety.

b Regular maintenance back-up of databases,

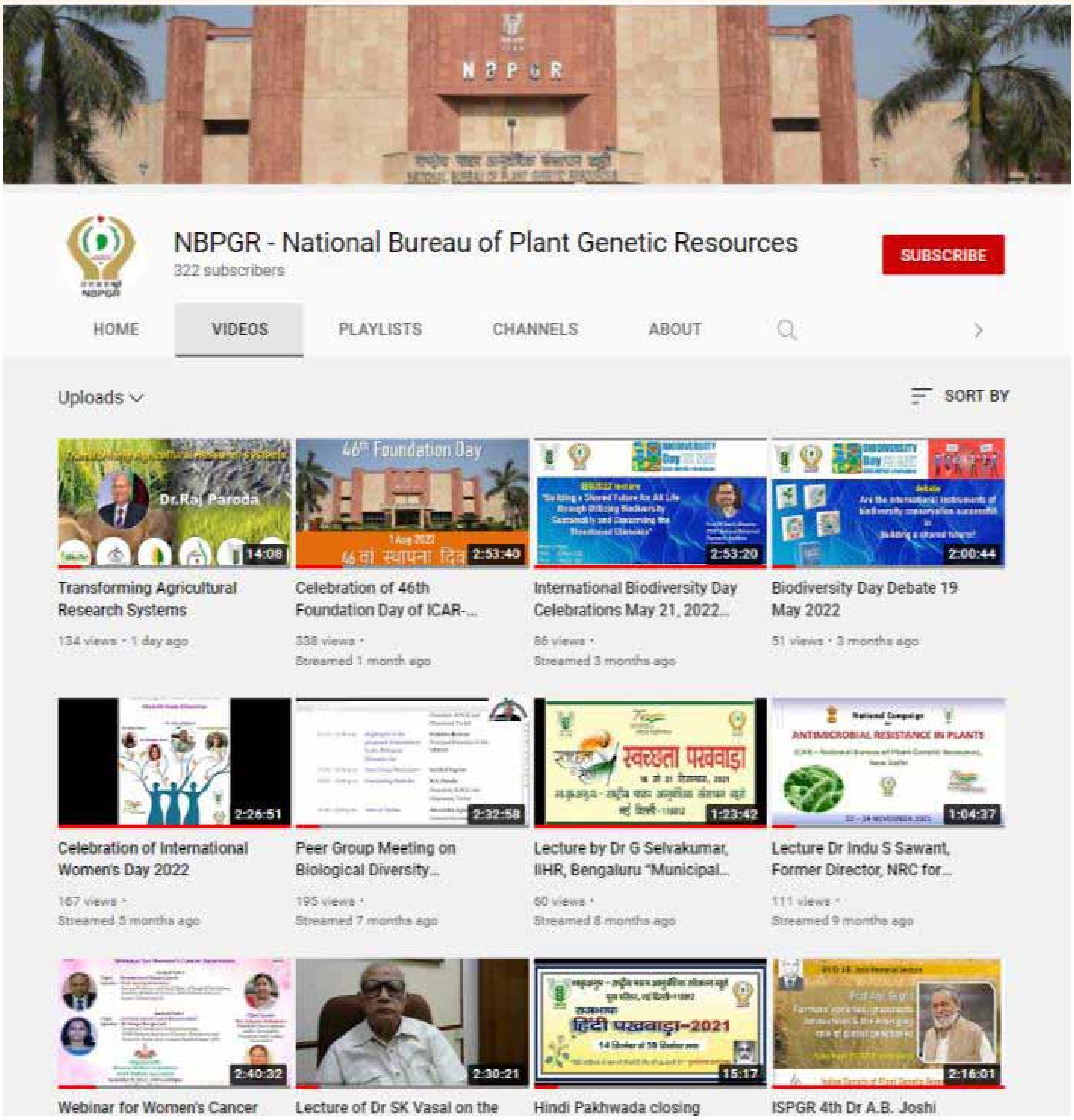


Fig. 8.2 PGR Map was launched for public use on 16 August 2021 by Honorable Minister for Agriculture Shri Narendra Singh Tomar.

Fig 8.3: PGR Clim was launched on 2 August 2021 during the 45th NBPGR Foundation Day by Prof. Paul Gepts, University of California, Davis.

NBPGR website and applications was carried out as per standard practices.

c NBPGR website was regularly updated by addition of advertisement (52), books/manuals/ bulletins (7); circulars (20); corrigendum (1); events (2); e-publications (3); newsletter (13); purchase / rate contract (3); tender (29); training (1); news (87)

8.11 Miscellaneous activities

a A virtual meeting of MTS managers, GEX unit and AKMU under the chairmanship of the Director was held on 9 July 2021 (i) to have a look at the MTS database and application as well as (ii) discuss about managing inland indents and germplasm supply in online mode.

b Data on various priority activities for implementation of the Second GPA was collated and uploaded for the period up to December 2020 on FAO-WIEWS Reporting Tool.

c Prepared and processed an updated document for renewal of CAMC of Computer Hardware and Local Area Network (LAN) in the office.

d Adhaar Enabled Biometric Attendance System (AEBAS) was resumed in the office.

8.9 PGR Informatics activities

Table 8.11. PGR data status (number of accessions)

Information	Activity	Additions during 2021	Status as on 31-12-2021
Indigenous collections	IC number allotment	4627	641938
Exotic collections	EC number allotment	34011	1101336
Genebank information	Data addition	14299	414132
Characterization data	Data porting	23311	226148
CryoBase	Data addition	226	10312
Plant Germplasm Registration	Data addition	242	1885

Table 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/
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
National Genomic Resource Repository	www.nbpgr.ernet.in:8080/NGRR
Cryogene Bank	www.nbpgr.ernet.in:8080/cryobank
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

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

PGR/ AKMU-BUR-DEL-01.00: Genetic Resources Information Programme **(Sunil Archak)**

Research Project (Code, Title, **PI**, CoPIs & Associates)

PGR/AKMU-BUR-DEL-01.01 (IXX10707): PGR Informatics (**S Archak,** Radhamani J, Anuradha Agrawal, MC Singh, DP Semwal, Pragya, Kuldeep Tripathi, Rajeev Gambhir, Nirmala Dabral, Anang Pal)

Externally funded projects

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

Summary: Four exploration and collection programmes were undertaken during the year and a total of 317 accessions of different crop species and wild relatives were collected from the districts of Maharashtra and Madhya Pradesh states. A total of 11142 accessions comprising 2837 accessions during *Rabi* 2020-21 and 8305 accessions during *Kharif* 2021 were characterized and evaluated. Crop-wise accessions characterized were linseed (2612), chickpea (100) and lathyrus (125) during *Rabi* 2020-21 and mung bean (550), horse gram (110), little millet (122), foxtail millet (120), winged bean (100), niger (3524) and sesame (3779) in *Kharif* 2021. Supplied 6958 accessions of various crops for research purpose to user agencies within India. Multiplied and regenerated 8164 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 for the collection of Wild *Cajanus* was undertaken from Washim, Yavatmal and Chandrapur districts of Maharashtra during 11 – 17 January 2021. In total, 20 accessions of *Cajanus scarabaedoies* were collected from six districts i.e. Akola (01), Washim (03), Yavatmal (04), Nanded (01), Chandrapur (10) and Nagpur (01) from distinct collection sites. The other targeted species *Cajanus albicans* and *Cajanus sericeus* were not found in these explored areas.

Second exploration programme for the collection of Pulses (Black gram, Green gram etc.) and vegetables particularly cucurbits from Latur and Osmanabad districts of Maharashtra was undertaken during 25th September – 05th October 2021. A total of 88 accessions were collected from 37 collection sites (Villages) from Latur, Osmanabad and adjoining districts. Maximum accessions were collected from Latur (44) followed by Osmanbad (40), Nanded (03) and Beed (01) districts. The collection included various species viz., *Momordica charantia (03), Vigna mungo (09), Lagenaria siceraria (17), Cicer arietinum (01), Citrullus colocyn this (01), Coriandrum sativum (01), Vigna unguiculata (04), Dolichos lablab (01), Vigna radiata (14), Macrotyloma uniflorum (02), Anethum graveolens (01), Cucumis melo (03), Abelmoschus esculentus (02), Cajanus cajan (03), Cucurbita maxima (09), Raphanus sativus (01), Luffa acutangula (10), Luffa aegyptiaca (05)* and *Canavalia gladiata (02)*. High variability was observed for fruit size and shape in Pumpkin, Ridge gourd and Bottle gourd (Fig 9.1).

Third exploration was conducted for the collection of Multi-crops, Pulses, minor millets and their wild relatives from Harda and Betul district of Madhya Pradesh during 08-17 October, 2021. A total of 136 accessions were collected from 54 collection

Fig. 9.1 Variability collected in Pumpkin from Latur and Osmanabad Districts of Maharashtra

sites which includes 47 villages from 14 tehsils in two districts *i.e.* Betul (92 accessions) and Harda (44 accessions). These includes, the targeted species of *Arachis hypogea (04), Amaranthus hypochondriacus* (01), *Brassica campestris* (04), *Capsicum annum* (03), *Cucumis sativus* (02), *Cajanus cajan* (02*), Coriandrum sativum* (01), *Cucumis hardiwikii* (04), *Hordeaum vulgare* (01), *Triticum aestivum* (06), *Vigna mungo* (17), *V. unguiculata* (04), *V. radiata* (09), *Cicer arietanum* (03), *Oryza sativa* (12), *Pisum sativum* (02), *Luffa cylindrica* (01), *Sesamum indicum* (10), *Sorghum bicolor* (07), *Glycine max* (03), *Guizotia abyssinica* (03), *Lens culinaris* (01), *Echinochloa frumantacea* (02), *Penniestum glaucum* (01*), Eleusine coracana* (01), *Trigonella foenum-graecum* (01*), Paspalum scrobiculatum* (03), *Panicum sumatrense* (14), *Trichosanthes cucumerina* (01) and *Zea mays* (13). Among the 136 accessions, highest and unique accessions of *little millet* were collected from tribal belt of Betul and Harda. Good variability was observed for fruit size in *Cucumis hardwickii, seed* variability in *Zea mays* and also fruit size and shape in *Cucumis sativus* (Fig 9.2).

The forth programme was carried out from Ratnagiri, Kolhapur and Sindhudurg (Western ghats) districts of Maharashtra during 19th – 29th October 2021 for the collection of (*Linum mysorense, Vigna,* Cucurbits, *Gymnema, Rauvolfia, Gloriosa*). A total of 73 accessions were collected from 32 collection sites (Villages) from Kolhapur, Sindhudurg, Ratnagiri and adjoining districts. Maximum accessions were collected from Kolhapur (28) followed by Sindhudurg (19), Ratnagiri (16), Satara (05), Pune (04) and Raigad (01) districts. The 73 accessions consisted of *Benincasa hispida (02), Vigna mungo (03), Vigna mungo* var. *silvestris (07), Phaseolus vulgaris (05), Vigna unguiculata (08), Vigna vexillata (06), Vigna dalzelliana (01), Cucumis sativus (01), Cucumis sativus* var. *hardwickii (04), Vigna radiata (03), Vigna radiata* var. *sublobata (06), Coccinia grandis (01), Dolichos lablab* L. *(03), Linum mysorense (07), Cucumis melo (01), Vigna aconitifolia (02), Cucurbita maxima (04), Luffa acutangula (04), Trichosanthes cucumerina (01), Luffa cylindrica (04).* The wild linseed (*Linum mysorense*) accessions were collected from Western Ghat region which is facing very high pressure on survival due to genetic erosion as a result of deforestation and urbanization (Fig 9.3).

Fig. 9.2 Variability collected in Maize from Madhya Pradesh

9.2 Characterization and evaluation of germplasm

9.2.1 *Rabi* 2020-21

A total of 2837 accessions were characterized and evaluated during *Rabi* 2020-21 and Crop-wise accessions characterized were linseed (2612), chickpea (100), and lathyrus (125). 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).

Linseed: Under DBT-linseed project a total of 2612 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 various traits were for days to 50 % flowering IC0523807, IC0118906 (33 days) followed by IC0526159 (35 days); for days to 80 % maturity IC0499110 (49 days), Shekhar (69 days) and Sheela (70 days); for plant height IC0498547

Fig. 9.3 Wild linseed (*Linum mysorense*) collected from Kaas Pathar, Satara

Fig. 9.4 Linseed Characterization- Field view

(61 cm), Shekhar (59.4 cm) and IC0499135 (59.2 cm)); for number of primary branches per plant IC0525912 (10), IC0096602 (9.4) and IC0054978 (9.2); for number of capsules per plant IC296039 (256), IC0499086 (199) and IC0118850-A (195); for number of seeds per capsule IC0397316 (6.22), IC0564657 (5.95) and IC0499115 (5.73) and for 1000 seed weight IC0499139 (10.68), IC0585294 (9.66) and IC572906 (9.40) were superior. Highest seed yield per plant was recorded in IC0499151 (12.10 g) followed by IC0096645 (11.84 g) and IC0532992 (9.36 g) (Fig 9.4).

Chickpea: A total of 100 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 2020-21. Promising accessions were identified for days to 50% flowering were PKV Kabuli-2 (45days), IC95214 (46 days) and IC9510 (48 days); For primary branches per plant : IC95217, IC117619 and IC117660 (7.0); for pods per plant: IC117653 (65), IC95191 (62.3) and IC95185 (60); and for test weight IC117611 (30.26g) and PKV Kabuli-4 (29.47g).

Grasspea: Grasspea characterization and evaluation trial 125 accessions along with four checks (Mahotra, Narayangaon, Pratik and Ratan) were sown in Augmented Block Design (ABD). Accessions for days to 50% flowering IC355442, IC355443 and Pratik (45days); Primary branches per plant IC120447 (5), IC120446 and IC12046 (4.6); Pod length (cm): N/08-28 (4.1cm) and N/08-157 (3.5cm); for Plant height: NIC-18866 (56.0 cm) and N/08-2 (48.3 cm); for number of pods per plant: IC345442 (60), NIC-18879 (55.7) and IC427679 (54.3); for seed yield per plant: IC427679 (8.62g) and IC345419 (7.78) and for 100 seed weight: IC345463 (9.54g) and Mahateora (9.45g) were promising.

9.2.2 *Kharif* 2021

A total of 8305 accessions were characterized and evaluated during *Kharif* 2021. Crop-wise accessions characterized were mung bean (550), little millet (122), foxtail millet (120), horse gram (110) winged bean (100), niger (3524) and sesame (3779). The experiments were conducted in ABD/RBD and the morpho-agronomical characters were recorded as per the Minimal Descriptors (For Characterization and Evaluation) of Agri-horticultural crops (Part-I), NBPGR (2000).

Mungbean: One hundred fifty accessions of mung bean and four checks (AK 8802, PKV AKM-4, BM 2003-2 and PKV Green Gold) were evaluated in ABD. Promising accessions identified for various traits. For days to 50% flowering IC39508 (35days), IC39395 and IC39545 (36 days); for Primary branches per plant IC39467-1, IC39505 and IC39516 (6); for pods per plant EC249655, EC251557 (44) and EC249652 (38): for seeds per pod IC39544, IC105502, EC246516 (15); For 100 seed weight BM 2003-2 (3.81g), IC39605 (3.8g) and EC246519 (3.73g) and for seed yield per plant EC251557 (17.0g), EC246506 (13.3g) and EC245972 (12.8g).

Mungbean core evaluation under DBT project:

A core set comprising 400 mungbean accessions and five checks (IPM02-3, IPM2-14, MH421, PDM 139, SML 668) were evaluated in ABD. Very high variation was observed for various qualitative and quantitative traits. For days to 50% flowering IC76460, IC472065 and PDM139 (32 days). For plant height IC39448 (116.8g), IC39318 (111.6

Fig. 9.5 Mungbean evaluation-Field View

cm) and IC488725 (105.6cm). Number of seeds per pod IC11296, IC283532 and IC75537 (17). Yield per plant was highest in IC436764 (26.2g), IC488941 (23.7g) and PLM666 (23.4g). For 100 seed weight EC251967-1 (7.03g), EC590222 (6.77g) and IC607146 (6.55g) were promising (Fig. 9.5).

Horse gram: One hundred and ten accessions of horse gram along with seven checks (AK-21, AK-38, Birsa, DPI-2278, HGGP, PHG-9 and Raigad Local) were evaluated in ABD. For trait days to 50% flowering accessions PLKV-76 (54 days), PLKV-61-13 and PLKV-108 (55 days) were early. Higher number of pods per plant were recorded in IC23441 (65), PLKV-128 (64) and PLKV-56-13 (63). Accessions IC23430 (11.2g), PLKU-165 (11.0g) and IC22761 (10.8g) were best for seed yield per plant. High 100 seed weight was reported in IC19450 (4.97g) followed by IC14965 (4.96g) and IC15734 (4.95g).

Screening of sesame germplasm for water-logging tolerance

Sesame germplasm comprising of 3779 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 ABD). The waterlogging tolerant accessions were identified on the basis of foliar damage score. A total 65 accessions which produced effective of capsules per plant exhibiting some degree of tolerance against water-logging were identified (Fig. 9.6).

Little millet trial-I: A set of 93 promising accessions and four checks (JK-8, BL6,, DHLM-36-6 and OLM-203) of little millet were evaluated in ABD. Promising genotypes identified for days to 50% flowering were IC483114, IC483166 (48 days) and IC482856 (49 days); for plant height IC483072 and IC482850 (168cm); for panicle length DHLM-36-6 (35.9 cm), IC483474 (35.5 cm) and IC482989 (35.0 cm); for seed yield per plant IC483152 (21.1g), IC483166 (17.2g) and IC483114 (16.4g). For 1000 seed weight, accessions IC405084 (3.54g), IC483042 (3.44g) and IC482993 (3.32g) were found promising.

Fig. 9.6 Saesame waterlogging screening- control and wterlogged plots

Little millet trial-II: Twenty Nine promising accessions and two checks (JK-8 and OLM-203) of little millet were evaluated in Randomized Block Design with two replications. Accessions IC0483302 and IC0483303 (60 days) were earliest in flowering. GPMR902 (35.1 cm) and IC0405074 (34.3 cm) recorded highest panicle length. For plant height, accessions IC0404929 (156 cm), IC0482907 (152 cm) and IC0483072 (151 cm) were best. Highest seed yield per plant was recorded in IC0482808 (16.6g), IC0483345 (15.6g) and IC0404913 (15.0g). For 1000 seed weight IC0482808 (3.17g) and IC0404913 (3.14g) were superior.

Foxtail millet: One hundred twenty accessions and six checks (Krishnadevaraya, Lepakshi, Narsimharaya, Prasad, SIA-3088 and SIA-3156) of foxtail millet were evaluated in ABD. Significant variation was observed for various quantitative traits. Promising accessions identified for traits days to 50% flowering were IC120251 (38 days) and IC120235 (39 days); for number of productive tillers per plant IC406590 (9.1), IC331169 (8.8) and IC406578 (8.7); for plant height IC120210 (186 cm), IC120346 and K-2660C (173 cm); for panicle length IC120235 , IC120346 (24.0 cm) and for 1000 seed weight K-2660C (3.56g) and SIA-3088 (3.40g) were superior. Highest seed yield per plant was recorded in IC120235 (23.4g), NIC18318 (22.7g) and NIC25541 (22.2g) (Fig 9.7).

Evaluation of Niger germplasm

A total of 3524 accessions along with four checks (JNS-9, JNS-28, JNS-30 and IGPN-2004-1) of niger were evaluated and characterized in ABD

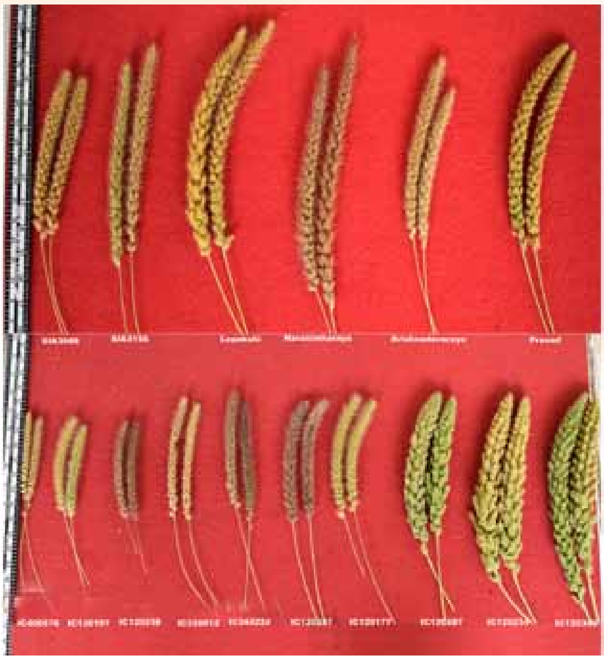


Fig. 9.7 Variation for panicle types in checks and accessions in Foxtail millet

during *Kharif* 2021. Promising accessions identified for various traits were for days to flowering IC0259377, IC0259378 (40 days) and IC3442114 (44 days): for plant height AJSR-36 (268 cm), IC499222 (264cm) and VANL (243 cm); Primary branches per plant AJSR-25 (21), IC0305879 (20), AJSR-101 (20); Yield per plant Dp24/SP-14 (8.84g), BMD-136 (8.75g) and for 1000 seed weight NSS-5622 (5.88g), IC0396516 (5.76g) and JNS-28 (5.76g) were for found promising (Fig 9.8).

AICRN on Potential Crops

One hundred accessions of winged bean were characterized and evaluated in two different trials

Fig. 9.8 Characterization of 3524 Niger accessions- Drone field view

under potential crops programme.

First evaluation: Fifty winged bean genotypes and three checks (AKWB-1, IWB-1 and RMDWB-1) were evaluated in ABD. Accessions RWBGP-53 (82 days) was earliest for days to 50% flowering. Superior pod length was recorded in RWBGP-55 (13.8 cm) and EC38995-A (13.4cm). Highest number of pods per plant was recorded in RWBGP-54 (30), RWBGP-35 (26.0) and RWBGP-72 (23). Seed yield per plant was superior in RWBGP-54 (58.5g), RWBGP-72 (52.0g) and RWBGP-52 (50.0g). Accessions RWBGP-57 (35.5g), RWBGP-56 (35.0g) and RWBGP-58 (33.9g) recorded higher 100 seed weight.

Second evaluation: Fifty accessions of winged bean were evaluated in ABD with three checks (AKWB-1, IWB-1 and RMDWB-1). Good variation was observed for various qualitative and quantitative traits. Promising accessions identified for traits were for Days to 50% flowering AKWB-1 (82 days) and RMDWB-1 (83 days): for pod length RWBGP-3, RWBGP-7 and RWBGP-19 (13.4 cm); Number of pods per plant EC178297 (22), RWBGP-3 (22) and RWBGP-32 (21); for seed yield per plant EC178297 (45.24g), RWBGP-3 (44.06g) and RWBGP-32 (40.4g); For 100 seed weight EC178310 (31.80g) and AKWB-1 (31.60g).

11.3 Regeneration and multiplication of germplasm

A total of 8164 accessions consisting of safflower (6984), niger (747) and chickpea (19) in *Rabi* 2020-21 and mungbean (150), chili (27), wild sesame (20), *Hibiscus sabdariffa* (14) and *Hibiscus cannabinus* (03) in *Kharif* 2021 were regenerated (Fig. 9.9).

11.4 Germplasm supply

Supplied 6958 accessions of germplasm of various crops/species to the indenters within India for their research purposes under Material Transfer Agreements. The crops/species (accessions) supplied were of different crops *i.e.* okra including wild (554), winged bean (264), grain amaranth (50), pigeon pea (25), safflower (5629), finger millet (260),barnyard millet (1), foxtail millet (1), kodo millet (1), little millet (1), grasspea (23) and sesame wild (149).

Fig. 9.9 Purification and multiplication of Niger accessions

11.5 Germplasm receipt

Received 4500 accessions/varieties of germplasm comprising Mungbean (405), linseed (347), niger (3524), grain amaranth (170), Horse gram (14), *Sesamum malabaricum* (10) and winged bean (30) from different agencies.

11.6 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.

11.7 Field Gene Bank

A total of 23 accessions consisting of *Aloe vera* (05), wild foxtail millet (08), soybean wild (03), West Indian cherry (01), *Simarouba glauca* (01), *Gymnema sylvestre* (05) are being maintained at field gene bank of Regional Station, Akola.

Research Programme (Code, Title and programme Leader) PGR/GEV-BUR-AKO-01.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources in the Central Indian Plains (**Dinesh Chand**).

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** and 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).

10 REGIONAL STATION BHOWALI

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 53 different collections were made in one national exploration plan. Total 1109 accessions of various field, horticultural, WEUP crops were characterized, multiplied and rejuvenated for MTS seed replacement. Total 601 accessions of various crop germplasm were shared with researchers across the country against MTA. In addition 8818 live plants/rooted plants/grafted plant were also supplied to the farming community. A total of 11,786 accessions in MTS and 1301 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 2,27,560/- was generated through sale of farm produce.

10.1 Germplasm exploration and collection:

One exploration crop was undertaken under NEP at high altitude regions of Saryu valley & Pindar valley area of Uttarakhand for collection of *Allium* species, temperate fruits, ornamental plants and total 51 accessions were collected (Table 1). During the exploration, unique germplasm like *Schisandra grandiflora* (Chinkati), *Viburnum grandiflorum* (Gania), *Sorbus aucuparia* (Galao), and *Sorbus cuspidata* (Mole) were collected from Pakua top area of Pindar valley.

Germplasm exchange and domestic supply:

- A total of 601 germplasm accessions of various crops *viz.* *Oryza sativa* (100), temperate fruit (35), *Capsicum annum* (313), *Luffa acutangula* (52), *Cucumis sativus* (38), *Lageneria siceraria* (36) and wild *Allium* (06) were supplied to different indenters under MTA.
- Total of 8818 live plants/rooted plant/grafted plant were supplied viz., Kiwi (2600), Kiwi seedling (4300), Strawberry (370), stone fruits (222) Malta (414), Kagazi lime (162), other fruit crops (240) and MAP (510) to different indenters or local farmers.
- A total of 21 accessions of newly introduced Kiwi germplasm have received from ICAR-NBPGR, RS, Shimla (U.K).

10.3 Germplasm characterization

- A total of 321 accessions of various *Rabi* season 2021 crops *viz.* Wheat (70), Barley (63),

Table 10.1: Detail of exploration undertaken

S. No.	Crop/Crop group	Period	Team	Collaborative institute	Areas Explored	Germplasm collected				
						MAP	WEUP	Fruits	Others	Total
Under National exploration Plan										
1	Crop specific (Wild temperate fruits, MAP and other economically useful species)	25th August to 05th Sept., 2021	Dr. K.M. Rai Dr. P.K. Malav & Dr. Badal Singh	--	Bageshwar, Uttarakhand	18	04	08	21	51
	Total					18	04	08	21	51

Mustard (33), Fenugreek (18), Coriander (25), Faba bean (21) and Pea (85) were grown for characterization, evaluation and multiplication.

- A total of 526 accessions of various *Kharif* season 2021 crops *viz.,* paddy (150), minor millets (43), finger millet (63), horse gram (187), french bean (73) and buck wheat (10) were grown for characterization, evaluation and initial seed increase.
- A total of 166 accessions of wild *Allium* were maintained in field gene bank and were also characterized for morphological characters such as vegetative growth, flowering character and seed morphology.

10.4 Germplasm evaluation

- 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.

10.5 Germplasm multiplication

- Multiplication and rejuvenation of field crops *viz.,* lentil (05), Barley (33) and Wheat (14) were done.
- Multiplication and rejuvenation of 450 accessions of chilli and 21 accessions of MAP crops was undertaken.

10.6 Germplasm conservation and maintenance

- A total of 11,786 accessions in MTS and 1,301 accessions in field gene bank (including newly introduced accessions) were maintained.

10.7 Collection of *Allium przewali skianum* from Uttarakhand

- First time *Allium przewali skianum* was collected from Trans-Himalayan region of Niti valley, Chamoli, Uttarakhand where had domesticated it for use the local community as seasoning spice. Earlier its distribution was reported to open rocky slopes of Durbuk and Nyoma area of Ladakh.

10.8 New Allium taxon collected and conserved from Uttarakhand

A new taxon of genus *Allium* was collected and conserved (*Allium negianum* Fig 10.1.a) from sandy soils along the rivers of Alpine meadow (Altitude 3000-4800 m asl.) of Malari region of Niti valley, Chamoli, Uttarakhand. It is a narrowly distributed species and morphologically more closer to *A. przewalskianum (Fig 10.1b)* Regel but differentiated by its tunic color of bulb, umbel with lax flowers, leaf anatomy.

Fig- 10.1a: Allium negianum: Collected as new taxon from Uttarakhand

Fig- 10.1b: Allium przewali skianum: First report from Uttarakhand

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,** *Dr. P.S. Mehta, Chief Technical Officer.*

PGR/PGC-BHO-01.02: Management of genetic resources of temperate horticultural crops (PI: **Dr. K.M. Rai,** *Anuj Kumar Sharma.*

PGR/PGC-BHO-01.03: Management of genetic resources of medicinal and aromatic, wild economically useful, rare and endangered species **K.M. Rai, A. Raina,** Pr. Sci. (Biochem.), Mamta Arya, *Mr Anuj Kumar Sharma.*

Externally funded projects:

Mainstreaming Agricultural Biodiversity Conservation and Utilisation in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability under UNEP-GEF and Bioversity International. Dr. Mamta Arya, Dr K.M. Rai

BASE CENTRE, CUTTACK

11

Summary: During the period of report, three exploration missions were undertaken and 311 acc. comprising wild rice, wild crop relatives, pulses, millets and valuable M&AP were collected from Odisha and Chhatisgarh. On compilation of germplasm collection and distribution, the occurrence of three taxonomic varieties of wild okra viz. *Abelmoschus angulosus* var. *grandiflorus*, *A. tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* were reported first time from Odisha and form new distributional records for Eastern India. A set of 1660 acc. of different crops and wild relatives was multiplied/ regenerated and 347 accessions comprising cultivated rice (197), wild rice (40), *Ocimum* spp (44), *Hibiscus sabdariffa* (22), *Abelmoschus* spp. (36), *Luffa aegyptiaca* (8) was characterized for different morpho-agronomic traits. *Ocimum* spp. (44) were evaluated. A set of 104 acc. comprising WRCP (27), wild rice (77) were supplied to ICAR-institutes and exotic rice germplasm (112) were received from NBPGR, New Delhi. A set of 1457 acc. comprising cultivated rice (1304), WRCP (87), M&AP (52), pulses (9) and others (5) were deposited in NGB for LTS; tuber crops (2) for *in-vitro* and FGB (23) were conserved. A total of 629 acc. comprising M&AP, horticultural crops, tuber crops and CWR are being maintained in the FGB and a total 1470 herbarium specimens are being preserved. Organized PGR awareness programs and biodiversity fair in Thakurmunda block of Mayurbhanj and Telkoi block of Keonjhar, Odisha under Tribal Sub-plan and 300 tribal farmers were benefited. Small farm implements, seeds/ seedlings of vegetable crops were distributed among tribal farmers.

11.1. Exploration and germplasm collection

Three exploration missions were undertaken and 311 acc comprising wild rice, wild relatives of crop plants viz. *Amaranthus, Abelmoschus, Cajanus, Corchorus,* cucurbits, *Dioscorea, Solanum, Vigna* and *Ziziphus*, pulses, millets and valuable M&AP such as *Ocimum* spp., *Argyreia nervosa, Senna* spp. etc were collected from Odisha and Chhatisgarh. Wide range of inter- and intra-specific variability was recorded among collected the germplasm accessions for various morpho-agronomic traits. The exploration wise details are given in Table-11.1.

11.1.1 Exploration and germplasm collection of crop wild relatives and M&AP from Odisha

First exploration mission was undertaken for germplasm collection of wild relatives of *Amaranthus, Solanum, Dioscorea, Luffa, Corchorus* and M&AP germplasm from Sundargarh and Deogarh districts of Odisha during 2nd – 9th March, 2021 in collaboration with ICAR-CHES (IIHR) Bhubaneswar. A total of 82 acc comprising *Amaranthus* spp. (12), *Solanum* spp. (14), *Luffa aegyptiaca* (12), *Ocimum* spp. (19), *Corchorus aestuans* (2), *Dioscorea* spp. (4), *Canavalia gladiata* (1), *Ziziphus mauritiana* var. *mauritiana* (3), *Senna (3), Datura metel* (3), *Argemone mexicana* (1), *Leonotis nepetifolia* (2), 1 acc each of *Bixa orellana, Argyreia nervosa, Xanthium indicum, Anisochilus carnosus* and others (2) was collected. Significant germplasm collections include diversity of wild relatives of *Amaranthus, Solanum, Luffa* and M&AP like *Ocimum* spp., *Anisochilus carnosus, Senna hirsuta, Argyreia nervosa, Leonotis nepetifolia* and *Xanthium indicum*. A wide range of variability in morphological traits such as colour and size of

Fig. 11.1. *Solanum sisymbriifolium,* a crop wild relative and rare species collected from Sundargarh district, Odisha

Fig. 11.2. *Senna hirsuta,* a rare and valuable medicinal plant collected from Deogarh , Odisha

Table-11.1 Crop-wise exploration and germplasm collection mission during 2021

Crops/ Species	Areas	Collaboration	Period of collection	Collection sites	No. of spp.	No. of acc
Wild relatives of *Amaranthus, Solanum, Dioscorea, Luffa, Corchorus* and M&AP	Sundargarh and Deogarh districts of Odisha	ICAR-CHES (IIHR), Bhubaneswar	2nd – 9th March, 2021	53	31	82
Multicrops and CWR including wild rice (*Oryza nivara, O.rufipogon, O sativa* var *spontanea*)	Nabarangpur, Nuapada (Odisha) and Gariyaband (Chhatishgarh)	ICAR-NRRI, Cuttack	25th Nov. to 4th Dec.2021	51	33	103
Multicrops: Pulses, millets, cucurbits, M&AP including CWR: *Abelmoschus, Cajanus, Cucurbits, Oryza, Solanum, Vigna* spp etc.	Sonepur, Bargarh and Jharsuguda (Odisha)	ICAR-CHES, Bhubaneswar	27th Dec.21- 5th Jan. 2022	60	37	126
TOTAL				**164**	**101**	**311**

flowers, fruits and seeds of *Luffa* and *Solanum* was recorded.

11.1.2 Exploration and germplasm collection of multi-crops and CWR including wild rice

The second exploration mission was conducted in collaboration with ICAR-NRRI, Cuttack during 25th Nov. to 4th Dec. 2021. A set of 103 multi-crop germplasm accessions comprising cultivated crops (55) and crop wild relatives (48) i.e. *Abelmoschus, Amaranthus, Corchorus, Oryza, Hibiscus, Vigna, Solanum, Luffa, Cajanus, Cucumis, Sesamum* were collected from Nabarangpur, Nuapada districts of Odisha and Gariyaband district of Chhatishgarh. Wide range of variability in morphological traits such as shape, size and colour of seeds in *Vigna* spp., *Cajanus cajan, Macrotyloma uniflorum* was recorded. Significant germplasm *viz. Oryza officinalis, Abelmoschus ficulneus, A. tetraphyllus, Cucumis hardwickii* etc was collected.

11.1.3 Exploration and germplasm collection of multi-crops: pulses, millets, cucurbits, M&AP, including CWR

The third exploration mission was undertaken in collaboration with ICAR-Central Horticultural Experiment Station (IIHR), Bhubaneswar during 27th December, 2021 to- 5th Jan. 2022. A total of 126 acc comprising cultivated crops (71) and crop wild relatives (55) including *Abelmoschus,*

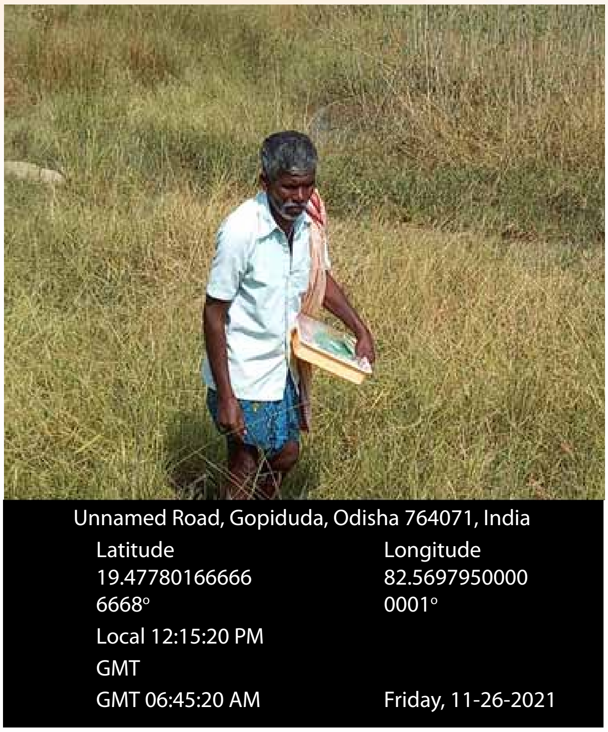


Fig. 11.3. Collecting wild rice (*Oryza rufipogon*) from Nabarangpur, Odisha

Cajanus, Cucumis, Luffa, Solanum, Amaranthus, Corchorus spp., *Hibiscus, Ocimum* spp., *Sesamum* and medicinal plants was collected from Sonepur, Bargarh and Jharsuguda (Odisha). Wide range of inter and intra-specific variability was recorded among collected germplasm accessions for various morpho-agronomic traits. Significant germplasm accessions such as wild *Oryza* spp, *Momordica, Mukia, Mucuna, Rauvolfia, Sesamum, Solanum* were collected.

In addition, a joint exploration mission was undertaken with ICAR-NBPGR, New Delhi during 9th–16th February, 2021 and 42 accessions comprising wild (21) and cultivated (5) under 26 species was collected from Odisha and Chhatishgarh. Significant accessions *viz.*, *Cajanus cajanifolius* and other wild economic species were collected from parts of Odisha and Chhattisgarh.

11.1.5 New distributional record of plant genetic resources

During exploration mission for germplasm collection and distribution of *Abelmoschus* in Eastern India, the occurrence of three taxonomic varieties of wild okra *viz. Abelmoschus angulosus* var. *grandiflorus*, *A. tuberculatus* var. *deltoidefolius*

Fig. 11.4. Seed variability in cowpea (*Vigna unguiculata*) collected from Odisha

Fig. 11.5. Seed variability in green gram (*Vigna radiata*) collected from Odisha

and *A. tuberculatus* var. *tuberculatus* were reported for the first time from Odisha and form new distributional records for Eastern India. *A. tuberculatus* was reported in wild state so far only from western and northern India and *A. angulosus* var. *grandiflorus* reported from the Western Ghats of the country. In the present report, however, in Eastern India, *A. angulosus* var. *grandiflorus* was reported to occur in small population in moist deciduous forests of Kendujhar district whereas *Abelmoschus tuberculatus* var. *deltoidefolius* and var. *tuberculatus* were found wild in low altitude hilly areas and open disturbed habitats in Kalahandi and Nuapada districts of Odisha. One germplasm acc of *A. angulosus* var. *grandiflorus* and six accessions comprising each three taxa of *A. tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* were explored from different landscapes of Eastern Ghats of Odisha and conserved in the National Gene Bank.

Table - 11.2 Variability and frequency distribution among qualitative traits in scented rice

Traits	Descriptor states (Frequency %)
Basal leaf color	Green (84.1), Light P.P (8.7), P.P. lines (2.4) purple (2.4), Mix (3.2)
Leaf Blade color	Green (50.8), Pale green (23.8), Dark green (25.4)
Leaf angle	Erect (93.7), Horizontal (6.3)
Flag leaf angle	Erect (41.3), Intermediate (58.7)
Internode color	Green (92.1), Purple lines (7.1), Light gold (0.8)
Ligule color	White (88.9), PP lines (9.5), Purple (1.6)
Collar color	Green (85.7), Pale green (2.4), Purple (11.9)
Auricle color	Pale green (88.1), Purple (11.9)
Panicle type	Intermediate (88.1), Open (11.9)
Awning	Absent (93.7), Short & partly (4.0), Long & full (2.4)
Apiculus color	Straw (85.7), Purple (13.5), Lt purple (0.8)
Stigma color	White (85.7), Lt. purple (0.8), Purple (13.5)
Lemma palea color	Straw (77.0), Brown furrow (6.3), Purple (9.5), Black (2.4), Brown (4.8)
Seed coat color	White (70.6), Lt. Brown (23.8), Brown (4.8)
Scent	Lightly scented (71.4), Scented (28.6)

11.2. Germplasm characterization

A set of 347 accessions comprising cultivated rice (197), wild rice (40), *Ocimum* spp (44), *Hibiscus sabdariffa* (22), *Abelmoschus* spp (36), *Luffa aegyptiaca* (8) was characterized for different morpho-agronomic traits to investigate the variability among different crops.

11.2.1 Cultivated rice

Cultivated rice (small grained aromatic rice)

126 acc of cultivated rice germplasm augmented from different exploration missions in Odisha and adjoining regions including accessions from the gene bank were grown in randomized block design (RBD) with two replications and five checks (Kalajeera, Geetanjali, Ketakijoha, CR Dhan-202, Tulasi) with a spacing of 20 X 20 cm between plants and rows. Observation on 15 qualitative and 10 quantitative traits was recorded (Table-11.2 & 11.3).

Cultivated rice (Purple Karnal)

71 accessories of purple rice germplasm augmented from National Gene Bank, ICAR-

Table -11.3 Variability among quantitative traits in scented rice

Traits	Range		Best check	Promising lines
	Minimum	Maximum		
Plant height (cm)	90.4 (IC203500)	194.8 (IC259929)	Geetanjali (123.4)	IC203500
EBT	3.4 (IC256845)	10.0 (AC35640)	Kalajeera (8.2)	AC 852131, EC 934737
Panicle length (cm)	18.8 (IC256947)	32.36 (IC203454)	Kalajeera (29.6)	IC203454, 256837
Panicle wt. (g)	0.82 (IC203500)	8.25 (IC259929)	Geetanjali (6.0)	IC259929
Spikelets/panicle	58.2 IC277655	260.6 IC203182	Geetanjali (206)	IC258781, 203182
Sterility %	3.92 (IC137599)	58.33 (IC277553)	Ketakijoha (4.8)	IC137599,144598
Leaf length (cm)	39.0 (AC35460)	76.34 (IC203536)	Kalajeera (58.64)	IC203536, 259929
Leaf width(cm)	0.54 (IC277307)	1.74 (IC256676)	Kalajeera (1.06)	IC256676
Ligule length (cm)	0.5 (IC280552)	3.3 (IC256837)	Geetanjali (2.2)	IC256837
100 seed wt. (g)	0.8 (AC35460)	3.02 (IC259929)	CR Dhan 202 (3.2)	IC259929

NBPGR, New Delhi were selected and grown in randomized block design (RBD) with two replications and 5 checks (Naveen, CR Dhan-101, CR Dhan-202, I-Lalat, Panidhan) with a spacing of 20 X 20 cm between plants and rows. Observation on various agro-morphological traits (25 traits) was recorded and promising types over best check values are identified for further study (Table 11.4).

11.2.2 Wild rice:

A set of 40 acc comprising *Oryza nivara* (18) and *Oryza rufipogon* (22) was characterized for different agro-morphological traits. Each accession was maintained in three rows in a plot size of 2.4m²/ entry following a spacing of 40x40cm between lines and plants. Observation on 23 different agro-morphological traits was recorded and range of variation for various quantitative traits was calculated (Table- 11.5 & 11.6).

Table-11.4 Variability among quantitative traits in purple rice germplasm

Traits	Range		Best check	Promising lines
	Minimum	Maximum		
Plant height (cm)	81.5 (EC934621)	195.2 (EC934561)	Naveen (121.4)	EC934621
EBT	4.4 (EC934617)	10.4 (EC934822)	CR Dhan 202 (9.2)	EC934822
Panicle length (cm)	20.5 (EC934870)	33.5 (EC934561)	Naveen (26.5)	EC934561
Panicle wt. (g)	1.04 (EC 934886)	7.8 (EC934561)	CR Dhan 202 (5.8)	EC934561
Spikelets/panicle	56.4 (EC934594)	231.0 (DP/DPS/BCM 2535)	CR Dhan 202 (209)	DP/DPS/BCM 2535, EC 934894
Sterility %	3.8 (EC934924)	64.9 (DP/BCM 2462)	Panidhan (3.5)	EC 934924,934621
Leaf length (cm)	40.2 (EC934886)	76.6 (EC934561)	I lalat (63.2)	EC934561
Leaf width(cm)	0.76 (EC934594)	1.66 (EC934831)	CR Dhan 202 (1.24)	EC934831
Ligule length (cm)	1.36 (EC934928)	3.02 (EC934561)	Panidhan (2.3)	EC934561
100 seed wt. (g)	0.9 (EC934886)	3.4 (EC934831)	CR Dhan 202 (3.01)	EC934831

Characterization of *Oryza nivara*

Table- 11.5 Range of variability among quantitative traits in *Oryza nivara* germplasm

Traits	Range		Mean	SEM (±)
	Min.	Max.		
Days to 50% flowering	90.2	118.5	116.84	0.67
Days to maturity	118.0	145.0	127.27	0.69
Plant height (cm)	62.0	142.7	101.05	2.40
Leaf length (cm)	23.35	55.2	39.9	1.76

11.2.3 *Ocimum* germplasm:

Forty four accessions of *Ocimum* spp. comprising *O. americanum* (7), *O. tenuiflorum* (9), *O. basilicum* (7), *O. citriodorum* (8), *O. gratissimum* (10) and O. *kilimandscharicum* (3)

Traits	Range		Mean	SEM (±)
	Min.	Max.		
Leaf width (cm)	0.6	0.86	0.71	0.04
Ligule length (cm)	0.55	1.45	0.86	0.05
EBT/Plant	4.5	10.0	7.76	0.99
Panicle length (cm)	14.35	25.35	20.47	0.84
Grains/panicle	54.2	181.2	105.70	4.95
Spikelet fertility (%)	31.1	88.5	65.41	1.16
100 grain weight (g)	1.52	2.65	2.09	0.24

Characterization of *Oryza rufipogon*

Table-11.6 Range of variability among quantitative traits in *Oryza rufipogon* germplasm

Traits	Range		Mean	SEM (±)
	Min.	Max.		
Days to 50% flowering	123.2	159.5	129.2	0.64
Days to maturity	139.5	168.0	148.20	0.70
Plant height (cm)	84.95	192.75	149.30	3.1
Leaf length (cm)	19.8	41.8	28.53	2.0
Leaf width (cm)	0.5	0.95	0.72	0.04
EBT/Plant	4.0	14.0	8.4	1.11
Panicle length (cm)	15.4	31.15	21.4	0.90
Grains/panicle	58.2	116.4	93.5	4.2
Spikelet fertility (%)	24.2	54.2	41.15	1.22
100 grain weight (g)	1.32	2.1	1.55	0.18

were characterized for 34 agro-morphological 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. americanum* (IC 599329), *O. basilicum* (IC599326, 599337), *Ocimum tenuiflorum* (IC-589192), *O. citriodorum* (IC 599357), *O. kilimandscharicum* (IC 627244) and *O. gratissimum* (IC or EC 589184).

11.2.4 *Hibiscus sabdariffa*

Twenty-two acc of *Hibiscus sabdariffa* (roselle), used as leafy vegetable, were characterized for 33 agro-morphological and economic traits in RBD with two replications and promising genotypes such as IC-610799, IC-610800, RCM/PK/19/22 and IC-

Table-11.7 Range of variability among quantitative traits in *Ocimum germplasm*

S. No.	Species Species	Highest estimation of herbage yield/plant (g)	Highest estimation of essential oil yield/ plant(ml)
1.	*O. americanum*	418.5 (IC 599329)	1.4 (IC 599329, 599362)
2.	*O. basilicum*	509.4 (IC 599337)	1.3 (IC 599337, 599326)
3.	*Ocimum tenuiflorum*	420.3 (IC 589192)	2.0 (IC 589192, 599341)

S. No.	Species Species	Highest estimation of herbage yield/plant (g)	Highest estimation of essential oil yield/ plant(ml)
4.	*O. gratissimum*	556.0 (IC589184)	2.6 (IC589184, 627242)
5.	*O. citriodorum*	416.8 (IC599357)	2.2 (IC599357, 599354)
6.	*O. kilimandscharicum*	421.2 (IC627244)	2.1 (IC627244)

630724 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

Information on micro-morphology of seeds using scanning electron microscope (SEM) was very useful for critical study on the surface pattern and trichome structure and density to substantiate the taxonomic attributes for identification of inter- and intra-specific taxa of wild okra i.e. *Abelmoschus tuberculatus*. Validated first time the recognition of two wild varieties viz. *A. tuberculatus* var. *deltoidefolius* and *A. tuberculatus* var. *tuberculatus* analyzing the seed micro-morphology through scanning electron microscope. *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 Biochemical evaluation of *Zingiber zerumbet*

Essential oil isolated from rhizomes of *Z. zerumbet*, a rare medicinal plant collected from Malkangiri district of Odisha and grown in FGB was analyzed through GC-FID and GC-MS method at DGE, NBPGR, New Delhi. A total of seventeen aromatic compounds were identified representing 99.96% of the essential oil composition. The main oil constituents were zerumbone (70.60%), α-humulene (5.65%), humulene epoxide I (5.22%) and humulene epoxide II (5.71%), camphor (1.90%), camphene (3.47%), and cayophyllene oxide (2.52%). Methanolic extracts of *Z. zerumbet* rhizome was found to be rich in total phenols (6.50 ± 0.01 mg gallic acid equivalents (GAE)/g DM), total flavonoids (22.57 ± 0.08 mg quercetin (QE)/g DM) and having high antioxidant activity of 69.34 ± 5.65%. It revealed that *Z. zerumbet* from Eastern India having high oil and zerumbone content can be used as potential natural source of zerumbone which has high pharmaceutical value.

11.3.3 Genetic diversity of cotton germplasm of Sundarbans/ coastal zones of West Bengal

Out of thirty nine germplasm accessions of cotton collected from Sundarbans and coastal zones of West Bengal, 32 represented *Gossypium hirsutum*, 6 represented *G. barbadense* var. *brasiliense* (kidney seed cotton) and one belonged to *G. barbadense*. The germplasm acc were evaluated in the field in collaboration with ICAR-CICR, Nagpur. The kidney-seed cotton (*G. barbadense* var. *brasiliense*) has unique character of fused seeds into kidney-shaped masses at the centre. The height of perennial species was ranged from 2 m to 10 m high with profuse branching and good crown cover. The leaf lobes of *G. barbadense* are deeply incised, about two-third the length of leaf, whereas it was half-cut in *G. hirsutum*. The corolla of *G. barbadense* was yellow with or without spot. Morphologic as well as DUS characterization was carried out for all the collected accessions, and the assembled lint were sent to Ginning Training Centre (GTC), ICAR-CIRCOT, Nagpur for fibre quality trait analysis (HVI mode). The traditional cotton cultivars collected from water-logging and salinity areas of Sundarbanand adjoining regions may possess resistant/tolerant genes against water-logging and salinity. Such novel genes can be identified through genomics-assisted breeding from among collected traditional cultivars and these genes can be introgressed into elite varieties of cotton. The collected accessions were conserved in FGB and MTS of ICAR-CICR, Nagpur for future utilization in cotton improvement programme.

11.3.4 Evaluation of wild rice germplasm for

submergence tolerance

Forty four accessions of wild rice germplasm (*Oryza nivara*-18, *O.rufipogon*-22 and *O. sativa* var. *spontanea*-4) and two checks of cultivated rice (resistant: Swarna *Sub*-1 and susceptible: IR-42) was evaluated to identify submergence tolerant accessions in controlled conditions. One month old seedlings were submerged in cement tanks of 1.5m depth for 2 weeks. Observation on seedling height and number of plants before and after submergence was recorded and observation on survival percentage and internode elongation was calculated. Based on the observation of resistant check values (Swarna *sub*-1) with survival percentage (90.5 %) and internode elongation (10.43 %), the acc viz. DP/BCM-2613 with survival percentage (94.5 %) and internode elongation (18.46 %) and acc DP/BCM-2609 with survival percentage (94.5 %) and internode elongation (27.83 %) were identified as promising for submergence tolerance.

11.4. Germplasm multiplication

A total of 1660 accessions comprising cultivated rice (1212), wild rice (263), *Ocimum* spp. (48), *Abelmoschus* spp. (36), *Hibiscus sabdariffa* (22), *Luffa* spp. (8), *Amaranthus* (8), blackgram (6), green gram(5), *Solanum* spp (4), *Trichosanthes* spp. (7), *Dioscorea* spp. (21), *Costus speciosus* (9), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Canavalia gladiata* (2) and *Scleichera oleosa* (1), *Fioria vitifolia* (1), *Pavetta indica* (1), *Abutilon indicum*(1), *Argyreia nervosa* (1), were multiplied/ regenerated for seed enhancement, characterization, herbage and oil yield and further biochemical evaluation.

11.5 Germplasm exchange

A set of 104 accessions comprising wild relatives of horticultural species (27) and wild rice (77 acc) collected during exploration mission in Odisha and Chhatisgarh were supplied to ICAR-CHES (IIHR), Bhubaneswar and ICAR-NRRI, Cuttack respectively for multiplication, characterization, conservation, maintenance and research purpose. Nine rhizome samples comprising *Costus speciosus* (5), *Hedychium* spp. (3) and *Zingiber zerumbet* (1) and seeds of *Abelmoschus moschatus* (4) were supplied to Division of Germplasm Evaluation for biochemical analysis. Besides, 112 accessions of exotic rice germplasm were received from ICAR-NBPGR, for regeneration and conservation in LTS.

11.6. Germplasm conservation

A total of 1457 accessions comprising of rice (1304) multiplied during *Kharif*, 2021, wild relatives of crop plants (87), M&AP (52), *Vigna* spp. (9), other crops (5) collected from Odisha were deposited for LTS in National Gene Bank, ICAR-NBPGR, New Delhi. Two rhizome/ tuber germplasm propagules viz. *Zingiber zerumbet* and *Dioscorea alata* (2) were deposited for *in-vitro* conservation. In addition, *Luffa aegyptiaca* (8), *Canavalia gladiata* (2), *Costus speciosus* (3), *Schleichera oleosa* (1), *Fioria vitifolia* (1), *Pavetta indica* (1), *Abutilon indicum* (1), *Argyreia nervosa* (1), *Solanum viarum* (2), *Amorphophallus paeoniifolius* (1), *Dioscorea alata* (1) and *D. oppositifolia* (1) were added to the FGB of the centre. Cultivated rice (672) collected during various explorations and multiplied at this Centre were conserved in MTS at NRRI.

11.7. Germplasm maintenance

A total of 629 acc comprising M&AP (205), *Ocimum* spp. (48), *H. sabdariffa* (22), tuber/ aroids (23), horticultural crops (6), wild *Oryza* spp (263), wild *Abelmoschus* (36), *Costus speciosus* (8), *Hedychium* spp. (3), *Zingiber zerumbet* (1), *Luffa aegyptiaca* (8), *Trichosanthes* spp. (3), *Canavalia gladiata* (2) and *Scleichera oleosa* (1) were maintained in the FGB/ experimental plots of the centre.

Important species of medicinal and aromatic plants viz. *Abutilon indicum, Amorphophallus paeoniifolius, Aristolochia indica, Argyreia nervosa, Pavetta indica, Costus speciosus, Abelmoschus moschatus, Asparagus racemosus, Bacopa monnieri, Celastrus paniculata, Centella asiatica, Costus speciosus, Hedychium coronarium, H. coccineum, H. flavescens, Zingiber zerumbet, Mucuna pruriens, M. monosperma, M. nigricans, Ocimum basilicum, O. citriodorum, Ocimum kilimandscharicum, O. americanum, O. tenuiflorum, O. gratissimum, Nicandra physalodes, Solanum viarum, Saraca asoca, Gardenia gummifera, Hibiscus panduriformis, Hemidesmus indicus, Litsea glutinosa, Mallotus philippensis, Nyctanthes arbortristis, Oroxylum indicum, Piper longum, Plumbago rosea, Pterocarpus santalinus, Rauvolfia serpentina, Scindapsus* *officinalis, Solanum viarum, Solanum sisymbrifolium, Strychnos potatorum, Tinospora cordifolia, Watakaka volubilis* etc are being maintained in the field gene bank of the centre for academic research purpose.

11.8. Herbarium preservation

A total of 1470 voucher specimens belonging to crop wild relatives, high valued M&AP and other economically useful plants are being maintained in the herbarium of the centre. These were collected from parts of Odisha, Bihar, Madhya Pradesh, West Bengal, Mizoram, Tripura and Manipur. Forty two specimens collected were identified and preserved. The important specimens such as *Amaranthus spinosus, A. viridis, Bixa orellana, Cassia hirsuta*, *Corchorus aestuans, C. olitorius*, *Abelmoschus angulosus* var. *grandiflorus, A. angulosus* var. *mahendragiriensis*, *Abelmoschus crinitus*, *A. ficulneus*, *Abelmoschus manihot* var. *tetraphyllus, A. moschatus*, *A. tuberculatus* var. *deltoidefolius, A. tuberculatus* var. *tuberculatus*, *Zingiber zerumbet, Hibiscus cannabinus*, *Solanum sisymbrifolium*, *Solanum lycopersicum* var. *cerasiforme, Trichosanthes tricuspidata* etc were augmented to the herbarium. Scanning of thirty-five voucher specimens of significant species/ crop wild relatives and high valued medicinal plants was initiated and documented.

11.9. Documentation

The passport data pertaining to three explorations and germplasm collections and information on identity, traditional uses of wild *Abelmoschus, Amaranthus, Canavalia, Cassia, Corchorus,* cucurbits, *Solanum, Dioscorea* including wild leafy vegetables and other medicinal and aromatic plants were collected and documented.

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

PGR/EXP- BUR-CUT- 01.00- Augmentation, characterization, evaluation, maintenance, regeneration, conservation documentation and distribution of plant genetic resources of Odisha and adjoining regions- (**RC Misra**)

Research Project (Code, Title, **PI,** CoPIs & *Associates*)

PGR/EXP-BUR-CUT-01.01- Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural and horticultural crops in Odisha and adjoining regions. (**DR Pani** & RC 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. (**RC Misra** & DR Pani)

12 REGIONAL STATION, HYDERABAD

Summary: During the period under report a total of 55,489 samples (16,262 imports; 39,227 exports) were processed for quarantine clearance. 43 Phytosanitary certificates were issued. Import crop germplasm samples (8,694), infested/ infected with pests/pathogens, were salvaged and released. *Drechslera maydis* on maize from Mexico, *Pyricularia grisea* on finger millet from Kenya, *Peronospora manshurica* on soybean from Taiwan, *Macrophomina phaseolina* on Casuarina and okra from Kenya and Thailand, respectively are some of the significant interceptions. Two accessions consisting of soybean infected with downy mildew (*Peronospora manshurica*) and maize infested with grain weevil (*Sitophilus granarius*) were rejected. Post-entry quarantine inspection was conducted on 3,563 accessions of different crops grown at ICRISAT (41) and World Vegetable Center (204), private industry (3,174), public organizations (40) and NBPGR greenhouse (104). Quarantine services were extended to 40 organizations in South India.

12.1 Germplasm quarantine

A total of **55,489** samples comprising **16,262 import** samples and **39,227 export** samples was received for quarantine processing as detailed below. In all, 4 international organizations, 7 public organizations (ICAR institutes, universities/state govt. organizations) and 29 private organizations received the quarantine service from this station. Resources worth **Rs.58,04,563/-** were generated through quarantine processing of imported consignments.

12.1.1 Import Quarantine

A total of **16,262** samples including paddy-4979, wheat-322, barley-150, maize-6074, sorghum-464, pearlmillet-20, fingermillet-761, groundnut-27, soybean-111, sunflower-42, mustard-375, niger-5, chickpea-232, pigeon pea-57, mungbean-326, lucerne (*Medicago sativa*)-3, tobacco-9, chilli-1178, tomato-305, bitter gourd-62, cucumber-63, brinjal-68, okra-192, canola-17, *Casuarina*sp.-70, cauliflower-174, onion-64, pumpkin-29, *Vinca* sp.-10, watermelon-32 and dragon fruit-41were imported from different countries.

12.1.2 Interceptions

During quarantine processing, the following major pathogens were intercepted.

Wheat: *Drechslera rostrata, Fusarium graminicola,* and *Stemphylium* sp. from Morocco; **Barley:** *Drechslera hawaiiensis* from Netherlands; **Maize:** *Pestalotiopsis microspora* from Thailand and USA, *Drechslera maydis* from Mexico, *Stenocarpella maydis* from USA and South Africa, *Lasiodiplodia maydis* from Argentina, Kenya and Philippines, **Sorghum:** *Drechslera rostrata* and *Phoma sorghina* from USA, *D. setariae* and *Rhizoctonia* sp. from Argentina; **Pearl millet:** *D. rostrata* from Kenya; **Finger millet:** *Pyricularia grisea* from Kenya; **Groundnut:** *Groundnut rosette assistor virus* (GRAV) from Malawi; **Niger:** *Ascochyta pinodes* from Ethiopia; **Soybean:** *Peronospora manshurica* from Taiwan; **Bitter gourd:** *Choanephora* sp., *Colletotrichum dematium, Drechslera sacchari, Fusarium oxysporum, Lasiodiplodia* sp., *Myrothecium roridum,* and *Pestalotiopsis* sp., from Thailand; **Okra:** *C. dematium*, *Macrophomina phaseolina*, and *Pestalotiopsis guepini* from Thailand, *Choanephora*

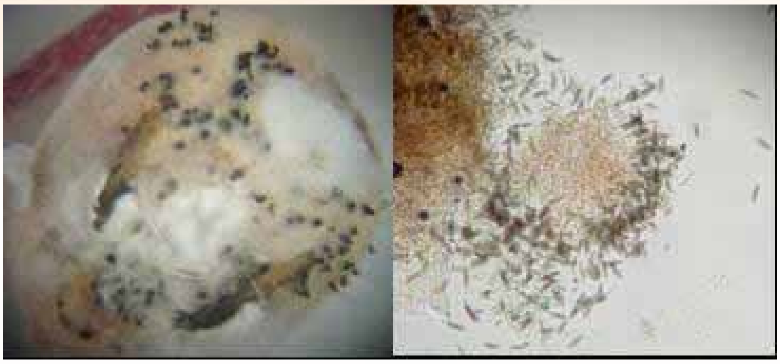


Fig. 12.1. *Stenocarpella maydis* intercepted on maize from USA

Fig. 12.2. *Peronospora manshurica* (Oospores) intercepted on soybean from Taiwan

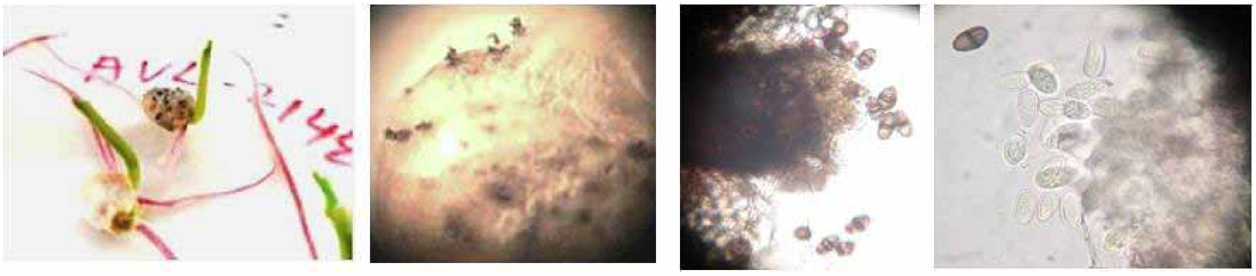


Fig. 12.3. *Lasiodiplodia maydis* on maize from Argentina

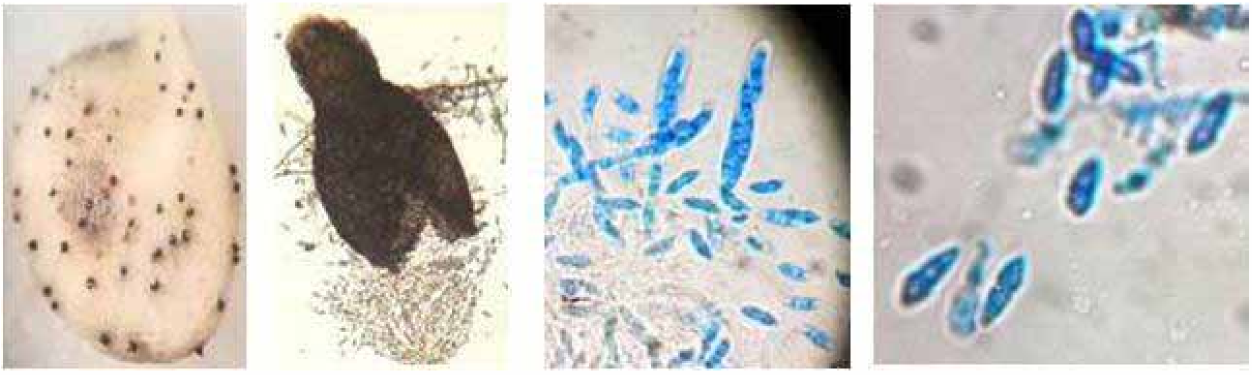


Fig. 12.4. *Ascochyta pinodes* perithecial bodies on chilli seeds, perithecium with asci and asci with single septate ascospores

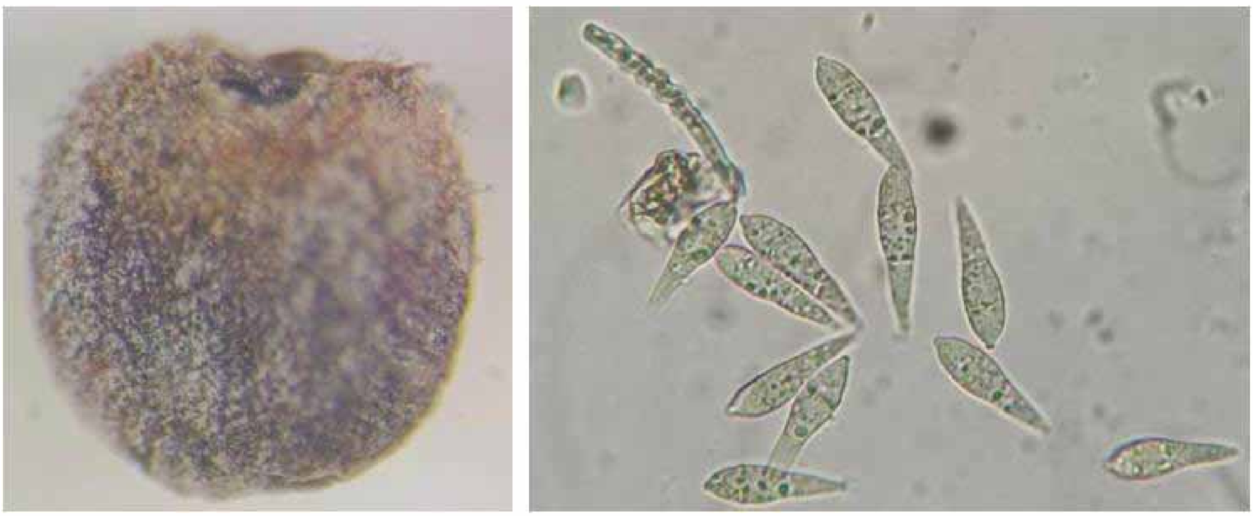


Fig. 12.5. *Pyricularia grisea* conidia on fingermillet seed from Kenya

Fig. 12.6. *Sitophilus granarius* infestation in maize from Kenya

Fig. 12.7. Contamination of barley seed with *Convolvulus* spp. from Netherlands

sp. from Taiwan; **Chilli:** *A. pinodes, D. rostrata, M. phaseolina,* and *Chilli leaf curl virus* from Taiwan; **Onion:** *D. rostrata* from Israel; **Casuarina:** *M. phaseolina* from Kenya.

Insects: One accession in maize (AFEA133216422) from Kenya was rejected due to live infestation of *Sitophilus granarius.*

Nematodes: *Aphelenchoides besseyi* on paddy from Philippines and Criconematids in soil clods mixed with barley seeds imported from Netherlands.

Weeds: *Convolvulus* spp. was intercepted in one accession of barley from Netherlands.

12.1.3 Imports released

Seed samples (**18276**) consisting of paddy-5555, wheat-322, barley-150, maize-5893, sorghum-244, pearlmillet-291, finger millet-1126, chickpea-257, sunflower-18, soybean-110, sesame-230, mustard-364, canola-17, niger-5, commonbean-585, chilli-1152, tomato-287, cauliflower-239, bittergourd-397, okra-785, brinjal-68, cucumber-53, onion-20, watermelon-16, *Casuarina* sp.-70, *Vinca* sp.-10, tobacco-9, and lucerne (*Medicago sativa*)-3 were released after necessary mandatory treatments.

12.1.4 TSOP treatment

Mandatory trisodium orthophosphate treatment (10% sol) was given to imported germplasm of tomato (287) and chilli (1152) before release to the consignees.

12.1.4 Import germplasm salvaging details:

Total number of samples infected/ infested: 8696

Fungi: 8696; (Pathogenic- 4068; saprophytes- 4625); Bacteria: 208; Viruses: 15; Nematodes: 138; Insects: 08; Weeds: 01

Number of samples salvaged: 8694

Number of samples detained: Nil

Number of samples rejected: 02

12.2 Export quarantine

Crop germplasm samples (39,227) consisting of maize (3,734) received from CIMMYT and chickpea-9037, sorghum-20805, foxtail millet-33, finger millet-121, pearl millet-5430 and pigeon pea-67 received from ICRISAT were processed for export purpose. In all, 182 samples were detained or withdrawn, which include 8 samples of sorghum due to Gram –ve bacteria (2) and nil germination (6); 32 samples of pearlmillet due to Gram –ve bacteria (23), and nil germination (9); 5 samples of pigeonpea due to Gram –ve bacteria (3), insect infestation (1) and nil germination (1); 137samples of chickpea due to Gram –ve bacteria (136) and insect infestation (1). In all, **43** Phytosanitary certificates were issued.

12.2.1 Post entry quarantine inspections

Post-entry quarantine inspection was conducted on 3,563 accessions of different crops grown at ICRISAT (41) and World Vegetable Center (204), private industry (3,174), public organizations (40) and NBPGR greenhouse (104).

12.2.2 NBPGR glasshouse

Bambara nut accessions from Ghana (10), Tanzania (6), Uganda (8) and Niger (9), received from ICAR-NBPGR, New Delhi were grown for post-entry quarantine and inspected at regular intervals. *Bean common mosaic virus* was intercepted in one accession (EC1050874) from Ghana and identity was confirmed using poty virus coat protein gene specific primers. The sequence was submitted to NCBI Genbank and obtained the accession no. MZ442315. All the accessions from remaining countries were found healthy and no exotic pest incidence was observed.

Groundnut accessions (25) from Malawi, grown at NBPGR greenhouse, were inspected regularly. Leaf samples from virus suspected plants of ICG 93437, ICGV-SM 0503 and ICGV-SM 99557 accessions were collected, and RNA was extracted from suspected samples and reverse transcribed with *Groundnut rosette virus* specific primers The amplicons were sequenced and confirmed. Further, molecular confirmation of associated *Groundnut rosette assistor virus* (GRAV) also diagnosed with all the three accessions.

12.2.3 PEQ at ICRISAT glass house

Post-entry quarantine inspection of pearlmillet (16) and sorghum (25) from Kenya, grown at ICRISAT glass house, was conducted and all accessions were found healthy.

12.2.4 PEQ at AVRDC

Post-entry quarantine inspection of 104 accessions comprising chilli (50), tomato (23, 14), soybean (110) and bittergourd (7) imported from Taiwan, and grown at ICRISAT field was conducted. *Chilli leaf curl virus* was found in chilli (confirmed through PCR test), mealy bug infestation was observed on several accessions of chilli and tomato. *Tomato leaf curl virus* was found in two accessions *viz*., EC1087243 and EC1087254. *Alternaria solani* was detected in tomato. Leaf samples of virus suspected plants from soybean and bitter gourd were tested for the presence of Poty viruses and found free.

12.2.5 Public organizations

Post-entry quarantine inspection of maize consignment (45 accessions) from USA, grown at ICAR-IIMR, Winter Nursery Centre, Hyderabad was conducted. All accessions were found healthy.

12.2.6 Private industry

Post-entry quarantine inspection of 70 consignments of different crop germplasm (3,174 accessions) consisting of maize (2057) imported from Brazil (34), France (25), Indonesia (260), Italy (88), Kenya (47), Mexico (22), Philippines (134), South Africa (177), Thailand (583) and USA (687); barley (97) from Netherlands; sorghum (244) from Argentina; sunflower (21) from Argentina (18) and USA (3), okra (312) from Taiwan (137) and USA (175); tomato (54) from Taiwan; chilli (8) from Taiwan; hot pepper (16) from Taiwan; onion (65) from USA (65); bitter gourd (103) from Thailand; ridge gourd (66) from Thailand (3) and USA (63); sponge gourd (68) from USA; pumpkin (5) from Taiwan (2) and Thailand (3); Celosia (3), Coleus (21) and Cosmos (11) from UK were conducted during 2021. The details of important pests observed are given in Table 12.1. All the virus and other quarantine pest suspected accessions mentioned in the table were uprooted and incinerated.

12.2.7 Facilitation of Germplasm conservation in Svalbard Global Seed Vault

In all, 3700 accessions of ICRISAT mandate crop germplasm (sorghum, pearlmillet, pigeonpea, groundnut, chickpea, and finger millet), along with 426 duplicate samples for viability tests, were examined for seed health aspects (Fig 12.8). These samples were meant for export to Norway for conservation in the Svalbard Global Seed Vault. All the samples were found healthy and free from pests.

12.2.8 IITA-Genebank, Nigeria as safety duplicates

Twenty thousand accessions consisting of sorghum (15000) and pearl millet (5000) were visually examined for seed health aspects and found healthy. These samples have been deposited at IITA - Genebank, Nigeria as second set of safety duplicates by ICRISAT.

12.3 Other activities

Predicted the potential geographic distribution of exotic nematode, *Aphelenchoides fragariae* in India based on MaxEnt ecological niche modelling. The model identified highly suitable regions for *A. fragariae* that are mainly located in Northern and Eastern parts of India, such as Himachal Pradesh, Uttarakhand, Arunachal Pradesh and few places in Jammu & Kashmir. Among the bioclimatic variables, isothermality (Bio3) and precipitation of driest month (Bio14) have more influence on geographic suitability for *A. fragariae* as indicated with highest gain value in Jackknife test. The MaxEnt model provided the reliable prediction of climate suitability for *A. fragariae* in India as measured by AUC values of 0.972 for training data and 0.942 for test data.

Table 12.1. Details of pests observed during post entry quarantine inspections (PEQI) at private industries during 2021.

Crop	Source country	Pests observed
Maize	South Africa	Southern corn leaf blight (*Drechslera maydis)* - EC1039396 Northern corn leaf blight (*Exserohilum turcicum*) - EC1039411, EC1039432, EC1039317 and EC1039343.
	Indonesia	*Maize streak virus* suspected plants - EC995676 (2 plants) and EC1036524 (1 plant) Northern corn leaf blight (*E. turcicum*) - EC995670
	USA	*Maize streak virus* suspected plants - EC1038115 (2 plants), EC1058423 (1 plants) and EC1058351 (1 plant)
	Kenya	Northern corn leaf blight (*E. turcicum*) - EC1058014 (3 plants) and EC1057984 (2 plants)
	Thailand	Northern corn leaf blight (*E. turcicum*) - SI-ID 139754149 (2 plants), 139753794 (2 plants), 140066896 (2 plants) and 139754499 (2 plants). Pokkahboeng disease - 139753982 (3 plants), 139754685 (4 plants), and 139754598 (3 plants).
	Mexico	Southern corn leaf blight - EC1087961
Barley	Netherlands	Loose smut - EC1039196 (1 plant) *Barley stripe mosaic virus* suspected plant - EC1039244 Stem borer - EC1039248 and EC1039259
Sorghum	Argentina	Pokkahboeng disease was observed in the most of the accessions. Mosaic virus symptom - EC1082883.
Ridge gourd	USA	Virus suspected plant - EC1039554
Hot pepper	Taiwan	Phyllody (1 Plant) and *Cucumber mosaic virus* (1 plant) suspected plants - EC1029199
Tomato	Taiwan	Early blight (*A. solani*) affected plant (1 no.) - EC1029208
Okra	Taiwan	Leaf spot of okra (*Choanephora cucurbitarum)* - EC1003093, EC1003119, EC1058455 and EC 1003125. Powdery mildew (*Oidium* sp.,) was observed in few accessions. Aphid, leaf hopper, *Spodoptera litura* and Semi looper infestation was noticed on several okra accessions.
	USA	Powdery mildew (*Oidium* sp.,) - EC106060, EC1060161, EC1060164, EC1060166, EC1060167, EC1060174, EC1060175, EC1060178, EC1060181, EC1060186, EC1060189, EC1060198, EC1060199, EC1060218 and EC1060248 YVMV incidence - EC1060226, EC1060227, EC1060244 and EC1060246
Bittergourd	Thailand	Wilt (*Fusarium* sp.,) - EC10229233 (1 plant), EC10229235 (1 plant), EC10229241 (2 plants), EC10229265 (2 plants). *Leaf curl virus* - EC1056932 (2 plants) and EC1056934 (1 plant)
Sunflower	Argentina	Sunflower leaf blight (*Alternaria helianthi*) - EC1096195

Fig. 12.8. Inspection of crop germplasm by NBPGR staff meant for conservation in the Svalbard Global Seed Vault

12.4 Germplasm exploration and collection

Rare phenotypic diversity especially in seed colour and ornamentation in Indian licorice (*Abrus precatorius*) was augmented from the Western Ghats region and Cucurbitaceae wild species *Corallocarpus epigaeus* and *Momordica cymbalaria* from Virudhunagar district, Tamil Nadu. A total of 20 accessions which include *A. precatorius* (17), *C. epigaeus* (1) and *M. cymbalaria* (2) could be sampled. The collection of *A. precatorius* belong to 10 major colour groups (Black, blue-green, blue, green, greyed-orange, orange-red, red, red-purple, violet-blue, white, yellow-orange) and 17 colour codes with significant variability in seed length (mm) (5.9 - 7.4), seed thickness (mm) (4.3 - 5.6) and 100 seed weight (g) (6.6-12.9) (Fig.12.7&12.8).

Fig. 12.9. *Abrus precatorius* diversity augmented from Western Ghats

In addition, a total of 50 accn. of diversity belonging to different Agri-horticultural crops was also augmented from the East Godavari district, Andhra Pradesh under APS Biodiversity Project. Some of the landraces collected include paddy (*Budamalu*), sorghum (*Pachcha jonna* and *Tella jonna*), Italian millet (*Bonthalu*) and green gram (*Nalla pesalu*) etc.

12.5 Germplasm characterization and evaluation

A total of 1,282 accessions of different agri-horticultural crops was raised for characterisation, evaluation, screening, rejuvenation and multiplication along with appropriate check varieties during *rabi*/ summer, 2020-21 (376 accessions- brinjal, chilli, cowpea, dolichos bean and tomato), *kharif,* 2021 (590 accessions- black gram (224), browntop millet (61), green gram (23), italian millet (60), kenaf (1), okra (6), pigeon pea (1), roselle (6), sesame (89), sorghum (19) and tomato (100)) and *rabi*/ summer, 2021-22 (316 accessions- chilli (56), dolichos bean (42), field bean (72), maize (74), sesame (50) and sorghum (22)). In addition, 450 accessions of black gram germplasm were taken up for screening against *Yellow mosaic virus* in association with Agri-biotech Foundation under the DBT Project.

12.5.1 Promising accessions identified for important traits in different agri-horticultural crops are as follows:

Browntop millet (Fig.12.11): Plant height (cm): IC617953 (116.7); basal tillers (no): IC617953 (22.0); inflorescence length (cm): IC613562 (20.2), IC613551 (18.8); seed yield/ plant (g): IC636144 (23.1), IC617957 (21.5); 100 seed weight (g): IC617958 (0.5); days to 50% flowering: IC325197 (35 days).

Italian millet (Fig.12.12): Plant height (cm): IC430606 (170.6), IC308939 (168.3); basal tillers

Momordica cymbalaria *Corallocarpus epigaeus*

Fig. 12.10. Wild cucurbit species from Virudhungar district, Tamil Nadu

(no): IC283688 (16.0), SK-13933 (15.6); panicle length (cm): IC306468 (31.8), IC308936 (31.7), IC306472 (31.2); days to 50% flowering: IC308934 (40 days).

Maize (Fig.12.13): Plant height (cm): BB-14318 (327.3); ear length (cm): IC636971 (20.2); kernel rows (no): IC636973 (17.5), IC636966 (16.5); 100 seed weight (g): IC627702 (35.6); days to tasseling: IC332069 (35.0 days), IC332070 (39.0 days); days to silking: IC332069 (39.0 days), IC332070 (40.0 days).

Sesame: Plant height (cm): IC043036 (135 cm), IC131565 (129.0); internode length (cm): IC043157 (15.1), IC096116 (15.1); capsule length (cm): IC056149 (3.8), IC0413199 (3.6), NSKMS-275 (3.6); capsules/ plant (no): IC110221 (163.0); 100 seed weight (g): IC096113 (0.5), IC073164 (0.4),IC131565 (0.4); days to 50% flowering: IC132164 (36 days).

Brinjal: Primary branches (no): IC136450 (13.1); fruit length (cm): IC136249 (20.5); days to 50% flowering: IC89905 (85.0 days).

Chilli (Fig.14): Plant height (cm): HRSM-7 (122.0), HRSM-9 (120.0), HRSM-6 (110.0), EC390029 (100.0); fruit length (cm): EC391083 (12.0), EC378688 (10.5), IC545735 (10.4); fruit width (cm): HRSM-5 (4.0), IC545728 (3.8), IC545731 (3.5), EC399572 (3.5); days to 50% flowering: IC344650 (66.0 days).

Cowpea (Fig.15): Days to 50% flowering: IC519720 (58.3 days); primary branches (no): IC436638 (5.4), IC519705 (5.1); pod length (cm): IC282059 (18.5), IC 582853 (17.2), IC282059 (17.6); seeds/ pod (no): IC261240 (17.2), IC436845 (17.2); clusters/ plant (no): IC519705 (40.5); pods/ plant (no): IC519705 (76.1); 100 seed weight (g): IC519751 (14.3), IC 519761 (13.2).

Dolichos bean: Pod length (cm): IC427462 (17.7); pod width (cm): IC383197 (4.3), IC384066 (2.8), IC427429 (2.8); 10 fresh pod weight (g): IC383197 (184.5), IC384066 (149.7), IC427429 (145.8); seeds/ pod (no): IC413710 (5.8), ADB-8 (5.6), IC427428 (5.5); 100 seed weight (g): IC384066 (61.9).

Field bean (Fig.12.16): Pod length (cm): IC261257 (6.8); pod width (cm): IC261257 (2.3), IC369582 (2.2), IC526943 (2.2); 10 fresh pod weight (g): IC261257 (55.2); seeds/ pod (no): NSJ-355 (4.7), NSJ-246 (4.3), PSRJ-12999 (4.3); 100 seed weight (g): RJR-196 (37.0), IC526944 (36.0).

12.5.2 Screening of blackgram germplasm against YMV

A total of 450 blackgram accessions were screened against *Yellow mosaic virus* in association with Agribiotech Foundation. Among these, 281 accessions were new ones and not tested earlier; 131 accessions were found free from disease in the earlier screening studies and 30 accessions showed more than 20% damage in the earlier studies. Of these, 261 accessions were infected with YMV. In addition, during Kharif, 2021, the minicore set consisting of 218 blackgram accessions, received from NBPGR, New Delhi was sown along with five checks (KU-6;

Fig. 12.11. Diversity in browntop millet germplasm

IC344033

IC308939

Fig. 12.12. Diversity and promising accessions in Italian millet germplasm

Mash 114; IPU 2-43; PU 11-14; Mash-479). In all, data on 25 morphological traits viz., plant height, peduncle length, primary branches, clusters per pod, pods per cluster, pod length, total pods per plant, seeds per pod etc were recorded on all the accessions.

12.5.3 Screening of germplasm for resistance against nematodes

The germplasm comprising of chilli, brinjal and jute was evaluated against root-knot nematode, *Meloidogyne incognita* for identification source of resistance. Resistance is quantified by visual examination and rating of infected roots using root-knot index (RKI) on a 1-5 scale. Chilli: A set of 68 chilli accessions were screened against *M. incognita,* all the accessions recorded root galling ranging from 34 - 58 and were found to be susceptible (RKI: 4). Besides, three accessions of chilli (EC391083, EC399535 and EC402105), which were previously identified as resistant were also evaluated at Hyderabad and New Delhi to test their stability and consistency and two accessions EC402105 (3-9 galls and 0-3 egg mass/ root system) and EC399535 (5-9 galls and 0-4 egg mass/ per root system) were found to be stable in their reaction as resistant (RKI: 2) based on two year data (Fig.12.17).

Brinjal: Among 50 brinjal wild species comprising of *Solanum incanum* (30 accn.), *S. insanum* (10 accn.) *S. indicum* (2 accn.), *S. macrocarpon* (1 accn.), *S. viarum* (2 accn.), *S. virginiacum* (1accn.), *S. nigrum* (1 accn.), *S. spirale* (1 accn.), *S. violaceum* (1 accn.) and *S. torvum* (1

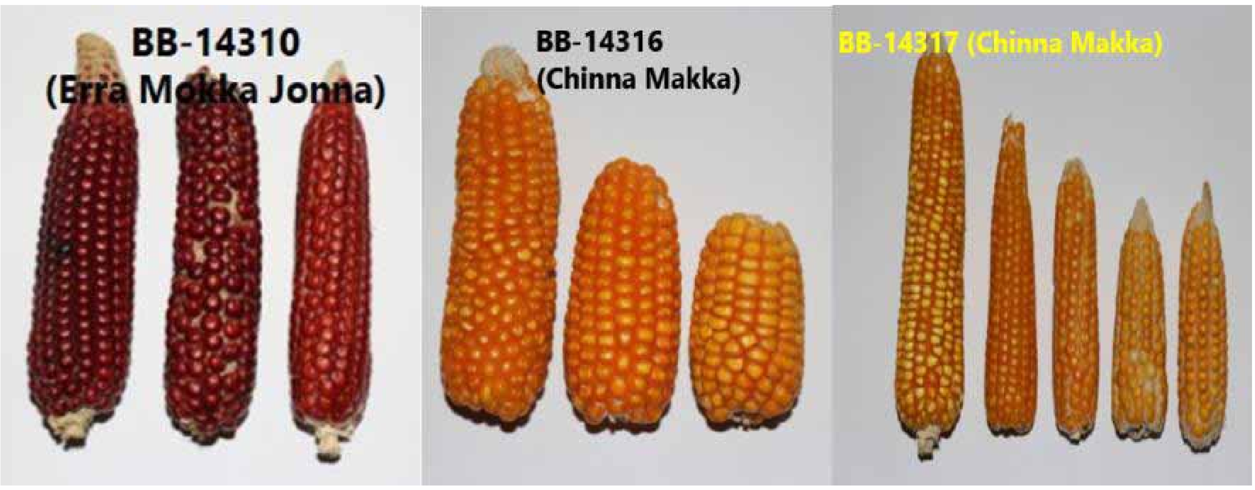


Fig. 12.13. Diversity and promising accessions in maize germplasm

Fig. 12.14. Diversity and promising accessions in chilli germplasm

Fig. 12.15. Diversity and promising accessions in cowpea germplasm

accn.) screened, resistance to *M. incognita* was found in accession IC618029 belonging to S. *torvum* (RKI: 3; (8-21 galls and 5-14 egg mass/ root system). The remaining wild species of brinjal were found susceptible with varied degrees.

Jute: Eight accessions of *Corchorus* germplasm, comprising of *Corchorus olitorius* (4 accn.), *C. aestuans* (3 accn.) and *C. capsularis* (1 accn.) received from ICAR-CRIJAF, Barrackpore were screened against *M. incognita* and resistance was found in wild species *C. aestuans* (WCIN-183A) (21 galls and 10 egg mass/ root system) (Fig.12.18).

12.6 Germplasm conservation

12.6.1 Germplasm sent to NGB

Thirty-four accessions of ICRISAT pigeon pea Mini-Core germplasm sent to NGB for Long-Term Conservation.

12.6.2 Germplasm sent to GHU

A total of 30 multiplied germplasm accessions consisting of cowpea (9 accs.) and paddy (21 accs.) were sent to Germplasm Handling Unit, ICAR-NBPGR, New Delhi for facilitating national accessioning and long-term conservation in NGB.

12.6.3 Medium Term Module

IC 526916

IC 526934

RJR-21

PSRJ-13102

Fig. 12.16. Diversity and promising accessions in field bean germplasm

Germplasm of different agri-horticultural crops (464), which were evaluated and multiplied consisting of chilli (124), cowpea (32), dolichos bean (45), field bean (70), sesame (84), brinjal (36), tomato (54) and sorghum (19) were added to the MTM at the station.

12.6.4 Germplasm distribution

A total of 1,344 germplasm accessions of different agri-horticultural crops was distributed to 35 SAUs/ ICAR institutes against 41 indents, which include barnyard millet (15), brinjal (300), browntop millet (65), chilli (469), dolichos bean (92), field bean (16), finger millet (15), Italian millet (15), kodo millet (15), little millet (15), maize (32), proso millet (15), tomato (278) and wild species *Solanum pimpinellifolium* (2).

In addition, 15 accessions of exotic Bambara nut from Mali and Niger multiplied at the station were sent to Headquarters for further evaluation. Besides these, the three farmers' varieties registered with PPVFRA, including pigeon pea (*Erramachcha kandi*) and sorghum (*Pelala jonna* and *Vayunowka jonna*) were also distributed to tribal farmers for popularization, multiplication, sharing and to form a cooperative for production, marketing and creation of a value chain.

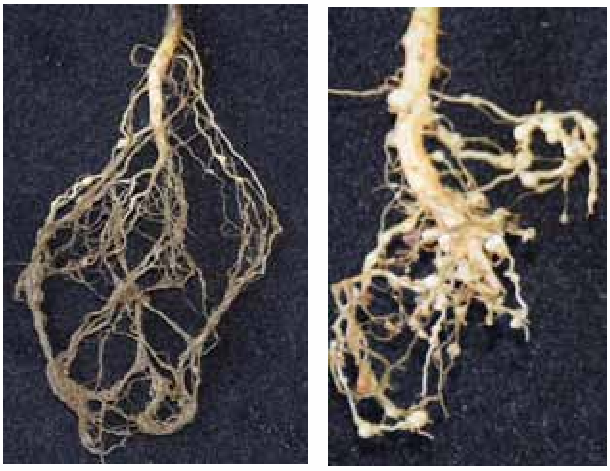
12.7 Supportive research

12.7.1 Studies on seed variability traits and chlorophyll spectrum on exotic Bambara nut germplasm

Variability in seed morphological traits were carried out on exotic bambara nut germplasm (33) imported from four African countries *viz*., Ghana, Niger, Tanzania and Uganda with an objective to group and identify unique germplasm based on seed traits and total chlorophyll content. Twenty seed colour morphotypes in bambara nut were identified. These 33 exotic bambara groundnut accessions broadly classified into six major colour groups Yellow-White (7), Greyed-Purple (5), Greyed-Yellow (5), Greyed-Orange (12), Black (2) and Grey Red (2) (Table-12). Interestingly, the colour group greyed-orange represents highest morphotypes (9) followed by greyed-purple group (4), greyed-yellow group (3), grey-red group (2), yellow-white group (1), and black (1) respectively. The highest seed length and seed width are recorded in Ugandan accessions EC1054951, EC1054949, respectively. The exotic germplasm exhibited good variability in seed features such as seed colour (Fig.12.19), testa with eye pattern around hilum, test weight, seed length and width. The total chlorophyll content (SPAD Values) ranged from 34.4 to 43.4 units with a mean value of 40.0. Among them EC1054954 recorded the highest value of 43.4 while EC1054950 recorded the

EC402105 (R) EC399535 (R) ArkaLohit (S)

Fig. 12.17. Host reaction (gall formation) in resistant (R) and susceptible accessions(S) of chilli



C. aestuans (WCIN-183A)(R) *C. capsularis* (Nalte) (S)

Fig. 12.18. Host reaction (gall formation) in resistant (R) and susceptible accessions (S) of jute

lowest value of 34.4. Measurements with the SPAD-502 meter produce relative SCMR values that are proportional to the amount of chlorophyll present in the leaf of bambara nut germplasm.

12.7.2 Facilitating introduction of new useful Crops - A success story of dragon fruit

Dragon fruit is a unique exotic health fruit that can be cultivated with poor resources of degraded lands and rainfed regions of India (Fig.12.20). Due to high demand both in domestic and international markets; dragon fruit production could be an economical avocation to both backyard growers as well as entrepreneurs of medium and large-scale plantations. Considering the importance of this exotic fruit, during the reporting period a total of 40 varieties/hybrids of exotic dragon fruit accessions from Philippines have been imported *viz*., *Big Red, Connie Mayer, Dark Star, Edger, Haleys Comet, Hawaiian Red, Makisupa, Maria Roza, Natural Mystic, Peruvian White, Purple Haze, Sugar Dragon, TLM White, Townsend Pink, Zamorano, S8 Sugar, Physical Graffiti, Godzila 26, George, ISIS Gold, Delight, Double Color, Vietnam Red, Vietnam White, Da Hong, Chameleon, ISIS Yellow, Guatemelon Red, Israel Yellow, Malaysian Red, Royal Red, Ruby Red, Siam Red, Thai Yellow, Orange, Palora, Pink Flesh, Taiwan Pink, Taiwan Red,* and *Vietnam Giant* for utilization in the State/country. In recent days, dragon fruit has been emerging as a super crop in the horticultural sector and has an export potential, and the contribution by ICAR-NBPGR would help in managing exotic dragon fruit crop genetic resources in the country by formulating suitable sustainable crop cultivation strategies and highly useful in micro-level planning of cultivation in degraded lands which in turn will help the farmers' to increase their livelihood security in the changed climatic regime.

Table 12.2. Grouping of Bambara nut germplasm based on Royal Horticultural Society (UK) Colour Chart 5th Edition

S. No	Colour Group (number of accessions)	Fan Number of chart	Accesssion (no)
A	Yellow-White (7)	158-A	EC1050866, EC1050867, EC1056417, EC1056420, EC1056421, EC1056424, EC1056425
B	Greyed-Purple (5)	187-A	EC1050868, EC1054955
		187-C	EC1050874
		187-D	EC1050880
		N186	EC1056419
C	Greyed-Yellow (5)	161-A	EC1050871
		161-B	EC1050869, EC1054950
		161-C	EC1054953, EC1054956
D	Greyed-Orange (12)	166-A	EC1054949
		166-C	EC1054951
		N 170 A	EC1054954
		172-A	EC1056418
		172-C	EC1056422, EC1056423
		175-A	EC1050870
		173-D	EC1050873, EC1050872
		173-C	EC1050875
		174-A	EC1050881, EC1050876,
E	Black (2)	203-C	EC1050877, EC1050879
F	Grey Red (2)	178-A	EC1050878
		178-B	EC1054952

Fig.12.19. Seed diversity in select germplasm accessions of exotic Bambara nut

Fig. 12.20. Dragon fruit habit, flower bud, flower & fruit

Externally funded projects

In - situ Management of Indigenous Crop Diversity through Community Managed Seed Systems for Value Addition and Improved Market Access for Climate Resilience in Rainfed High Altitude Tribal Areas (Scheme Code:40228; Project Code: 16113180013: Project No: 1009847). B Sarath Babu (up to 31.05.2020), N Sivaraj, SR Pandravada, Kamala Venkateswaran, K Anitha, SK Chakrabarty (till 31st December 2019), Ms. P Pranusha. Funding Agency: Rashtriya KrishiVikas Yojana (RKVY), Government of Andhra Pradesh.

Genetic resource assessment, *in-situ on-farm* conservation and impact of banana waste as a feed for animals in North-East region of India (Scheme Code: 40003; Project Code:1010183). Dr N Sivaraj, PI Cooperating Centre, RS Hyderabad. Funding Agency: DBT NER-Banana Program for the NE.

Documentation and sustainable management of Agro-Biodiversity (Crop Genetic Resources) in Andhra Pradesh through developing diversity databases, crop atlas, GIS mapping and modelling (Project No. 1012783). PI: N Sivaraj, Co-PI: K Anitha, V Kamala, SR Pandravada, B Parameshwari, Prasanna Holajjer, P Pranusha, Bajaru Bhaskar, and Babu Abraham. Funding Agency: Andhra Pradesh State Biodiversity Board, Guntur, Andhra Pradesh.

Network Project on Genetic Enhancement of Minor Pulses, the Regional Station is part of a New Project 'Characterization, Evaluation, Genetic Enhancement and Generation of Genomic Resources for Accelerated Utilization and Improvement of Minor Pulses (Scheme Code: 40003; Project Code: 1010668). Dr K Anitha, PI Cooperating Centre, RS Hyderabad. Funding Agency: DBT

Pathological and morphological investigations of *Hylocereus undatus* (Consultancy project) (Scheme Code: 40395-565; Project Code:161141002). PI: Anitha Kodaru, Co PIs N. Sivaraj, B. Parameswari, Prasanna Holajjer, Bhaskar Bajaru. Funding Agency: Deccan Exotics (FPO)

Development of Recombinase Polymerase Amplification Combined Lateral Flow Dipstick Kits for Rapid Detection of Major Viruses Infecting Sugarcane (Scheme Code: 40346-564; Project Code: 1611320003). PI: Dr. B. Parameswari. Funding Agency: DST-SERB.

Research Programme (Code: Title, Programme Leader)

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

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

PGR/PQR-BUR-HYD-01.01: Detection, identification and control of pests associated with import and export of seed/plant material (**K Anitha**; Prasanna Holajjer; Bhaskar Bajaru; B Parameswari; L Saravanan (w.e.f. 20.01.2021); *Babu Abraham* (up to 31.05.2021))

PGR/PQR-BUR-HYD-01.02: Post-entry quarantine processing of imported germplasm (**Prasanna Holajjer**; K Anitha; Bhaskar Bajaru; B Parameswari; L Saravanan (*w.e.f.* 20.01.2021); *Babu Abraham* (up to 31.05.2021))

Programme II: PGR/PQR-BUR-HYD-02.00: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of south east coastal zone (**K Anitha**)

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

PGR/PQR-BUR-HYD-02.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of agricultural crops (cereals, millets, pulses, oilseeds etc.) and their wild relatives (**V Kamala** (up to 30.11. 2021); S R Pandravada; N Sivaraj; P Pranusha; Bhaskar Bajaru; L Saravanan (*w.e.f.* 20.01.2021); *Babu Abraham* (up to 31.05.2021))

PGR/PQR-BUR-HYD-02.02: Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources of horticultural crops (vegetables, fruits, spices, medicinal and aromatic plants etc.) and their wild relatives (**SR Pandravada**; V Kamala (up to 30.11. 2021); N Sivaraj; P Pranusha; Prasanna Holajjer; B Parameswari (*w.e.f.* 26.10.2020); L Saravanan (*w.e.f.* 20.01.2021); *Babu Abraham* (up to 31.05.2021))

REGIONAL STATION, JODHPUR

13

Summary: An exploration trip was conducted during the year in collaboration with ICAR-DMAPR Anand, AICRP on MAP and Betelvine Center Agriculture University Jodhpur for collection of M&P (*Withania coagulens*, *Senna alexandrina*, *Pedalium murex*), CWR (*Luffa, Momordica, Cucumis, Sesamum*) from Sikar and Nagaur Districts (Rajasthan); Bhiwani District (Haryana). 38 germplasm accessions of local landraces belonging to nine taxa were collected during exploration tour. Significant morphological variation with respect to fruit shape, size and colour was observed. Total 1383 germplasm accessions of various crop groups comprising 944 accessions during *Rabi* 2020-21 and 439 accessions during *Kharif* 2021 were characterized and evaluated at Jodhpur. During *Rabi* 2020-21, total of 541 accessions of mustard and 170 accessions of fenugreek were characterized and evaluated for agro-morphological traits and screened against biotic and abiotic stresses. Total 233 accessions of various horticultural crops including Ber (26), Karonda (18), Aonla (41), Phalsa (19), Ker (15), Bael (19) and Jojoba (95) were characterized and evaluated for various quantitative and quality parameters. Crop wise accessions characterized and evaluated during *Kharif* 2021 including moth bean (300) and cluster bean (139) 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. Trait specific promising germplasm accessions were identified in these crops. A total of 1959 germplasm accessions of various agri-horticultural crop species were supplied from MTS and FGB to 19 various indenters from India. Multiplied and regenerated 50 germplasm accessions of mung bean and 200 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 43,120 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

An exploration was conducted in collaboration with ICAR-DMAPR Anand, AICRP on MAP and Betelvine Center, Agriculture University, Jodhpur for collection of landraces of M&P from Sikar and Nagaur Districts (Rajasthan); Bhiwani District (Haryana) was undertaken from 17.10.2021 to 24.10.2021. A total of thirty eight germplasm accessions of local landraces of *Cucumis, Sesamum, Momordica, Luffa, Pedalium* and *Citrullus* were collected during exploration tour. Significant morphological variation with respect to fruit shape, size and colour cucumis accessions was observed. Tender fruits with good shape (pointed, oval or round), size (small to large) and colour (light green to golden yellow) having desirable marketable traits were collected during the exploration from the farmer's field. The explored region represents unique genetic diversity for Momordica, Luffa, Cucumis and Sesamum species landraces. Collected accessions would help build the base material for future crop improvement programme as until now not much improvement work is carried out in these crops.

Fig. 13.1: Fruit collection from wild sesame plants and morphological variation in cucumis germplasm

13.2 Characterization and evaluation of germplasm

13.2.1 *Rabi* 2020-21

A total of 944 accessions were characterized and evaluated during *Rabi* 2020-21. Crop wise accessions characterized and evaluated were Mustard (541), fenugreek (170), Ber (26), Karonda (18), Aonla (41), Phalsa (19), Ker (15), Bael (19) and Jojoba (95). The experiments were conducted in ABD/RBD design.

Characterization and evaluation of horticultural germplasm

A total of 233 accessions of horticultural germplasm belonging to Ber (26), Karonda (18), Aonla (41), Phalsa (19), Ker (15), Bael (19) and Jojoba (95) conserved in FGB, Jodhpur were characterized and evaluated for morphological characters, as well as for qualitative and quantitative traits during 2020-21.

Characterization and evaluation of ber germplasm

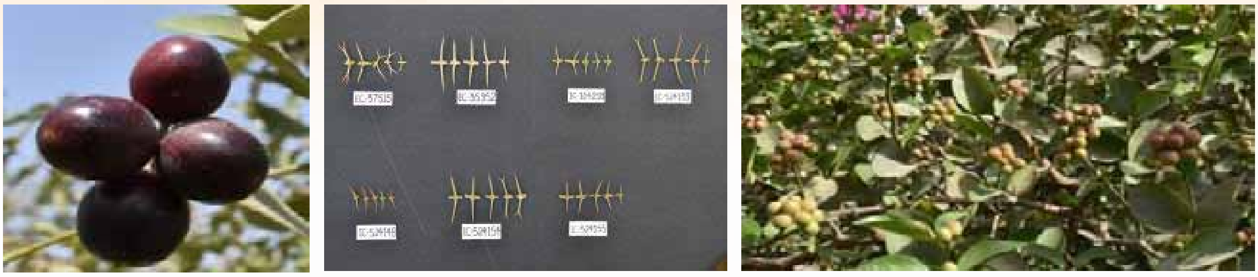
Among 26 ber germplasm accessions high variability was observed in term of fruit weight (1.07 to 53.08g), fruit length (10.08 to 70.05 mm) fruit width (12.44 to 57.9 mm), stone wt. (0.23 to 3.21gm) TSS content (13 to 24.2 °B), Vitamin C content (24 to138.7 mg/100gm), phenol content (256.2 mg/100gm). The promising trait specific genotypes identified viz. IC625863 suitable for processing with high TSS content (24.2 °B), IC 625849 high Vitamin C content(138.7 mg/100g), IC625864 (256.2 mg/100g) for high phenol content, IC625849 for high antioxidants (138.7 mg/100g) content and IC625848 for higher shelf life at ambient condition **(fig. 13.2)**

Characterization and evaluation of karonda germplasm

Total 18 accessions of Karonda belonging to three species (*Carissa carandas, C. edulis and C. grandiflora*) were evaluated for yield contributing traits during 2020-21. **(fig. 13.3)** Wide variation observed among the species and within species for quantitative and qualitative traits. Genetic variation was recorded in, fruit per cluster (3.5 to 10.7), fruit weight (1.64 to 4.0 gm) fruit yield per plant (0.4 to 20 Kg). On the basis of morphological and physico-chemical analysis following accessions were identified for further evaluation viz. IC644655

IC625863 IC625864 IC 625848 IC625849

Fig. 13.2 Promising ber germplasm accessions identified



IC644656 IC124148 IC644655

Fig. 13.3 Promising karonda germplasm accessions identified

for flowering and Reddish black fruit colour at the time of maturity with sweet tarte early. IC524148 reported to have least thorn length, IC 644656 found with high yield potential (20 kg/plant) and IC644655 produced for more fruits per cluster (6 to10).

Characterization of aonla germplasm

Total 41 accessions of aonla (*Emblica officinalis*) were characterized for quantative traits. **(fig. 13.4)** IC644659 identified promising for blue on fruit at time of maturity, IC644657 having prominent fruit segmentation and IC644658 found late in maturity.

Characterization of jojoba germplasm

Total 95 accessions of Jojoba (*Simmondsia chinensis*) were characterized for quantitative traits. High range of variability was recorded in capsule length (18.51 to 24.99 mm), seed length (13.63 to 19.07 mm) and capsule weight (0.66 to 1.45 gm). The promising genotype identified for high yield potential was: EC699691 (3.51 kg).

Characterization of ker germplasm

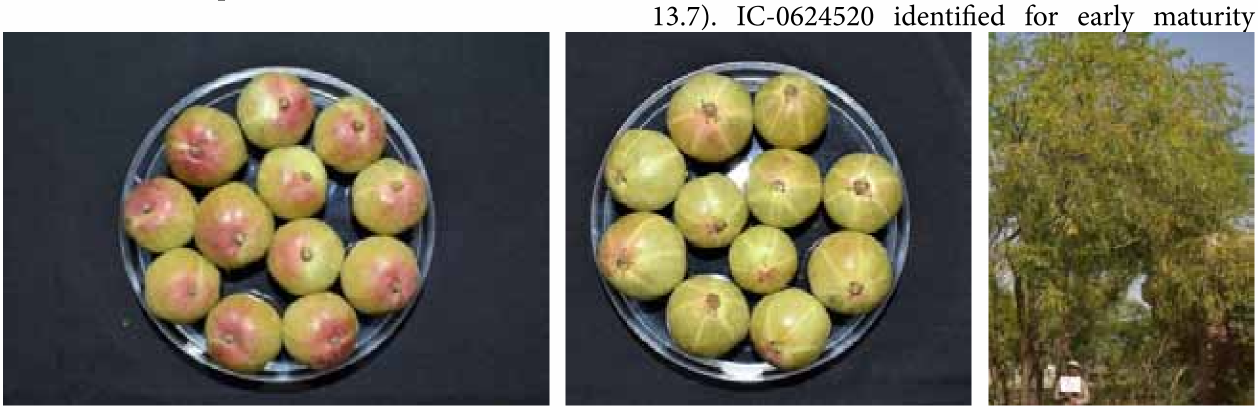
15 accessions of Ker (*Capparis decidua*) were characterized for quantative traits. IC103393 found promising in term of higher fruit weight (13.8gm) with pink flower and IC103362 found red veined flower with medium fruit size (4 to 6 fm) while round the year flowering reported from IC103395.

Characterization of bael germplasm

Total 19 accessions of Bael (*Aegle marmelos*) were characterized for vegetative and yield contributing characters. Different genotypes showed wide variation in vegetative, quality and quantitative traits. Variability was observed in fruit shape *i.e.* oval, elliptical, round and flat. **(fig. 13.5)** Pulp colour was (yellow to saffron) locules scattered, centric and peripheral. High range of variability was recorded in plant height (4.9 to 9.7 meter), No. of fruit per plant (7 to 627), fruit length (47.7 to 118.49 mm), fruit width (50.1 to 107.8 mm), fruit weight (67.34 to 742.3 gm), no. of seed per fruit (24 to 108) and shell thickness (0.63 to 3.17 mm). (Fig 13.6)

13.2.2 Preliminary evaluation of fenugreek germplasm for agronomic trait

170 accessions of fenugreek were multiplied and characterized for agro-morphological traits in Rabi 2020-21. Recorded on morphological traits. Wide range of variability in agro-morphological traits was recorded and promising accessions identified (Table 13.7). IC-0624520 identified for early maturity



IC644659 IC644657 IC644658

Fig. 13.4 Promising aonla accessions identified during 2021-22

Flowering in IC103393

Higher fruit wt. in IC103393

IC103395 (Saffron colour flower) IC103362 (Red veined flower)

Fig. 13.5 Variability in ker germplasm and promising accessions identified

(90 days), EC510658 identified for dense foliage, EC510685 for green- copper colour leaf with high antioxidants value.(Fig 13.7)

13.2.3 Preliminary evaluation of Brassica germplasm:

264 accessions of *Brassica spp* were evaluated in ABD for agronomic traits. Data were recorded for morphological traits and promising accessions identified for further breeding programme. EC206723 identified as dark green stem, upright siliquae and non-waxy stem, tolerant to aphid infestation. IC 426381P5 accession identified as having white flower, smooth and broad leaf with thick stem.

13.2.4 Preliminary evaluation of brassica germplasm for abiotic stresses

A set of 47 accessions of *Brassica juncea* along with three checks were screened for moisture stress to study the effect of drought on agro-morphological traits. These accessions were grown under irrigated

IC644661 saffron colored pulp with thin shell (0.63mm)

IC644660 (Egg shaped fruit)

Fig. 13.6 Promising accessions identified in bael germplasm

(normal) and rainfed (moisture stress) conditions. Pre-sowing irrigation and one life saving irrigation was applied in rainfed condition trial when more than 80 % plants showed leaf rolling. Data were recorded for morphological traits. **(fig.13.9)** Promising accessions for drought tolerance on the

Fig. 13.7: Promising accessions identified (EC510717, EC510664, EC510658, EC510712 and EC510678) for various agro-morphological traits in compare to check Afg-1.

Fig. 13.8: Dr. D. K. Yadava observing green-copper leaf colour of Fenugreek germplasm

basis of DSI have been identified (Table 13.1).

13.2.5 Screening of fenugreek germplasm against powdery mildew disease

A set of 170 accessions of fenugreek along with four local checks (Rmt-1, Afg-1, Afg-2 and Afg-3) were screened under natural condition for identifying resistance level against powdery mildew disease caused by *Erysiphe polygoni*. During the season percent disease incidence of powdery mildew disease ranged from 2 to 81 % in all the accession. Out of 170 accessions seven accessions EC510559, EC510558, EC510588A, EC510741, EC 510662, EC-510633 and EC 510561 gave resistant reaction against powdery mildew disease under natural conditions. Thus, these accessions can be used in resistance breeding against powdery mildew disease. All the other accessions showed various degree of susceptibility to powdery mildew disease.

13.2.6 First report of '*Candidatus* phytoplasma asteris' related strain associated with fenugreek

Little leaf and witches' broom symptoms were

Fig. 13.9: Promising accessions identified in mustard germplasm

recorded in fenugreek germplasm accessions during the season with percent disease incidence ranging from 1 to 21%. Out of 170 accessions, phytoplasma suspected symptoms were noticed in 146 accessions under natural field condition. The detection of phytoplasma association was confirmed by nested PCR amplification of 16S rRNA gene specific primers (P1/P7 and R16F2n/R2) and sec A gene primer pairs (secA for-1/secA for-3). 16S rRNA and SecA gene sequence comparison of fenugreek phytoplasma isolates confirmed the association of '*Candidatus* phytoplasma asteris' related strain (16Sr I-B) sub group. Out of different leaf hoppers trapped in fenugreek fields, only *Empoasca* and *Orosius albinctus* species detected positive with '*Ca.* P. asteris' related strain by utilizing similar set 16S rRNA gene specific primers. **(fig. 13.12)** This is the first report of phytoplasma association with fenugreek from India to the best of our knowledge.

13.2.7 Screening of mustard germplasm against white rust and powdery mildew diseases

A total of 541 accessions of mustard including its crop wild relative (CWR) along with susceptible checks were screened under natural condition for identifying resistance level against white rust disease caused by *Albugo candida* and powdery mildew disease caused by *Erysiphe cruciferarum*. There was heavy incidence of both the diseases during the crop. Out of 541 germplasm accessions, 67 accessions gave complete resistance reaction against the white rust disease and 44 accessions gave complete resistance against powdery mildew disease. Out of these 26 accessions belonging to different species of mustard gave complete resistance against both the diseases (Table 13.1). These accessions will be further evaluated under natural as well as artificial conditions of high disease inoculum pressure.

Fig 13.10: Fenugreek germplasm accessions EC510561 and EC510741 giving resistance reaction against powdery mildew disease

13.2.8 Screening of ber germplasm against black leaf spot disease

Twenty six ber accessions being grown in field gene bank of ICAR-NBPGR Regional Station Jodhpur were screened for leaf spot disease caused by *Alternaria* species. Leaves shwd with brown circular spots 3 to 6 mm in diameter with a gray to tan center and distinct brownish-yellow margins. Leaves with severe infection had lesions that gradually enlarged, coalesced, and covered the entire surface of the leaf, causing an early leaf drop. **(fig. 13.14)**Disease Index varied from 0 to 50.8 per cent. The disease index was highest in accession IC0625850 giving highly susceptible reaction and lowest in IC0625862 with immune response. Two germplasm accessions IC0625856 and IC0625872 gave resistance reaction with PDI between 0.1-5.0. All the other accession did show susceptible response against the disease. These selected germplasm accessions with better levels of resistance can serve as additional sources of resistance in future ber breeding programs.

13.2.2 *Kharif* 2021

A total of 439 accessions were characterized and evaluated during *Kharif* 2021. Crop wise accessions sown for characterization and evaluation include moth bean (300) and cluster bean (139) for agor-morphological traits. The experiments were conducted in Augmented Block Design/ Randomized complete Block Design using appropriate checks and the agro-morphological characters were recorded as per the Minimal

Fig. 13.11: Witches' broom, little leaf, stunting, shorter internodal distance, leaf yellowing and leaf curling symptoms observed on fenugreek plant

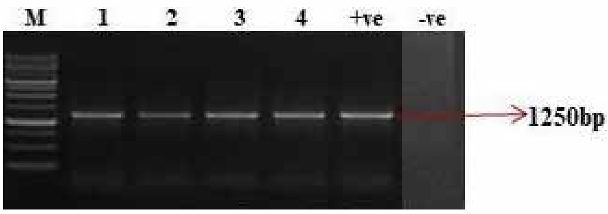


Fig 13.12 : Different fenugreek accessions showing positive bands for 16s rRNA gene with R16F2N/R2 primer pair, where M: 1kb DNA ladder, 1: , 2: , 3:, 4: . +ve and –ve samples

Descriptors Published by ICAR-NBPGR.

Preliminary evaluation of moth bean germplasm

Total 300 accessions of moth bean along with four checks were evaluated in an ABD during *Kharif* 2021 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

Fig. 13.13: Mustard germplasm accessions IC426381 giving resistance reaction against white rust disease and EC338968 giving resistance reaction against powdery mildew disease

Fig. 13.14: Symptoms of black leaf spot in ber and identified resistant germplasm accession IC 0625856

identified (Table 13.1). The genotype IC329051 identified early in maturity in just 55 days and having high yield potential.

Preliminary evaluation of Guar germplasm

Total 139 accessions of *Cyamopsis tetragonoloba* were evaluated in ABD for agronomic traits plant height, no of cluster /plant, no pod/plant, yield per plant, days to 50 % flowering and days to maturity and 1000 seed weight. Identified accessions IC140783 showed indeterminate growth habit with higher pod bearer and IC140773 with long pod suitable for vegetable type guar. Earlier identified accessions IC569261 (Leaf determinate type), PLG 296P1 (Early maturity 72 days), IC140784P1 (Determinate growth habit with single stem and all node pod bearing) were revalidated for their traits at two locations during the season i.e. ICAR-NBPGR RS Jodhpur and ICAR-CAZRI research farm (fig. 13.16

13.3 Regeneration and multiplication of germplasm

- During the period under report, 50 accessions of mung bean were grown in *Kharif* -2021 for regeneration and multiplication.
- Multiplied Ber unique stone less Genetic stock (INGR No. 19100) and fruit fly resistant genetic stock (INGR No. 19099) for supplying to horticultural institutes and SAU.
- Multiplied and Supplied 05 Ber budded stone less Genetic stock (INGR No. 19100) and 05 budded plant resistant to fruit fly genetic stock

Fig. 13.15: Promising accession IC 329051 of mothbean identified for early maturity

(INGR No. 19099) to ICAR-CIAH, Bikaner.

- Prepared 50 cutting of pomegranate (18 Acc.), 50 cutting of phalsa (02 Acc), 35 cutting of guggal (10 Acc), 15 cutting of lemon (02 Acc.), 15 cutting of karonda (03 Acc), 04 sucker of date palm (02 Acc) from horticultural germplasm being maintained at FGB Jodhpur.
- Prepared 30 budded plant of promising ber accession for replacement of damaged accessions.
- Developed wild species garden of economic important plants belonging to rare, endangered and threatened species of Rajasthan. Presently 08 species are being conserved.

13.4 Germplasm conservation

13.4.1 Germplasm conservation in MTS unit

Fig 13.16: Identified promising accessions of guar

The 43,120 accessions of agri-horticultural crops are being conserved at the station, either being maintained as live plants in the field gene bank or seeds being conserved in the MTS facilities. In MTS, seeds of a total of 42576 accessions of cereals & millets (14,024), legumes (16,276), oilseed (5183), plants of economic importance (943), medicinal and aromatic plants (1519), Indian grasses (361), fiber and fodder plants (544), Indian fruits (1571), Indian spices (659) and Indian vegetables (1495) are being maintained in MTS.

13.4.2 Germplasm conservation in FGB

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

13.5 Germplasm supply

During the period, a total of 1961 accessions of various crops, viz., cluster bean (131), pearl millet (150), mung bean (301), moth bean (350), cowpea (302), muskmelon (575) Water melon (66), *Cucurbita* foetidissima (8), Bottle gourd (14), *Cucumis* spp. (50), Ber (02), *Prosopis cineraria* (10) and *Leucaena leucocephala* (2) were supplied from MTS to 13 indenters belonging to ICAR Institutes, SAUs and other research organizations engaged in crop improvement programmes.

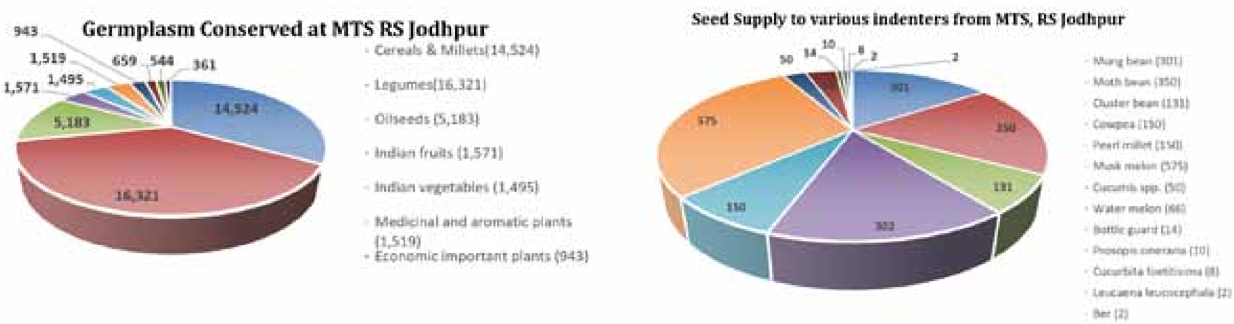


Fig. 13.17 Germplasm conserved at MTS, and seed supply states

Table 13.1: Characterization and evaluation of agri-horticultural crops germplasm during 2021

S. No.	Crops	Characters	Promising accessions
1	Mustard	Drought tolerant accession with DSI (<0.5) for days to 50 % flowering and Days to maturity	IC422173, IC422176
		Drought tolerant accession with DSI (<0.5) for number of siliqua per plant	IC422171, IC422282, IC422188
		Drought tolerant accession with DSI (<0.5) for 1000 seed weight	IC422169, IC422171
		Drought tolerant accessions with DSI (<0.5) for seed yield per plant	IC422160, IC422168
		Extra dwarf and Early in maturity	IC76735 (75 cm,75 days), IC363656 (61cm, 80 days), IC262994 (82 cm, 78 days), IC392314 (61 cm, 75 days), IC424412 (76 cm, 78 days)
		Tetra locular siliqua with Downward siliqua arrangement (Jhumka)	IC414603, IC355350, IC267710, IC414302, IC399288, IC423430, EC206653
		Late in flowering	IC396602 (64 DAS), IC268319 (60 DAS), EC206653 (68 DAS)
		Dark green stem, upright siliqua, Resistant to aphid, Dark green & shining leaf	EC206723, IC521378
		Broad & smooth leaf, Thick stem with white flower	IC426381P5
		Resistant against both white rust and powdery mildew diseases	IC399881, EC302488, IC361512, IC405232, EC338997, IC426381, EC206653, EC339005, EC338968, EC206653, EC694138, EC694145, EC694159, IC341907, IC577706, IC62597, IC62713, EC338968, EC206653, IC555891, IC-422166
2	Fenugreek	Flower color	Blue flower IC-510559, EC-510588A Yellow flower IC-EC-510741, EC-510662, EC-510633
		Early Flowering (50%)	IC0624520 (39 days), EC510678 (40 days), EC510664(43 days), EC510676(43 days), EC510630 (43 days), EC510637 (43 days)
		Dwarf Growth Habit (<30 cm)	IC0624520 (23.1), EC510624 (27.1), EC510642 (29.2), EC510659 (27.9), EC510661 (24.2), EC510671 (27.8), EC510677 (26.4), EC510695 (26.1)
		Higher branches/ plant (>6)	EC510559 (10), EC510662 (7), EC510633 (8), EC510588 (8), EC510593 (9), EC510598 (7), EC510717(7), EC510712(7), EC510705(7)

S. No.	Crops	Characters	Promising accessions
		High pod length (>12 cm)	EC510631 (16.6 cm), EC510635 (15.4 cm), EC510681 (15.3 cm), IC-333214(13.9 cm), EC-510571(14.1 cm), EC-510594(13.2 cm), EC-510597 (13.2 cm), EC-510595 (15.4 cm), EC-510596 (13.0 cm)
		Early maturing	IC-0624520 (90 days)
		Green-copper Leaf Color	EC510631, EC510644, EC510671, EC510685, EC510701
		Plant Height (> 63 cm.)	EC510725 (68.26 cm), EC510559 (87.4), EC510724 (67.66 cm), EC510588A (66.8), EC510609 (66 cm), EC510576 (65.5 cm), EC510653 (64.6 cm), EC510664 (62.9 cm), EC510678 (66 cm), EC510712 (64.3 cm), EC510717 (63.6 cm)
		Number of pods per plant (>58)	EC510577 (88), EC510597 (89), EC510598 (99), EC-510661(90)
		Seed yield per plant (> 8 gm)	EC510678, EC510658, EC510689, EC510717, EC510712, EC510583, EC510678, EC510689, EC510664
3	Moth bean	Early days to 50 % flowering (<35)	IC8851, IC329051, IC402286, IC415116, IC415127, IC415139, IC415143, IC415155, IC39784, IC35850A, IC370470, IC415127, IC415139
		No. of cluster per plant (>30)	IC103154, IC39836, IC129194, IC251908, IC311399, IC311413 IC311415, IC35841
		Seed yield per plant (>6 gms)	IC39836, IC129194, IC251908, IC258109, IC251893, IC311399, IC311415, IC311435, IC311436

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 (**Programme leader:** Dr. Vijay Singh Meena).

Research Project: (Code, Title, PI, CoPI and associate)

PGR/DGC-BUR-JOD-01.01- Management of genetic resources of agri-horticultural crops in arid and semi arid regions (**PI:** Dr. Vijay Singh Meena; **Co-PIs:** Dr. Kartar Singh and Dr. Neelam Shekhawat).

PGR/DGC-BUR-JOD-01.02 - Evaluation of Agri-horticultural crops germplasm against abiotic stress tolerance in arid and semi arid regions (**PI:** Dr. Neelam Shekhawat; **Co-PI:** Dr. Vijay Singh Meena and Dr. Kartar Singh).

PGR/DGC-BUR-JOD-01.03- Evaluation of Agri-horticultural crops germplasm against biotic stress tolerance in arid and semi arid regions (**PI:** Dr. Kartar Singh; **Co-PI:** Dr. Vijay Singh Meena, Dr. Neelam Shekhawat and Mr. Bharat Raj Meena).

Research Programme (Code: Title, Programme Leader)

DBT-GOI : Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery (Subproject-3; Component-7)

PI: Kartar Singh **Co-PI:** Vijay Singh Meena Neelam Shekhawat

UNEP-GEF: Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability **Co-PI:** Vijay Singh Meena, Neelam Shekhawat and Kartar Singh

DBT-GOI: Genetic Enhancement of minor pulses: Characterization, evaluation, genetic enhancement and generation of genomic resources for accelerated utilization and improvement of minor pulses **Co-PI:** Neelam Shekhawat

Kirk House: Evaluation of Stress Tolerant orphan Legumes for use in dryland farming system across sub-Saharan Africa and India- Promoting India-Africa Framework for strategic cooperation **Co-PI:** Neelam Shekhawat

REGINAL STATION, RANCHI

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Summary: Two exploration programme were undertaken in Jharkhand to collect 179 accessions of cereals, pulse, vegetable, oilseed and crop wild relatives. A total of 179 accessionsof Lentil, 14 genotypes of Niger,60 genotypes of Fababean, 140 accessions of Jackfruit and 38 accessions of Tamarind were evaluated/characterized for yield attributes and morphological traits. A total of 617 horticultural plant accessions and 300 medicinal plant accessions are being conserved in field gene bank. A one day Plant Genetic Resources Conservation Awareness Workshop cum Biodiversity Fair was organized by ICAR-NBPGR Regional Station, Ranchi on 30.09.2020 in Rania block of Khunti district of Jharkhand.

14.1. Exploration and Germplasm Collection:

Germplasm exploration (2)

14.1.1.A total of two explorations conducted during during the reporting period. From 30.11.2021 to 11.12.2021 a total of 47 accessions of field crop and their wild relatives collected from Gumla, Latehar and Palamu districts of Jharkhand. Further, another exploration programme conducted for collection of Millets, Mungbean, Chilli, Sesame, Cucurbits, CWR and ornamental crops in Purulia district of West Bengal and adjoining areas of Ranchi and Saraikela districts of Jharkhand during 20.10.2021 to 30.10.2021 in collaboration with ICAR-IARI, Hazaribagh, Jharkhand. A total of 132 accessions belonging to 39 taxa were collected. Other than targeted crop diversity i. e. millets, mung bean, chilli, sesame, cucurbits, CWR and ornamental some accessions of rice landraces, urd, cowpea, horsegram, turmeric (intense colour and aroma), maize and some underutilized crops like winged bean, *Teramnus labialis* a forage legume and *Alysicarpus* (tanrbirhi) a wild edible legume were also collected. Areas with diversity in Barleria germplasm are identified. Kashipur block, Ajodhya hill and Dalma wild life sanctuary has good diversity in Barleria sp. Reinawardita indica (Yellow Flax) was found at higher altitude in Chhirubera, Saraikel-Kharsawan district. Collection of Clitoriaternatia (Single and double type and two flower colours blue and white) and one accessions of jasmine was made during this exploration.

14.1.2. Collection of trait-specific Jackfruit germplasm

Survey for identification of areas having barahmasikathal (continuous bearing jackfruit) was conducted in Ranchi, Khunti and Simdega districts of Jharkhand during Januray-Feb 2021. Based on the areas identified during the survey three accessions of BarahmasiKathal was collected this year during Nov 2021. The semi-hardwood cutting was collected and is under establishment through grafting.

14.2. Gemplasm Evaluation, Characterization and Multiplication:

We evaluated Lentil core (a total of 179 accessions) along with four checks namely IPL 220, L 4727, L 4729, RVL 31 by following Augmented Block Design under rainfed and irrigated conditions. Their performance under irrigated condition summarised in Table 14.1.

2.2.A total of 14 genotypes including 10 Indian cultivars and 4 Egyptian genotypes of Niger (*Guizoticaabyssinica*)evaluated in kharif, 2021-2022 for agro-morphological traits including yield

Table 14.1. *Per se* **performance of Lentil accessions**

S. No.	Characters	Range	CD (0.05)	CV (%) Error	CV (%) Phen.
1	Leaflet length (cm)	0.46-1.60	0.32	12.68	16.66
2	Leaflet width (cm)	0.20-0.38	0.50	16.22	20.61
3	Days to 50% flowering (DAS)	42.00-136.00	9.47	5.25	21.66
4	No. of secondary branches	2.00-9.00	3.35	24.61	39.17
5	Plant height (cm)	19.00-56.00	13.37	16.99	19.41
6	Pods per plants	5.00-110.00	16.32	18.12	46.50
7	Seeds per pod	1.00	0.88	19.95	34.96
8	Seed yield per plant(g)	0.19	6.22	10.43	66.45

by following Randomised Block Design with three replications (Table 2). In general Indian cultivars found early in germination, days to 50% flowering, 80% maturity, 1000 seed weight and individual plant yield. Egyptian genotypes were recorded with slow germination but vigorous leaf size. However, days to 50% flowering found longer in Egyptian genotypes compared to Indian cultivars. In Egyptian genotypes individual plant seed yield as well as 1000 seeds weight recorded lower despite of having higher number of heads per plant in comparison to Indian cultivars. For qualitative traits Indian cultivars recorded good to very good early vigour while all Egyptian genotypes recorded only good early vigour. That may be attributed to their exotic origin. For branching habit, leaf margin and flower color no variations recorded. Similarly there were no variations for leaf color except two Indian cultivars namely DNS 4 and JNS 28 as having green leaves. Cultivars of India and Egyptian genotypes could be segregated based on seed shattering nature and Bihar Hairy Caterpillar (BHC) response as all Egyptian genotypes recorded shattering behaviour of seed and resistance response against BHC under field conditions.

14.2.3.A total of thirty entries of Fababean along with five checks evaluated for fresh green pod as vegetable by following Randomized Block Design with tree replications. Each entry represented by six lines and data recorded from five randomly selected plants per entry except for plot yield. Their

Table 14.2. *Per se* **performance of Niger cultivars**

Genotype	Plant height (cm)	Days to 50% flowering	No. of head/plant	Days to 80% fruiting	Days to harvesting	Seed yield/ plant (gm)	1000 seed weight (gm)
Indian cultivars							
DEOMALI	118.00	77	162	99	115	0.37	3.2
RCR 18	65.00	55	30	77	106	2.26	4
UTKAL NIGER 150	177.00	74	110	98	106	1.32	3.3
GNNIG3	105.00	54	91	79	106	5.75	4.3
JNS 9	155.00	58	113	82	106	3.81	4.5
JNC 6	134.00	59	78	85	106	4.29	3.8
DNS 4	114.00	47	43	71	106	4.79	4.8
JNS 28	166.00	61	71	84	106	4.15	4.5
JNC 1	121.00	63	204	94	106	3.36	3.5
GN 1	79.00	55	29	79	106	3.56	3.8
Range	**65.00 – 177.00**	**47 - 77**	**29-162**	**71-99**	**106-115**	**0.37 – 5.75**	**3.2 -4.8**

Genotype	Plant height (cm)	Days to 50% flowering	No. of head/plant	Days to 80% fruiting	Days to harvesting	Seed yield/ plant (gm)	1000 seed weight (gm)
IIORN-1	123.00	102	185	127	148	0.97	2.4
IIORN-2	105.00	100	341	130	148	1.20	2.5
IIORN-3	79.00	102	196	127	148	1.15	2.6
IIORN-4	134.00	100	200	130	148	0.59	2.2
Range	**79.00 – 134.00**	**100-102**	**185-341**	**127-130**	**148**	**0.59 -1.20**	**2.2. – 2.6**

performance summarised in table 3. Entry 272829, 273821 and 273801 found superior for plot yield of fresh pod and hence could be advanced as promising genotypes for vegetable purpose in the region.

In another experiment a total of thirty entries of Fababean along with five checks evaluated for grain yield by following Randomized Block Design with tree replications. Each entry represented by six lines and data recorded from five randomly selected plants per entry (Table 4). Entry number 272832, 273797 and 273796 found superior for 100 seed weight.

14.2.5.A total of 140 accessions of Jackfruit (*Artocarpus heterophyllus* Lam.) were evaluated for 21 traits including fruit, seeds and Flakes related traits. Some potential accessions are Fruit size- IC 24327, IC 24393 (Very Big >20 kg), No of flakes per kg of fruits- IC 21628, IC 201594, IC 591149, IC 376024, IC 591207 (High->21 flakes per kg of fruits) and Sweetness-IC 21640, IC 24369, IC 24394, IC 201602, IC 320952 (high >20 Brix).

14.2.4. A total of 38 accessions of tamarind were evaluated for 12 DUS traits and Some potential accessions identified are-Mature pod length- IC 209896, IC 312360 (long >15 cm), Pod weight- IC 209882, IC 209888, IC 209890, IC 209892, IC 209896, IC 339918, IC339921, IC 594328, IC 594335, IC 594346, IC 285280, IC 312360, IC 312361, IC

Table14. : *Per se* performance of *Vicia faba* entries for vegetable purpose

Traits	Mean	Maximum	Minimum	Best check
Pod Length (cm)	8.86	14.37	6.97	Hama 2 (7.8)
Pod Width (cm)	1.54	1.80	1.33	Hama 2 (1.6)
Pod Total Weight (g)	9.00	14.61	4.11	Hama 2 (8.0)
Pod fresh seed Weight (g)	3.66	6.56	2.04	Hudeiba9 (3.4)
Pod fresh Pulp Weight (g)	5.20	7.67	1.99	Hama 2 (4.3)
Plot yield (g)	446.82	793.52	68.11	Hama 2 (559.57)

Table 14. : *Per se* performance of *Vicia faba* entries for grain purpose

Trait	Mean	Minimum	Maximum	Best check
Plant Height (cm)	59.05	32	74.5	Rebya 40 (79.5 cm)
Number of Days (days)	135.2	134	137	SLL (137 days)
Seed Length (cm)	1.36	1	1.9	SLL (2 cm)
Seed Width (cm)	1.01	0.8	1.3	SLL (1.3 cm)
100 Seed weight (g)	37.84	58.54	27.31	SLL (52.3g)
Pod Length (cm)	6.51	4.3	8.7	Rebya 40 (6.9 cm)
Individual pod weight (g)	2.037333	1.11	3.71	Rebya 40 (3.5 cm)

594363 (Medium Pod weight 15-25 gm), Ripening period -IC 209889, IC 209903, IC 339919, IC 339921(Medium ripening period of approximately 270 days)

14.3. Germplasm Multiplication and Maintenance:

14.3.1. A total of 617 accessions of fruit/ vegetable/ natural dye yielding plants are being conserved in field gene bank of the station (Table 5).

Table 14. Details of accessions conserved in field gene bank

S. No.	Crop		No. of accession
	Common name	Botanical name	
1	Jamun	*Syzygiumcumini*	52
2	Bael	*Aegle marmelos*	162
3	Jackfruit	*Artocarpus heterophyllus*	246
4	Aonla	*Phyllanthus emblica*	19
5	Banana	*Musa* species	34
6	Lakoocha	*Artocarpus lacucha*	14
7	Mehandi	*Lawsoniainermis*	25
8	Drumstick	*Moringa oleifera*	14
9	Tamarind	*Tamarindus indica*	51
Total			617

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

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

(PGR/PGC-BUR-RAN-01.00): Augmentation, characterization, evaluation, maintenance, regeneration, conservation, documentation and distribution of genetic resources in Bihar, Jharkhand and adjoining areas. (PI: **S.B. Choudhary**)

Research Projects (Project Code: Title, PI, CoPIs and Associates)

Project-1 (PGR/PGC-BUR-RAN-01.01): Management of PGR of agriculture crops, their wild relatives and economic species including medicinal plants

[PI: Dr. S. B. Choudhary; Co-PI: Dr. Shephalika Amrapali]

Project-2 (PGR/PGC-BUR-RAN-01.02): Management of PGR of horticultural crops and perennial medicine[PI : Dr. Shephalika Amrapali ;Co-PI: Dr. S.B. Choudhary]

Externally funded:

Project code: 1010668; Scheme code: 40003: Characterization, Evaluation of Genetic Resources for Genetic Enhancement and Improvement of Minor Pulses" (Co-PI: S. B. Choudhary)

Project code: 1012312; Exploitation of genetic and genomic resources for improvement of niger (*Guizotiaabyssinica* L.F. Cass.) through breeding and biotechnological tools (Co-PI: S. B. Choudhary)

Project Code: 1013051: DUS testing of Fababean(Co-PI: S. B. Choudhary)

REGIONAL STATION SHILLONG

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Summary: Two exploration and collection tours were undertaken at Dima Hasao, Assam for multi crops and Garo hills, West Khasi hills and East Jaintia hills for Citrus germplasm. In multi crops exploration tour 60 germplasm belonging to *Capsicum annuum*(02), *Capsicum chinense* (02), *Oryza sativa* (23), *Zea mays* (11), *Cucumis melo* (02), *Ash gourd* (01), *Cucurbita moschata* (03), *Perilla frutescens*(02) Cucumis melo ssp.(01) were collected. While in the Citrus exploration 43 collections were made including various citrus species belonging to *Citrus reticulata, Citrus medica, Citrus pseudilimon, Citrus macroptera, Citrus jambhiri, Citrus aurantium, Citrus grandis, Citrus limon, Citrus sinensis C. megaloxycarpa* and *C. indica* from Garo hills district, West Khasi Hills and East Jaintia hills of Meghalaya. Preliminary evaluation of 24 accessions of rice collection revealed maximum test weight(1000seeds) in accession RUM-21/75. During evaluation of 126 accessions of rice bean superior genotypes were identified viz.IC-009634 recorded highest value for seed length (1.20 cm), seed width (0.70 cm) and 100 seed weight (27.60g). Potential crop evaluation of 26 accessions of sohphlang revealed superior accession for tubers/plant (IC-0627405, 37.00), tuber-length, tuber-width (IC-0627421, 11.22cm, 2.39cm) and HI/plant (IC0627421, SH-SOH-2019, 0.94). no. of seed/ inflorescence (IC108907, 16.33) and 1000 seed weight (IC109236, 35g). Evaluation of 645 accessions of buckwheat showed superior germplasm for no. of seed/ inflorescence (IC108907, 16.33) and test weight-1000 seed weight (IC109236, 35g). In Job"s tears evaluation of 126 accessions led to identification superior genotype such as IC591727, IC591730 for seed length (1.33cm), IC89391 for seed width (0.97cm), IC618548 for kernel length (0.76cm) and IC629198 for kernel width (0.7cm). Station conducted one training awareness programme under Tribal Sub-Plan on PGR awareness in Miyungkhro village, Dima Hasao Assam benefiting 100 farmers belonging to dimasa tribal community and knapsack sprayer were distributed to the participating farmers. Maintained and regenerated 1717 accessions of various agri-horticultural cropgermplasm. Supplied 219 germplasm accessions (Buckwehat 200, Mustard-16 and Rice-03) to three research institutes based on MTA indents.

Germplasm exploration and collection:

Two exploration and collectiontours were undertaken at Dima Hasao, Assam for multi crops and Garo hills, West Khasi hills and east Jaintia hills for Citrus germplasm. In multi crops exploration 60 germplasms belonging to *Capsicum annuum*(02), *Capsicum chinense* (02), *Oryza sativa* (23), *Zea mays* (11), *Cucumis melo* (02), *Ash gourd* (01), *Cucurbita moschata* (03), *Perilla frutescens* (02) *Cucumis melo* ssp. (01) were collected. While in Citrus exploration 43 collections were made of various citrus species belonging to *Citrus reticulata, Citrus medica, Citrus pseudilimon, Citrus macroptera, Citrus jambhiri, Citrus aurantium, Citrus grandis, Citrus limon, Citrus sinensis C. megaloxycarpa* and *C. indica* from Garo hills district, West Khasi Hills and East Jaintia hills of Meghalaya.

15.2 Germplasm evaluation:

Rice: Preliminary evaluation of 24 rice

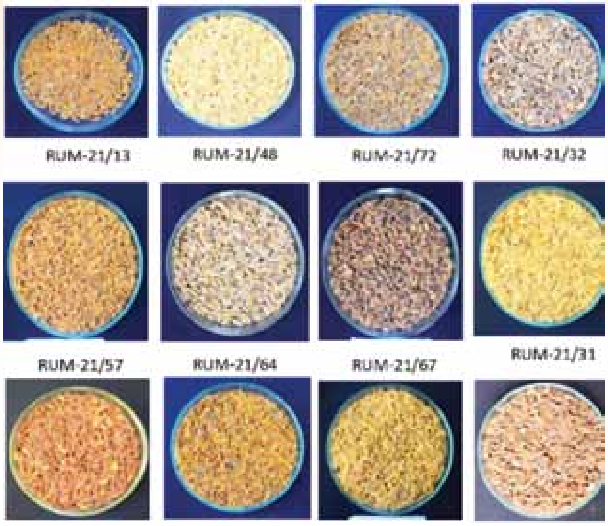

Fig15.1: Variability in Rice grain collections from Dima Hasao, Assam

IC0643288(*C. chinense*) RUM-21/42 (*C. chinense*)

Fig 15.2: Variability in Chilli from Dima Hasao, Assam

IC - 0643289(*C. annuum*) IC- 0643274 (*C. frutescens*) IC- 0643277 (*C. frutescens*)

Fig 15.3 : Diversity in color of cobs in maize

Fig 15.4: Variability observed in collection of Rough lemon (*Citrus x jambjiri*).

germplasms collected from Dima Hasao, Assam revealed that kernel length ranged from 5.0 mm (RUM-21/13)- 8.0mm((RUM-21/64). Test weight(1000seeds) ranged from 16g (RUM-21/13, RUM-21/14, RUM-21/72) to 32g(RUM-21/75).

Turmeric: Evaluation of 154 accessions in turmeric germplasm revealed that highest individual mother cormel was recorded in IC-385755(101.7g), Maximum individual clump weight (795g) in IC-394694, and maximum number of daughtercormel (7.3) in IC-2300918 and IC-212606.

Rice bean:

Evaluation for one hundred and twenty-six rice bean accessions for 11 different agro-morphological traits revealed that genotypes differed significantly for morphological traits such as pod length (cm), seed width (cm), days to 50% flowering, 100 seed weight (g) and seed yield per plot (g thereby indicating that there was enough genetic diversity among the studied genotypes for breeding purpose and effective selection for improvement of the crop. The highest value for GCV was observed in seed yield per plot (44.54%) followed by 100 seed weight (27.85%) and number of primary branches per plant (22.89%). Minor differences between GCV and PCV for most of the traits indicated that most of the observed variation was due to genetic factors. The lowest (19.27%) and highest (99.75%) broad sense heritability were observed for stem thickness and 100 seed weight, respectively. According to results, 100 seed weight could be used as a proper selection index for selection of parents in hybridization program of rice bean genotypes. Heritability estimates were high for other traits such as days to 50% flowering, seed width, leaf length and seed yield per plot indicating that selection based on these traits would be effective.

IC-009634 with highest value for seed length (1.20 cm), seed width (0.70 cm) and 100 seed weight

Table 1: ANOVA for morphological traits in rice bean

Source of variation	DF	Mean Squares										
		PH	PB	LL	LB	ST	D50F	PL	SL	SW	100SW	SYP
Blocks	4	4318.58	43.82	8.63	3.13	0.01	62.83	7.4	0.006	0.004	9.41	7644.85
Genotypes	129	299.91^{ns}	1.48^{ns}	1.05^{ns}	0.74^{ns}	0.02^{ns}	7.85**	0.86^{*}	0.005^{ns}	0.017^{**}	4.17^{**}	3659.32^{**}
Error	12	268.45	1.36	0.48	0.42	0.01	0.9	0.65	0.002	0.0007	0.01	599.38

Table 15.2: Range, genotypic (Vg) and phenotypic variance (Phenotypic variance), coefficient of variance (GCV and PCV) and heritability (H^2 broad sense)) for different morphological traits in rice bean

Traits	Range	Vp	Vg	PCV (%)	GCV (%)	H^2 (%)
PH	22.00-115.00	410.2	141.74	33.7	19.81	34.55
PB	1.00-7.67	2.47	1.11	34.16	22.89	44.91
LL	5.61-12.06	1.25	0.77	13.31	10.47	61.82
LB	2.94-7.50	0.74	0.33	17.41	11.54	43.94
ST	0.11-0.93	0.02	0.0033	24.28	10.66	19.27
D50F	50.00-60.00	8.45	7.55	5.31	5.02	89.35
PL	6.56-12.1	1.07	0.42	10.73	6.7	38.97
SL	0.63-1.20	0.01	0.0025	9.61	6.65	47.83
SW	0.33-0.70	0.0018	0.0011	9.17	7.19	61.39
100SW	4.30-27.60	4.54	4.53	27.88	27.85	99.75
SYP	10.00-330.00	3741.48	3142.1	48.6	44.54	83.98

PH: Plant height (cm); **PB**: Number of primary branches/plant; **LL**: Leaf length (cm), **LB**: Leaf breadth (cm); **ST**: Stem thickness (cm); **D50F**: Days to 50% flowering; **PL**: Pod length (cm); **SL**: Seed length (cm); **SW**: Seed width (cm); **100SW**: 100 Seed weight (g); **SYP**: Seed yield per plot (g)

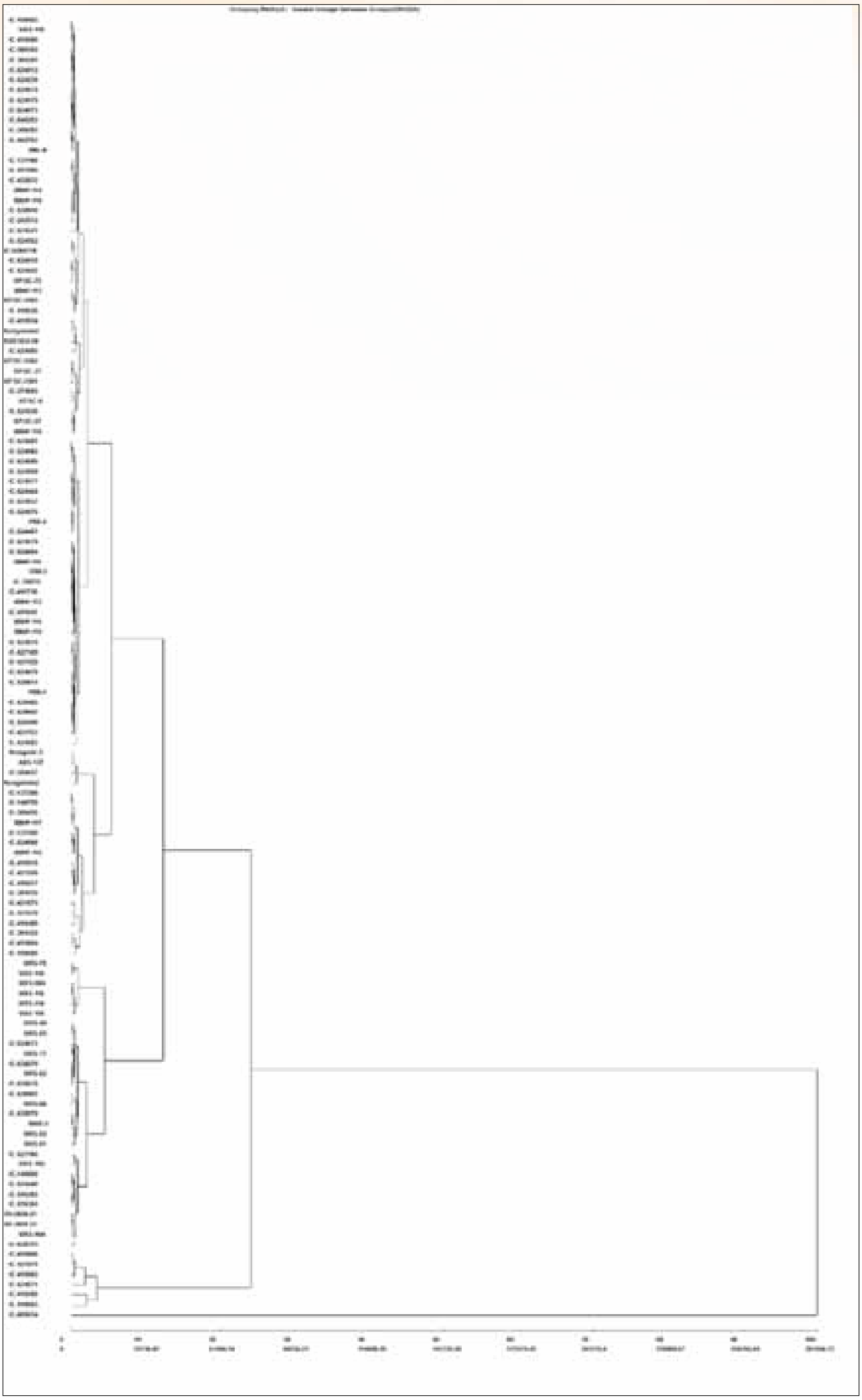

Fig 15.5 : Clustering based on agro-morphological traits. The genotypes clustered into five main groups with 69, 21, 29, 6 and 1 number of genotypes, respectively.

The accession IC009634 have been separated from the rest of the clusters and formed a single cluster. This is probably due to highest values observed for seed length (1.20 cm), seed width (0.70 cm) and 100 seed weight (27.60g).

Field evaluation of ricebean germplasm

Variability in ricebeanseed size and colour

Fig 15.6 : Field evaluation and seed variability in ricebean germplasm

(27.60g) can be identified as a superior genotype for the respective traits.

Flemingia procumbens (sohphlang) germplasm

Twenty-eight accessions of *Flemingia procumbens* (sohphlang) were characterised for 17 agro-morphological traits. Superior accessions were identified for various traits such as plant-cover, plant height (IC0627421, 99.00 cm, 72.78cm), number of nodes/plant (IC0627409, 14.11), petiole length (IC0627410, 3.92cm), leaf length, leaf width (IC0627413, 2.92cm, .91cm), days to 50%-flowering (IC0627411, 153days), number of flowers/inflorescence (IC0627417, 5), pedicel length (IC0627413, 0.50cm), single-tuber-weight (IC0627405, IC0627416, IC0627421, 32.78g), tuber weight/plant and tuber+shoot weight/plant (IC0627421, 458.33g, 491.67g), tuber weight/plot (IC0627421, 1375.00g), number of tubers/plant (IC0627405, 37.00), tuber-length, tuber-width

Table 15.3: Descriptive statistics of agro-morphological traits of *Flemingia procumbens* (Sohphlang) accessions

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
1	Plant cover (cm)	65.99	41.67	99.00	13.65	20.69	IC0627421
2	Plant height (cm)	47.06	26.89	72.78	11.07	23.52	IC0627421
3	No. of nodes/plant	11.99	8.89	14.11	1.15	9.58	IC0627409
4	Petiole length (cm)	2.96	2.03	3.92	0.47	15.79	IC0627410
5	Leaflet length (cm)	2.51	1.89	2.92	0.29	11.61	IC0627413
6	Leaflet width (cm)	2.46	1.86	2.91	0.27	11.12	IC0627413
7	Days to 50% flowering	168.18	153.00	179.00	6.27	3.73	IC0627411
8	No. of flower/ inflorescence	4.17	3.33	5.00	0.45	10.78	IC0627417
9	Pedicel length (cm)	0.42	0.33	0.50	0.04	9.19	IC0627413
10	Single tuber weight (g)	16.52	2.03	32.78	8.39	50.77	IC0627405, IC-0627416, IC0627421
11	Tuber weight/plant (g)	196.55	18.33	458.33	106.61	54.24	IC0627421
12	Tuber+Shoot Weight/ Plant (g)	219.96	25.00	491.67	113.41	51.56	IC0627421
13	Tuber weight/Plot (g)	663.93	175.00	1375.00	350.27	52.76	IC0627421

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
14	No. of tuber/Plant	22.72	9.33	37.00	8.06	35.46	IC-0627405
15	Tuber length (cm)	6.65	2.08	11.22	2.29	34.49	IC-0627421
16	Tuber width (cm)	2.06	1.50	2.39	0.23	11.36	IC-0627421
17	HI	0.86	0.40	0.94	0.12	13.90	IC-0627421, SH-SOH-2019

Field evaluation of *Flemingia procumbens* germplasm

Diversity in *Flemingia procumbens* tubers

Fig 15.7: Field evaluation and variability in tuber shape in Sohplang.

(IC-0627421, 11.22cm, 2.39cm) and HI/plant (IC-0627421, SH-SOH-2019, 0.94).

Bukwheat (*Fagopyrum spp.*) germplasm

Six hundred and forty-five accessions of *Fagopyrum* spp. (buckwheat) were characterised for 14 agro-morphological traits. Superior accessions were identified for various traits viz. minimum days to germination (IC107993/ IC467919/ IC274431/ IC204020, 3 days), plant height (IC109438, 130cm), no. of primary branches (IC329456/ IC107988, 9.33), no. of internodes (IC49661, 24.33), no. of leaves (IC109438, 250), petiole length and leaf length (IC79147, 7.22cm and 7cm), leaf width (IC329194, 9.11cm), days to 50% flowering (JRC1, 22), no .of inflorescences/ plant (IC109728, 174), cyme length (IC2057, 9.33cm), days to 80% maturity (IC107993/ IC202288/ IC310104/IC108907, 60), no. of seed/ inflorescence (IC108907, 16.33) and 1000 seed weight (IC109236, 35g).

Table 15.4: Descriptive statistics of agro-morphological traits of *Fagopyrum spp.* accessions

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
1	Days to germination	5.84	3.00	8.00	0.94	16.17	IC107993/ IC467919/ IC274431/ IC204020
2	Plant height (cm)	83.48	25.00	130.00	19.07	22.85	IC109438
3	No. of primary branches	5.03	1.33	9.33	1.06	20.99	IC329456/ IC107988
4	No of internodes	13.71	3.00	24.33	2.81	20.51	IC49661
5	No. of leaves	84.90	6.00	250.00	19.77	23.29	IC109438
6	Petiole length (cm)	2.84	0.06	7.22	1.08	38.24	IC79147
7	Leaf Length (cm)	4.00	1.98	7.00	0.80	20.03	IC79147
8	Leaf width (cm)	4.00	1.78	9.11	1.04	26.00	IC329194
9	Days to 50% flowering	37.58	22.00	50.00	9.53	25.36	JRC1

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
10	No of inflorescrence/ plant	42.26	4.00	174.33	19.78	46.81	IC109728
11	Cyme length (cm)	1.80	0.50	9.33	1.00	55.35	IC2057
12	Days to 80% Maturity	75.41	60.00	90.00	10.10	13.39	IC107993/ IC202288/ IC310104/IC108907
13	No. of seed/ inflorescence	7.50	1.00	16.33	2.17	28.89	IC108907
14	1000 seed weight (g)	20.91	9.00	35.00	2.99	14.30	IC109236

Field evaluation of buckwheat germplasm

Variability in buckwheat seed size and colour

Fig 15.8: Variability of seed size in Buckwheat germplasm

Job's tear *(Coixlacryma-jobi)*

Twenty agro-morphological traits were studied in 126 accessions and 02 checks of *Coixlacryma-jobi*. Superior genotypes were identified for various traits such as SH/2021-16 for number of tillers per plant (4.67) and number of seeds per plant (1461.60), SH/2021-12 for plant height (78cm), SH/2021-9 for number of nodes/plant (5.33), SH/2020-20 for culm diameter (2.33 cm), SH/2020-3 for angle between leaf and stem (6.77cm), SH/2020-7 for leaf blade length (122cm), SH/2020-6 for leaf blade width (7cm), IC-89385 (87.00), IC-89386, KP-DAL-7 for days to 50% flowering (87days), SH/2021-16 for no. of seeds/plant (1461.60), SH/2021-6 for 100 seed weight (75g), IC-629198 for seed weight/plant (175g), IC-629198 for seed weight/plot (1600g), IC-591727, IC-591730 for seed length (1.33cm), IC-89391 for seed width (0.97cm), IC-618548 for kernel length (0.76cm) and IC-629198 for kernel width (0.7cm).

Table 15.5: Descriptive statistics of agro-morphological traits of *Coixlacryma-jobi* accessions.

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
1	Days to germination	9.96	5.00	13.00	1.29	12.95	SH/2021-10 (5.00) SH/2021-11, SH/2021-12, SH/2021-13, SH/2021-15 SH/2021-16
2	First leaf unfolding	13.00	7.00	18.00	1.66	12.80	SH/2021-10, SH/2021-11, SH2021-12, SH/2021-13, SH/2021-15 SH/2021-16
3	No. tillers/plant	1.578	0.00	4.67	1.01	64.31	SH/2021-16 (4.67)
4	Plant height (cm)	309.00	78.00	491.00	89.32	28.92	SH/2021-12 (78)

Sl. No.	Traits	Mean	Min	Max	SD	CV%	Superior genotypes
5	No. nodes/plant	12.72	5.33	17.33	2.20	17.32	SH/2021-9 (5.33)
6	Culm Diameter (cm)	1.46	0.73	2.33	0.27	18.31	SH-2020-20 (2.33)
7	Angle between Leaf and Stem (cm)	4.80	2.67	6.77	0.70	14.67	SH-2020-3 (6.77)
8	Leaf blade length (cm)	75.00	29.00	122.00	13.71	18.22	SH-2020-7 (122)
9	Leaf blade width (cm)	4.80	3.00	7.00	0.76	15.98	SH-2020-6 (7)
10	Days to 50% flowering	119.62	87.00	155.00	11.56	9.66	IC-89385 (87.00), IC-89386, KP-DAL-7
11	No. seeds/ plant	393.04	98.00	1461.60	218.12	55.49	SH/2021-16 (1461.60)
12	100 Seed weight (g)	35.07	20.00	75.00	9.09	25.94	SH/2021-6 (75.00)
13	Seed weight/plant (g)	51.62	10.00	175.00	31.31	60.66	IC-629198 (175.00)
14	Seed weight/plot (g)	358.99	55.00	1600.00	254.09	70.78	IC-629198 (1600.00)
15	Seed length (cm)	0.80	0.40	1.33	0.19	24.35	IC-591727, IC-591730 (1.33)
16	Seed width (cm)	0.63	0.30	0.97	0.11	18.19	IC-89391 (0.97)
17	Seed length/width ratio	1.32	0.60	3.33	0.41	30.71	SH/TM-2020-32 (3.33)
18	Kernel length (cm)	0.46	0.23	0.76	0.09	21.38	IC-618548 (0.76)
19	Kernel width (cm)	0.43	0.20	0.70	0.01	24.35	IC-629198 (0.7)
20	Kernel length/width ratio	1.09	0.56	2.50	0.23	21.28	SH/TM-2020-32 (2.5)

Field evaluation of *Coixlacryma-jobi* germplasm

Variability in *Coixlacryma-jobi* seed shape, size and colour

Fig. 15.9: Fruiting stage and seed variability in *Coixlacryma-jobi*

Germplasm regeneration/maintenance and conservation:

A total of 1717 accessions comprising of agricultural – Horticultural crops: Buckwheat (630), Taro (100), Yam (45), Yard Long bean(85), Rice Bean (126), Maize (287), Sohplang (28), Ginger (90), Turmeric (210), Chilli (03), Cucumber (07), Ash gourd (28), Seasame (02), Perilla (10), Brinjal (03), Mustard (56), Horse Gram(01), Millet (02), Sorghum (04) were regenerated and maintained and additionally fruit crops Citrus (35) seedlings were also sown in the nursery for future establishment in the FGB.

Germplasm supply: A total of various crops including buckwheat (200 accession), Rice (03 accesions), mustard (16 accessions) were supplied to indentors under MTA.

Table 15.6: List of different germplasm supplied

Institute name	Germplasm name	Number of germplasm
ICAR Research complex for NEH region, Umiam, Meghalaya	Buckwheat	200
ICAR-VKPAS, Almora Uttarakhand	Mustard	16
Cotton University, Guwahati-781001.	Rice	03
Total		**219**

Institute Research Projects (Code: Title, PI, CoPIs)

PGR/PGC-BUR-SHL-01.01: Augmentation, characterization, evaluation, maintenance, regeneration, conservation and documentation of genetic resources of agricultural crops (paddy–low land/upland, maize and mustard) and their wild relatives. (PI: **Harish GD** (Upto 30.08.2021) , Co-PI: 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. (PI: **S Hajong**;CoPI: 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. (PI: **Harish GD** (Upto 30.08.2021), Co-PI: Julius Uchoi (*w.e.f.*, 13.01.2020) and S Hajong).

Externally funded project:

(Project no:1012951, Project code: 16113210009, Scheme code: 40003) Collection, conservation and morpho-phenological characterization of citrus germplasm of NE region. (PI- Julius Uchoi, Co-PI: Harish GD.).

(**Project No. 1011967, Project code: 16113200014, Scheme code: 40004**). Genetic diversity and biochemical profiling of Job's tears (*Coixlacryma-jobi* L.) accession from North East India". (PI: SubarnaHajong).

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REGIONAL STATION, SHIMLA

Summary: Two explorations were undertaken to collect genetic resources of various agri-horticultural crops from Salooni block of Chamba Himachal Pradesh and Bhaderwah block of Doda in Jammu & Kashmir. A total of 192 accessions, comprising of fruits (86), pulses (21), pseudo cereals (19), cereals (17), millets (18) vegetables (13), medicinal plants (12) and oilseeds (6), were collected. Furthermore, a total of 1,043 germplasm accessions of various field crops were characterized and evaluated against important agro-morphological traits of interest and remarkable variability was observed for important target traits. In grain amaranth, promising accessions for elite traits were identified for six important agronomic traits *viz.,* IC35448 (inflorescence length, 97.95 cm), IC35445 (plant height, 329.20 cm), IC35463 (seed yield/plant, 161.76 g), EC519515 (early maturity and dwarf type, 95 days and 61.3 cm) and IC108805 (1000-seed wt. 0.96 g). Besides, 228 derivatives of F_8 generation of cross VL44 x PLP-1 were evaluated along with their parental lines for certain traits. In buckwheat, IC16552 (early maturity, 68 days); IC423489 (no. of inflorescence/plant, 53.33); EC216635 and EC125940 (higher 1000-seed wt., 41.11 g and 39.87 g) were found to promising. Likewise, in chenopod, IC341697, KP/SC1533 and KP/SC1511 showed early maturing type, high inflorescence length and higher seed yield/plant. In adzuki bean, promising accessions were identified *viz.,* EC340252, EC340246 and EC340250, for high no. of clusters/plant and 100-seed weight (g)). Two varieties, one each, of Quinoa, "Him Shakti and Buckwheat, "Him Phaphra" were developed under AICRP on Potential crops. In chickpea, six interspecific derivatives obtained from *Cicer reticulatum* and *C. echinospermum* species, fruitful heterosis (%) was also estimated as promising selection criteria for identifying superior lines for earliness and high seed yield including resistance against prevailing stresses (Ascochyta blight, Botrytis gray mold, Dry root rot and Fusarium wilt). Likewise in french bean, screening of $F_{3:4}$ derivatives resulted in identification of resistant lines also having good agronomic base. Two genetic stocks of wild chickpea were also developed for botrytis gray mold resistance. One PGR awareness programme was organized under SC-SP to create awareness among farmers to facilitate the registration of Farmers' Varieties with the PPV& FR Authority and to undertake capacity development programme on PGR conservation of local diversity of traditional crops.

germplasm exploration & collection

Two collaborative germplasm explorations were undertaken. First exploration, in which 161 samples of multi-crop collection including minor temperate fruits was undertaken from Salooni block of Chamba, Himachal Pradesh and Bhaderwah block of Doda (Jammu & Kashmir) **(Fig 1)**. The collected accessions comprised of *Hordeum vulgare* (5), *Oryza sativa* (5), *Triticum aestivum* (2), *Zea mays* (5), *Amaranthus* spp. (10), *Chenopodium album* (5), *Fagopyrum* spp. (4), *Echinochloa esculenta* (1), *Eleusine coracana* (9), *Panicum miliaceum* (2), *Setaria* spp. (5), *Brassica campestris* (1), *Glycine max* (2), *Seasmum indicum* (3), *Lens culinaris* (2), *Macrotyloma uniflorum* (5), *Phaseolus vulgaris* (6), *Vigna spp.* (8), *Allium* spp. (5), *Capsicum annuum* (3), *Cucumis sativus* (1), *Cucurbita spp.* (2), *Cyclanthera pedata* (1), *Lycopersicon esculentum* (1), *Pisum sativum* (1), *Solanum villosum* (1), *Cotoneaster microphyllus* (1), *Cydonia oblonga* (1), *Elaeagnus latifolia* (1), *Juglans regia* (11), *Parthenocissus* spp. (2), *Phytolacca acinosa* (1), *Prunus spp.* (11), *Pyrus* spp. (4), *Rosa* spp. (5), *Rubus* spp. (7), *Sorbus cuspidata* (4), *Stauntonia latifolia* (1), *Vitis* spp. (2), *Ziziphus jujuba* (4), *Avena sativa* (1), *Berginia ciliata* (1), *Corylus jacquemontii* (2), *Nicotiana tabacum* (1), *Ocimum basilicum* (3), *Senna occidentalis* (1), *Trigonella foenum-graecum* (1), *Valeriana jatamansi* (1), *Viburnum grandiflorum* (2). Likewise, in second exploration, a total of 31 *Prunus ceresoides* accessions were collected from low to mid hills region of Himachal Pradesh comprising districts of Solan, Shimla, Kullu, Kinnaur and Mandi. All collections have been selected based on morphological variability observed for important horticultural traits.

Fig16.1 Interaction and collection of information with local people

Collection of Allium strachey!

Stautonia latifolia

Fig 16.2: Germplasm exploration & collection from diversity rich sites of Salooni block of Chamba of Himachal Pradesh and Bhaderwah block of Doda (Jammu & Kashmir)

Germplasm characterization and evaluation of field crops

A total of 1043 germplasm accessions, comprising 366 of grain amaranth, 289 of buckwheat, 76 of chenopod and 56 of adzuki bean, were grown during Kharif 2021 and 230 accessions of barley and 26 accessions of wheat in *Rabi* 2020-21, along with standard checks under Augmented Block Design (**Table 16.1**). The observations were recorded as per minimal descriptor of NBPGR for important agro-morphological traits and impressive variability was observed among the germplasm accessions. Promising accessions were also identified against important traits using range, mean and coefficient of variation

Assessment of genetic variability of field

Table 16.1 Germplasm characterization and evaluation of field crops

Crop	Accessions	Checks
Grain amaranth	366	Durga, PRA-2, Annapurna, PRA-3
Buckwheat	289	PRB-1, Himpriya, VL-7, Shimla B-1
Chenopod	76	EC-507741, NIC-22503, PRC-9801
Adzuki bean	56	Totru local, HPU-51
Wheat	26	HS-507, HS-542, HS-562
Barley	230	BHS400, BHS380
Total accessions	**1043**	

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

Character	Range	Mean ±SE	CV%	Promising accessions
Grain Amaranth				
Days to flowering	37-113	79.89±0.83	19.98	EC519515, IC551462, IC551483
Days to maturity	95-177	150.88±0.65	8.20	EC519515, IC108429, IC551462
Plant height (cm)	61.3-329.2	178.99±3.38	36.08	IC035445, IC035458, IC035457
Infl. length (cm)	20.1-97.95	52.87±0.91	32.79	IC035448, IC035443, IC035454
Seed yield/plant(g)	11-161.76	48.62±1.79	70.29	IC035463, IC35467, EC333749
1000-seed wt. (g)	0.4-0.96	0.72±0.01	17.10	IC108805, IC35473, IC447684
Buckwheat				
Days to flowering	26-70	41.21±0.52	21.31	IC016552, IC024300, IC026755
Days to maturity	68-157	107.34±0.89	14.17	IC016552, IC026755, IC037279
Plant height (cm)	41.1-257	125.11±2.82	38.34	IC329201, IC37279, IC37309
No. of infl./plant	8-53.33	23.28±0.70	51.11	IC423489, IC313130, IC361131
Seed yield/plant(g)	0.83-11.55	3.03±0.11	59.08	EC125940, IC37276, IC204080
1000- seed wt. (g)	11.9-41.11	19.19±0.25	22.26	EC216635, EC125940, IC37306
Chenopod				
Days to flowering	46-104	73.25±1.39	16.12	IC341697, IC381106, IC540842
Days to maturity	101-169	134.42±1.79	11.26	IC341697, IC381078, NIC22506
Plant height (cm)	129.40-299.80	222.62±5.31	19.47	KP/SC1533, IC108817, IC108816
Infl. length (cm)	21.40-66.20	31.43±0.84	21.99	KP/SC1533, IC107535, IC582965
Seed yield/plant(g)	6-84.82	32.38±1.83	53.49	KP/SC1511, IC329470, IC415421

Character	Range	Mean ±SE	CV%	Promising accessions
1000-Seed wt. (g)	0.50-1.60	0.99±0.04	35.97	IC341698, IC540842, IC341701
Adzuki bean				
No. of clusters/plant	4.50-18.65	10.05±0.59	44.22	EC340252, EC340270, EC340246
No. of pods/plant	8.00-44.53	22.06±1.49	50.61	EC340246, EC340269, EC340253
No. of seeds/pod	3.50-9.50	6.54±0.20	22.35	EC340253, EC340251, EC340272
Days to flowering	51-86	60.54±1.12	13.89	EC340240, SMLAB-6, EC340257
Days to maturity	99-129	115.89±0.98	6.33	EC340272, EC340253, EC340249
100-seed weight (g)	8.72-20.17	13.08±0.32	18.44	EC340250, EC340254, EC281186
Barley				
Days to 75% spike emergence	78-124	96.34±0.53	8.33	JCR/SK-1413, AS/NAIP-28, AS/NAIP-20
Plant height (cm)	64.90-150.10	106.14±0.88	12.58	JCR/SK-1433, IC299364, IC356076
Days to 80% maturity	124-187	145.64±0.60	6.22	BLG75, BLG23, BLG26
100 seed wt (g)	2.74-7.22	4.87±0.06	17.21	DWRUB160, IC299364, BLG26
Wheat				
Days to 75% spike emergence	83-127	97.19±1.80	9.42	JCR/JV-76, JCR/JV-81, SKY-61
Flag leaf length (cm)	13.70-32.90	26.86±0.85	15.90	AS/NAIP-53, JCR/JV-77, AS/NAIP-110
Plant height (cm)	87.46-158.10	114.48±3.87	17.22	JCR/SK-1454, AS/NAIP-14, AS/NAIP-10
Days to 80% maturity	152-185	165.42±1.67	5.14	JCR/JV-67, JCR/JV-62, SKY-61
100 seed wt (g)	2.64-6.31	4.76±0.16	17.62	JCR/JV-67, JCR/JV-76, IC568165

crops

In Grain amaranth, the average plant height was 178.99 cm (while it ranged from 61.3-329.2 cm), mean inflorescence length 52.87 cm (20.1-97.95 cm), mean days to maturity 150.88 days (95-177 days), 1000-seed weight 0.71 g (0.40-0.96 g) and seed yield/plant 48.62 g (11-161.76 g). The data resulted into the identification of some promising accessions for target traits such as, IC35448 (inflorescence length, 97.95 cm) **(Fig 2)**, EC519515 (early maturity and dwarf type, 95 days and 61.3 cm) **(Fig 3)**, IC35445 (plant height, 329.20 cm), IC35463 (seed yield/plant, 161.76 g). Likewise, in buckwheat, wide range of variation ranged from 68-157 maturity days, mean no. of inflorescence/plant was 23.28, mean 1000-seed weight was 19.19 g ranging from 11.90-41.11 g and mean seed yield/plant 3.03 g varied from 0.83-11.55 g.

Fig.16.2: IC035448 identified superior for long inflorescence length

The data has resulted into identification of promising accessions namely, EC216635 and EC125940 (higher 1000- seed wt., 41.11 g) **(Fig 4)**; IC423489 (no. of inflorescence/plant, 53.33);

Fig 16.3: EC519515 identified superior for early maturity and dwarf type

IC16552 (early maturity, 68 days) **(Fig 5)**. In chenopod, mean days to maturity were 134.42 days which ranged from 101 to 169 days, average infl. length was 31.43 cm and ranged from 21.40-66.20 cm, mean seed yield/plant was 32.38 g. The promising accessions were identified *viz*., IC341697 (early maturing, 101 days), KP/SC1533 (plant height, 298.80 cm and inflorescences height, 66.20 cm), KP/SC1511 (higher seed yield/plant, 84.82 g) and IC341698 (higher 1000-seed weight 1.60g). In adzuki bean, plant height has mean value 64.43 cm and ranged from 34.40-115.75 cm, no. of clusters/plant 10.05 (4.50-18.65), no. of pods/plant 22.06 (8.00-44.53), days to maturity 115.89 (99-129) and 100-seed weight 13.08 g (8.72-20.17g).

Fig.16.4: EC125940 identified superior for high seed yield per plant (g)

Fig.16.5: IC16552 identified for early flowering & maturity

Promising accessions were identified such as, EC340252 and EC340246 (higher no. of clusters/plant and no. of pods/plant), EC340272 (early maturity type) and EC340250 (high 100-seed weight (g)). In wheat, plant height had a mean value of 114.48 cm and ranged from 87.46-158.10 cm, flag leaf length 26.86 cm (13.70-32.90 cm), days to maturity 165.42 (152-185) and 100-seed weight 4.76 g (2.64-6.31g). Promising accessions were identified such as, JCR/JV-67 and JCR/JV-62 (early maturity type) and JCR/JV-67, JCR/JV-76 and IC568165 for high 100 seed weight. In barley, mean days to maturity were 145.64 days which ranged from 124 to 187 days, average plant height was 106.14 cm and ranged from 64.90-150.10 cm, mean 100 seed weight was 4.87g and varied from 2.74 to 7.22 g. elite accessions were identified for plant height (JCR/SK-1433, IC299364), early maturity (BLG75, BLG23, BLG26) and high 100 seed weight (DWRUB160, IC299364, BLG26).

Evaluation of F_8 derivatives of grain amaranth

In grain amaranth, 228 derivatives of F_8 cross of VL44 x PLP-1 was evaluated along with their parental lines for important traits. An average seed yield/plant varied among derivatives ranging from 39.10 to 148.17 g, Infl. length (28.30-62.21cm) and plant height (111.31-229.54 cm). Maturity time was also observed lesser in some of the derivatives as compared to their parents and other ruling check varieties.

Development of crop varieties

Two varieties, one each, of Quinoa and Buckwheat, were developed under AICRP on Potential crops. "Him Shakti" is the first variety of Quinoa in the country **(Fig 16.6)**.

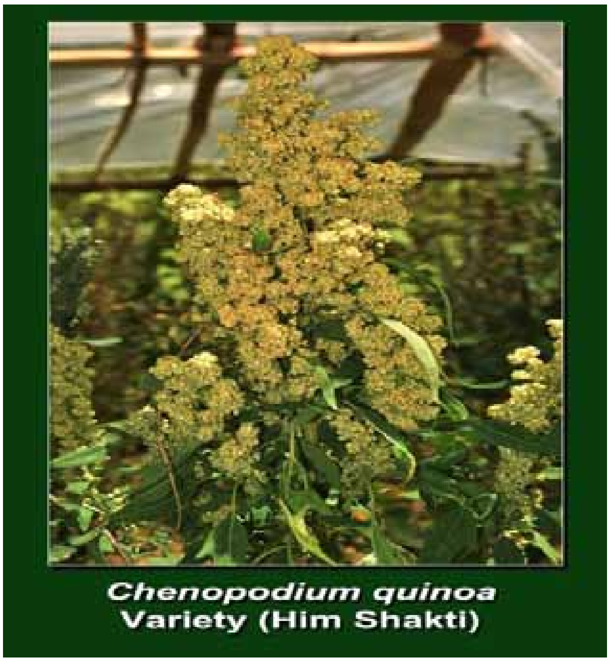

Fig 16.6: Him Shakti-Quinoa variety released under AICRP on

It has high yield potential coupled with protein content (15.64%) and oil (8.91%). It is recommended for cultivation in the Northern plains, Western India and parts of the Deccan plateau. The second crop variety "Him Phaphra" of Buckwheat has high protein (13.1%) with methionine and iron (6.6 mg/100g) content **(Fig 7)**. It is recommended for cultivation in the Hill region (Himachal Pradesh, Uttarakhand and Jammu & Kashmir). These crop varieties were notified by the CVRC, Sub Committee on Crop Standards and released by the Hon'able Prime Minister of India on 28th September, 2021.

Fig.16.7: Him Phaphra- Buckwheat variety released under AICRP on PC

Development of genetic stocks

EC720438 (INGR720481) A Wild Chickpea Accession Resistant Against Ascochyta Blight (*Ascochyta rabiei)*

The wild annual *Cicer* accession EC720438 belongs to *C. reticulatum* species. The genotype was screened and validated against ascochyta blight resistance using artificial inoculation by frequently spraying with ascosporic suspension ($1x10^6$ spores ml^{-1}) using local isolates of *Ascochyta rabiei.* After validation, an accession EC720438 (INGR740655) has been reported resistant against the disease. The germplasm has its significant value for enhancing genetic gains of cultivated varieties of chickpea

EC720481 (INGR720438) A Wild Chickpea Accession Resistant Against Botrytis Gray Mold (*Botrytis cinerea*)

The wild annual *Cicer* accession EC720481 belongs to *C. echinospermum* species. The genotype was screened against BGM resistance using artificial inoculation of Botrytis cinerea (10,000 spore's ml-1) and validated twice under controlled screening test using cut-twig screening technique, in which water was used as supportive medium. The germplasm has its significant breeding value for enhancing genetic gains of cultivated varieties of chickpea.

Evaluation of Pre-breeding genetic materials

Lentil

Two F10:11 interspecific population's derivatives (ILL10829 x ILWL30 and ILL8006 x ILWL62) of lentil were evaluated in augmented design at two locations viz. International Centre for Agricultural Research in Dry Areas (ICARDA), India and Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), India. The analysis of variance showed remarkable variability for all target characters at both the locations. The heritability estimates were high and correlation analysis exhibited significant association between majority traits assessed at ICARDA and SKUAST, India. Further, SKUAST identified most promising lines named as 'Jammu Lentil 144' and 'Jammu Lentil 71'. These derivatives were further validated separately for their agronomic potential and resistance against major biotic stresses. The results revealed that Jammu Lentil 144 and Jammu Lentil 71 produced 16.65% and 9.40% more seed yield than local and national checks including earliness by 25 days and 15 days, respectively. These promising interspecific derivatives were also found to be resistant against Fusarium wilt, root rot, pod borer and aphid infestations.

Chickpea

In chickpea, a set of six interspecific derivatives (Pusa372 × EC720438, PBG5 × EC720438, BGD72 × EC720438, BGD72 × EC720481, PBG5 ×EC720481 and Pusa372 × EC720481) were advanced using single seed descent (SSD) method of breeding. The F7 generation of these crosses was assessed in two diverse agro-ecological regions of India. The data revealed a wide range of variation with respect to seed yield and its important component traits, which resulted into identification of most promising derivatives carrying desirable characters as indicated by range, mean and coefficient of variation at PAU experimental farm Ludhiana, Punjab (Fig 8). Further, fruitful heterosis was also estimated as promising selection criteria for identifying superior lines for earliness and high seed yield including resistance against prevailing stresses (Ascochyta blight, Botrytis gray mold, Dry root rot and Fusarium wilt).

Fig.16.8: Performance of F_7 chickpea interspecific derivatives at PAU, Ludhiana

Common bean

A panel of 516 germplasm accessions of common bean was evaluated for some of agronomic traits, BCMV and anthracnose disease resistance screening under natural epiphytotic condition at ICAR-NBPGR Regional Station Shimla. Based on BCMV percent disease incidence (PDI) data revealed that germplasm accession viz., IC340947 and IC360831 were found highly resistant against the disease as they recorded 0.00% PDI. Likewise, the same set of germplasm accessions was also screened against anthracnose resistance, which resulted into identification of EC755281, EC755282, EC755283, IC328372, EC755285, and EC755286 as complete resistance against the pathogen.

16.3 Horticultural genetic resources

Variability of *Prunus cerasoides* D. Don (Himalayan cherry)

A total of 31 *Prunus cerasoides* accession have been collected from Solan, Shimla, Mandi and Kullu district of Himachal Pradesh. Accession has been selected based on visual observations on important horticultural traits. We have assessed good variability among collected accessions. Based on visible fruit parameters *viz.*, fruit dimension (length, width, weight) stone dimension (length, width, weight), pulp stone ratio, pulp percentage, TSS, kernel dimension (length, width weight) and peduncle length, remarkable variability was found in TSS ranged from 13.5 to 47.3 °B (33.78 % CV) followed by 100 fruit weight from 35.4 g to 127.4 g (28.29 % CV) and pulp % from 26.49 % to 66.64 % (21.70 % CV).

Collection and evaluation of Ground apple (*Smallanthus sonchifolius*)

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 after that it started flowering and later the above ground part started drying and tubers were harvested in the month of November. There was no pest and disease observed during the growing season. The average tuber yield per plant was 3.5 kg along with 10-15 numbers of propagating material. TSS of edible tuber after harvest was 15 °B and when it stored for 2 months at room temperature the TSS increased upto 24 °B without deterioration the quality of tubers.

Characterization of walnut collections

The walnut germplasm were collected from the Salooni and Bhardwah block of Chamba and Doda districts of Himachal Pradesh and Jammu & Kashmir respectively. Accession has been selected based on important horticultural traits *viz*., nut (size, weight), kernel (size and weight). We have observed good variability among collected accessions **(Table 3)** and the collection no. RC-NN-SK-33 collected from village Ladhwa, Block Salooni recorded with large size nut (l x b; 52.60 x 47.78 mm) and nut weight (30.50 g) and kernel weight (14 g). All these collections were analyzed for oil and total phenol content. Oil content ranged from 52.50 to 57.48 % with an average value of 54.86 % whereas total phenol content varied from 1.03 to 1.26%. Collection RC-NN-SK-81B had highest oil content with 57.48 % and collections RC-NN-SK-36 and RC-NN-SK-129 had highest phenol content with 1.26%.

Validation of stone fruits accessions for economic traits

Various stone fruits (peach, apricot and plum) accessions were validated for various economic traits; in peach EC280769 recorded with higher TSS 10.18 °B with white flesh colour, earliness and good quality fruits and it has taken 88 days to maturity;

Table 16.3: Germplasm characterization of walnut collections

Collector no.	Length of nut (mm)	Width of nut (mm)	Kernal thickness (mm)	Nut weight (g)	Kernal weight (g)
RC-NN-SK-33	52.60	47.48	2.09	30.5	14.0
RC-NN-SK-34	53.24	36.91	1.71	19.0	9.0
RC-NN-SK-35	48.97	39.94	2.02	20.0	10.0
RC-NN-SK-36	45.61	36.14	2.57	15.5	6.5
RC-NN-SK-49	42.75	38.70	2.56	21.0	10.0
RC-NN-SK-57	39.75	33.08	1.84	13.5	5.5
RC-NN-SK-64	32.90	31.69	1.67	12.0	5.0
RC-NN-SK-81 A	41.01	36.36	2.49	18.5	9.0
RC-NN-SK-81 B	45.99	32.26	1.35	15.0	8.5
RC-NN-SK-91	34.55	28.67	1..56	10.5	6.0
RC-NN-SK-122	31.78	26.26	2.08	8.0	3.5
RC-NN-SK-123	42.68	36.84	1.77	17.0	7.5
RC-NN-SK-129	40.03	30.07	1.77	13.5	6.0
Minimum	31.78	26.26	1.35	8.0	3.5
Maximum	53.24	47.48	2.57	30.5	14.0
Mean	42.45	34.95	1.99	16.46	7.73
CV	0.16	0.16	0.19	0.34	0.36
CV %	16.19	15.81	19.36	34.57	35.68
SE	1.91	1.53	0.11	1.58	0.76

EC38737 recorded with the large fruit size and weight with yellow flesh colour; EC38736 recorded with yellow flesh colour with good quality large fruit. In apricot, IC558065 is ready to harvest in the second week of May; EC539003 is validated for heavy and regular bearer. In plum, EC382826 recorded for free stone, regular bearer and good quality fruit whereas, IC555306 have unique character of flowering in first (4th week of February) and matures in the month of September when there is no other plum available in the market; it almost takes 180 – 210 days taken for the fruit harvest (**Table 16.2**).

Germplasm Conservation

Germplasm sent to LTS: A total of 106 accessions of Chenopodium were sent to the National Gene Bank for long term storage. In fruit crops, 27 accessions were sent to Cryo-gene bank.

Medium Term Storage: A total of 12,565 accessions of various seed propagating crops are conserved in MTS.

Table 16.4: Performance of most promising genotypes against target traits

Crop	Accession no.	Fruit length (mm)	Fruit width (mm)	Fruit weight (g)	TSS (°B)	No. of days taken to maturity	Remarks
Peach							
Yum Yong	EC280769	62.20	55.30	89.53	10.18	88	White flesh, early and good quality fruit
Kanto -5	EC38737	59.48	59.87	108	10.3	115	Yellow flesh
Nishiki	EC38736	49.13	53.19	85	8.8	94	Yellow flesh
Apricot							
Sahib	IC558065	35.01	38.68	48	12.5	81	Maturity in the second week of May
NJ-96	EC539003	53.35	52.2	55	13.9	90	Heavy and regular bearer
IC22037	IC22037	51.15	51.85	53	14.86	89	Free stone and heavy bearer
EC539004	EC539004	51.44	48.80	56	16.2	86	Large size fruit with high TSS
Plum							
Au-Rosa	EC382826	40.64	40.5	55	12.76	97	Free stone
IC555306	IC555306	38.94	38.41	56	14.9	210	Maturity in the month of September
Frier	EC513684	41.51	46.02	52	13.02	85	Early, good quality fruit

Crop	No of acc.	Crop	No of acc.	Crop	No of acc.
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

Field Gene Bank: A total of 1023 germplasm accessions of various perennial crops such as fruits, medicinal and aromatic plants including other economic plants are conserved in the field gene bank at NBPGR Shimla.

16.5 Germplasm Supply

Germplasm comprising of 3368 seed samples of agricultural crops were supplied to researchers/ indenters across the country.

Crops	Accessions	Crops	Accessions
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		

- **Seed Crops**: Buckwheat (461), Amaranth (473), *Chenopodium* (1262), French bean (295), Adzuki bean (291), Cicer (113), Rice bean (31), Pea (425), Barley (17).

17

REGIONAL STATION, SRINAGAR

Summary: Two exploration and germplasm collection programmes were undertaken by the station in the year 2021 and a total of 150 accessions of agri-horticultural crops and crop wild relatives (CWR) were collected from various areas of Kashmir. The germplasm collected include several unique accessions some collected for the first time. 135 germplasm accessions comprising of fababean (40) and barley (95) were characterized for agro-morphological traits as per the minimal descriptors during *rabi* 2020-21. Besides, 41 entries of fababean including 16 entries under IVT, AVT-I and AVT-II were evaluated during *rabi* 2020-21 under AICRN on Potential Crops. Under TSP three awareness programmes were organized in remote tribal areas like Uri (Baramulla distt.) in Kashmir and Garkon (Kargil distt.) in Ladakh. A total of 410 farmers including 132 women participated in these programmes. More than 200 kg seeds of field pea and local rajmash landraces were distributed among the farmers. Three research papers and a book chapter were published.

1. Germplasm exploration and collection

Under National Exploration Plan for 2021-22, two exploration programmes assigned to the station have been carried out:

1. Buckwheat, soybean, *Vigna* spp., *Allium* spp. and *Vitis* spp. (for rootstock) and temperate fruits (cultivated and wild) from the areas of Ganderbal district of J&K.

2. *Linum corymbulosum*, *Linum perenne*, *Linum strictum*, wild *Allium* spp. and wild Triticeae from areas of Ganderbal, Budgam and Baramulla districts of J&K.

Exploration and germplasm collection of buckwheat, soybean, Vigna spp., Allium spp. and Vitis spp. for root stock and temperate fruits (cultivated and wild) from the areas of Ganderbal district of J&K was conducted : During this programme different areas of Ganderbal district including Nagbal, Parimpora, Arampora, Safapore, Kurhama, Batwina, Wakura, Takun, Shadipore, Tullmulla, Lar, Walivar, Wangat, Baba Nagri, Narnag Arahama, Anderwan, Yarmuqam, Sonmarg, Nilgrath, Sarbal, Nunar, Babsipora, Gotlibagh, Urpash and Manigam were explored in the month of September. A total of 39 germplasm samples belonging to *Vigna* species (*Vigna radiata*, *Vigna mungo*, *Vigna uniguiculata* and *Vigna angularis*), *Glycine max*, *Phaseolus vulgaris*, *Cucumis sativus*, *Fagopyrum tataricum* and some fruits were collected. The cuttings of the fruits collected *viz*., *Prunus persica*, *Prunus armeniaca*, *Rubus* spp., *Diospyros lotus*, and *Vitis* spp. were immediately submitted for cryopreservation at HQ. During this exploration programme a unique soft shelled walnut genotype has been identified and tagged in Walivar area.

Exploration for Linum corymbulosum, L. perenne, L. strictum, wild Allium spp. and wild Triticeae from areas of Ganderbal, Budgam and Baramulla districts of J& Kwas conducted : Different areas in Ganderbal, Budgam and Baramulla districts of J&K including very remote and border areas in Uri Baramulla have been explored during this programme mostly in the month of August. The exploration has yielded a total of 111 diverse crop wild relative (CWR) germplasm accessions belonging to 13 genera and 22 species. However, *Linum* species were not found growing in any of the areas surveyed during this exploration programme. The maximum numbers of species *i.e.* eight have been collected in wild rye *Elymus* with a total of 73 accessions. Maximum number of 27 accessions of *Elymus semicostatus*, followed by 23 of *E. caninus* and 11 of *E. dentatus* have been collected. Fifteen (15) accessions of *Hordeum murinum* subsp. *leporinum* have also been collected. Eleven (11) accessions of *H. murinum* subsp. *leporinum* were collected in the month of June as they matured earlier. Besides, seventeen (17) accessions of different CWR were collected from Ladakh in the month of September during TSP programme organized in Garkon Kargil. *Elymus* species having PGR value collected first time from the valley include *Elymus caninus*, *E. dentatus*, *E. dahuricus*, *E. longearistatus* and *E. nutans* mostly from Sonamarg area of District Ganderbal. Besides, five (5) accessions of wild Hing *Ferula jaeschkeana* have been collected from areas of Kashmir and Kargil. Other notable collections include two (2) accessions each of *Podophyllum hexandrum* from Sonmarg and Gurez areas and lotus *Nelumbo nucifera* from Dal and Mansbal Lakes of Kashmir, one (1) accession each of wild olive *Olea europaea* (SHEIKH/SR-1048) collected first time from Gowalata Uri Kashmir, wild melon *Cucumis melo* subsp. *agrestis* from Kashmir, currant, *Ribes orientale* locally called as 'Kharmapilli' from Batalik Kargil, lyme grass *Leymus secalinus* from Kargil area and *Cotoneaster integerrimus* var. *nummularius* (SHEIKH-1097) also collected for the first time near Ajuri village of Drass Ladakh.

Most of the collected material has been sent for LTS at NGB ICAR-NBPGR New Delhi. One accession each of *Allium consanguineum* collected from Sonamarg Kashmir and *A. tuberosum* collected from Garkon Kargil as live plants have been sown in pots at the farm for maintenance.

Fig 17.1 Spike and seed diversity collected in wild Triticeae and unique collections SHEIKH/SR-1004 of wild barley (*Hordeum murinum subsp. leporinum*) from Budgam area of Kashmir and SHEIKH-1093 of wild rye (*Elymus longearistatus*) collected near Lalung Pass (3835m) Kargil, Ladakh

Fig: 17.2 Significant collections SHEIKH/SR-1087 of wild Hing (*Ferula jaeschkeana*) from Pahalgam area, SHEIKH/SR/SS-1102 of Podophyllum hexandrum from Bagtur Gurez, SHEIKH/SR-1085 of lotus (*Nelumbo nucifera*) from Dal Lake Srinagar, SHEIKH/SR-1048 of wild olive (*Olea europaea*) from Gowalata Uri, SHEIKH-1097 of *Cotoneaster integerrimus* var. *nummularius* from Ajuri Kargil and SHEIKH/SR-1105 (IC-0643396) of wild melon Cucumis melo subsp. agrestis from Ladhoo Pampore

17.2. Germplasm supply

Three accessions of *Allium cepa* var. *proliferum* were supplied to Advanced Research Station for Saffron & Seed Spices, SKUAST (K) Konibal Pampore. One accession of wild melon *Cucumis melo* var. *agrestis* was supplied to ICAR-NBPGR RS Thrissur. During TSP programmes seeds of 50 kg field pea and 150 kg local rajmash landrace were distributed among 410 farmers. During a Millet and Tree Planting Campaign, 53 packets of finger millet and proso millet seeds were distributed among the participants.

17.3. Germplasm characterization

Characterization of fababean (*Vicia faba*) germplasm: A total of 40 local germplasm accessions of fababeans (*Vicia faba*) were characterized along with two checks (HFB-1 and Vikrant) for their agro-morphological traits as per the minimal descriptors during *rabi* 2020-21 under rainfed conditions using randomized block design and based on different traits promising genotypes have been identified (**Table 17.1**).

Characterization of barley germplasm: 95

Fig: 17.3 Distribution of seed packets of finger millet and proso millet among participants during Millet and Tree Planting Campaign (17th September 2021)

Fig: 17.4 Diversity in pod bearing habit in fababean *(Vicia faba)*

Table 17.1. Promising accessions identified for some important agro-morphological traits in fababean *(Vicia faba)*

Trait	Range	Mean	Best check value	Promising accessions
Plant height (cms)	54.5 - 92.2	73.7	54.1 (HFB-1)	IC0637971 (92.2), IC0637972 (90.7), IC0637973 (84.7), SHEIKH/SR/SA/SS-913A (83.4)
Days to 50% flowering	137 - 145	142.2	140.7 (HFB-1)	IC0637963 (137), SHEIKH/SR-903B (138), SHEIKH/SR-903C (138)
Pod length (cm)	5.7 - 10.8	7.9	6.1 (Vikrant)	SHEIKH/SR/SA/SS-913A (10.8), IC0637972 (10.7), IC0637971 (10.3),SHEIKH/SR/SA/SS-917 (9.5)
Pod width (cm)	0.9 - 1.8	1.3	1.1 (HFB-1)	IC0637976 (1.8), IC0637971 (1.7), IC0637972 (1.7), SHEIKH/SR/SA/SS-913A (1.7)
Days to 80% maturity	196 - 200	198.2	197.7 (Vikrant)	IC0637970 (196), SHEIKH/SR-911 (196), SHEIKH/SR-926 (196), IC0637962 (197)
No. of seeds/pod	2.2 - 3.8	2.9	3.3 (HFB-1)	SHEIKH/SR/SA/SS-922B (3.8), IC0637962 (3.6), SHEIKH/SR/SA/SS-917 (3.6), IC0637961 (3.4)
Seed yield/plant (g)	21.025 - 41.604	30.441	26.354 (Vikrant)	IC0637967 (41.604), SHEIKH/SR/SA/SS-923A (39.310), SHEIKH/SR-925 (39.144), IC0637973 (36.868)
100-seed weight (g)	39.200 - 88.400	60.777	33.667 (Vikrant)	SHEIKH/SR/SA/SS-917 (88.400), SHEIKH/SR-924 (84.200), IC0637978 (83.500), SHEIKH/SR/SA/SS-913A (81.900)

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* 2020-21 under rainfed conditions using Augmented Block Design and based on different traits promising genotypes have been identified (Table 2).

Evaluation of fababeans (*Vicia faba*) under AICRN trial (hills): As a cooperating centre of All India Coordinated Research Network on Potential Crops, 41 entries including 16 entries under IVT, AVT-I and AVT-II along with two checks (Vikrant and HFB-1) were evaluated using augmented block design at the station during *rabi* 2020-21.

Characterization and diversity analysis of flowering genes in almonds (IXX12784): Transcriptomic analysis was performed in almond cultivars to identify the genes associated with blooming. RNA seq data of almond cultivars Waris and Ferralise was processed using FASTQ, Trimmomatic, HISAT2, Stringtie, Stringtie merge and DESeq2 pipeline. Results revealed the differentially expressed genes. The prominent genes with significant up-regulation in local cultivar

Table 2. Promising accessions identified for some important agro-morphological traits in barley

Trait	Range	Mean	Best check value	Promising accessions
Dwarf plant height (cm)	56.2 - 133.8	101.9	92.9 (DL-36)	IC446103 (56.6), EC578716 (72.8), IC-138114 (80.6), EC578711 (85.4), EC50675 (85.5)
Spike length (cm)	5.2 - 12.8	8.7	7.9 (Jyoti)	IC533203 (12.8), IC113052 (12.6), IC445834 (11.6), IC13890 (11.6), EC492317 (11.6)
Seed yield/ plant (g)	5.140 - 40.240	14.362	22.373 (Jyoti)	EC492362 (40.420), IC445542 (25.420), IC13206 (25.400), IC138119 (24.725), EC578504 (22.880)
100-seed weight (g)	1.900 - 6.300	4.008	4.767 (Jyoti)	IC138120 (6.300), IC247753 (5.500), IC445980 (5.400), IC542197 (5.300), IC138009 (5.300)

Waris included Ethylene Insensitive 3 while BADH acyltransferase and accelerated cell death were down-regulated.

17.4. Germplasm conservation

Thirteen germplasm accessions of agri-horticultural crops collected from different parts of Jammu and Kashmir have been conserved under LTS at National Gene Bank.

17.5. Germplasm maintenance

Eleven accessions of saffron (*Crocus sativus*) received from SKUAST-Kashmir and two accessions each of walnut (*Juglans regia*) and pecan nut (*Carya illinoinensis*) received from SKUAST-Jammu have been sown in Field Gene Bank for evaluation and maintenance (**Fig17.6**).

Fig: 17.5 Late flowering pea genotype, three weeks late than 'Arkel' variety with an average plant height 155.83 cm, Branches/plant 4.50, Nodes on main stem 25.67, Pod clusters/main stem 5.50, Pod length 6.10 cm, Pods/plant 47.50, Seeds/pod 5.87, Dry pod yield/plant 40.420 g and Seed yield/plant 35.070 g

Fig: 17.6 Saffron *(Crocus sativus)* blooms at the Farm (12 accessions are being maintained at the station)

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).

ICAR-NBPGR REGIONAL STATION, THRISSUR

18

SUMMARY: During the year under report, 394 samples of germplasm were collected in four exploration missions, covering districts of Tamil Nadu, Karnataka and Valmiki Tiger Reserve, Bihar. A total of 861 collections comprising 21 of fox tail millet, 400 of greengram, 300 of horsegram, 44 of cucumber, 19 of melon, 40 of taro, 18 of curry leaf and 45 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. One new taxon each of Momordica and Trichosanthes was described. Germplasm of 270 collections and 353 of multiplied germplasm comprising various crops and their crop wild relatives/ medicinal plants were sent for LTS in NGB. Thrissur has a germplasm holding of 11,760 accessions of various crops/ perennial horticultural plants and their wild relatives of which 9832 are in the MTS and 1928 in the FGB. A total of 6221 accessions in various species/taxa were supplied to 47 user agencies under MTA. Two Germplasm exchange day with farmers and two field days on pulses and okra amphidiploids were conducted.

Germplasm Exploration and Collection:

A total of four explorations were conducted and 394 samples were collected as detailed below (Table 18.1).

Table 18.1: Details of germplasm explorations conducted

Trip No.	Area Covered	No. of samples collected
1& 2	Thoothukudi, Ramanathapuram, Virudhunagar and Theni districts of Tamil Nadu (Collaborator: ICAR-IIVR, Varanasi)	264 samples in cucurbits, rice, millets, okra, other vegetables and their wild relatives
	Unique collections 1. *Indigofera coerulea* (KP/DRB/21-130) and *Physalis pruinosa* (KP/DRB/21-31) were first time collections for the bureau 2.'*Chinnar*' was a peculiar farmer's variety of rice (KP/DRB/21-43) with fully purple pigmented plant morphology, however with white kernels. 3. Two chilli landraces - '*Champa*' (long fruit type) (KP/DRB/21-82, LSV/21-06) and '*Gundu*' (round type)(KP/DRB/21-76, KP/DRB/21-160, LSV/21-07) 4. *Kulasaikathiri* (KP/DRB/21-53) and *Vellakkai* (KP/DRB/21-53, LSV/21-13) landraces of brinjal former with big light green fruits and big unlobed leaves, and latter with white coloured ovate-round fruits. 5.'*Karunaikizhangu*', a landrace of elephant footyam (KP/DRB/21-11, KP/DRB/21-161 having oblong corms - not the usual oblate shape 6. Sorghum landrace '*Karuncholam*' (KP/DRB/21-42) 7. Wild *Cucumis* – *Cucumis dipsaceus* (LSV/21-57) 8. Ajwain (*Trachyspermum ammi* L.) - (LSV/21-05), a primitive cultivar 9. *Momordica dioica*- a semi-domesticated vegetable (KP/DRB/21-69, LSV/21-76) 10. *Momordica cymbalaria* – a wild edible vegetable (LSV/21-02, LSV/21-45, KP/DRB/21-40) 11. Drumstick (LSV/21-56) found to be high yielding with slender long fruits suitable for cultivation in North India where there is a consumer preference for young pods for vegetable purpose.	
3	Northern districts of Karnataka	57 samples
	Unique collections Saline tolerant rice landrace Kagga, coastal *Sesamum malabaricum* with potential for salinity tolerance, *Sesamum laciniatum*, wild banana (*Musa balbisiana*), wood apple (thin and thick fruit rind), *Citrus* spp.	

Trip to Valmiki Tiger Reserve, Bihar

For the first time, an exploration cum collection trip was made to the protected area, Valmiki Tiger Reserve, West Champaran Dt., Bihar along with HQ and collected a total of 83 accessions belonging to 56 species of agri-horticultural crops and their wild relatives. Most significant collections include traditional rice landraces like *Meghnath* (flood-tolerant), *Ananti*, *Local Basmati* and *Saati* (early maturing), teosinte, wild germplasm such as wild rice (*Oryza rufipogon*), wild banana (*Musa balbisiana*), orange-pulped acid lime (a natural hybrid between acid lime and sweet orange), *Zingiber chrysanthum* and *Z. capitatum*. Some unique collections are depicted in Fig. 18.1.

18.2 Germplasm Characterisation and evaluation foxtail millet

Twenty-one accessions along with three checks were characterized in replicated trial for 14 quantitative and eight qualitative characters. Wide variability was observed for seed morphology (Fig. 18.2), number of tillers, length of peduncle (cm), peduncle exertion, number of panicles, spike length and yield per plant. Maximum single plant yield was observed in IC619106 (42.34 g) which was above the best check (PS-4 with yield of 29.82 g). With regard to seed color three accessions STR/20/78, STR/20-74 and IC624680 exhibited orangish color. The panicle shape was cylindrical in two accessions while oblong in 22 accessions.

Abelmoschus amphidiploids:

Pre-breeding was initiated during previous years in the station, to incorporate genes for resistance to YVMVD and OELCV from wild *Abelmoschus* species to cultivated okra. In order to undertake generation advancement and preliminary characterization, a total of 102 crosses comprising BC_1s with *A. esculentus* as maternal parent (15

Fig 18.1 (a: Purple coloured rice landrace 'Chinnar', a farmer's variety (KP/DRB/21-43) from Srivaikuntam area of Thoothukudi dist., TN (inset: closeup of plants); **b:**A rice saline tolerant landrace 'Kari Kagga' (PPSY/21-31), cultivated in backwaters area in Uttarakannada dt. Karnataka; **c:** Rice landrace 'Saathi' (KP/PR/21-11) with inserted panicle (in North Champaran dt., Bihar)

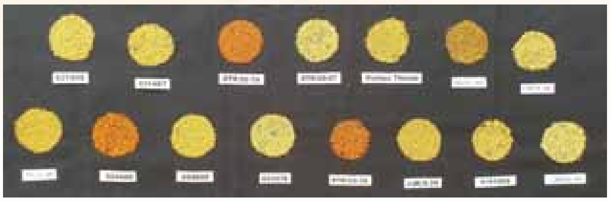

Fig 18.2 Variability in grains of foxtail millet germplasm

nos.), BC_2s with *A. esculentus* as maternal parent (1), F_3s (13), F_1s (3), F_4s (1), BC_1s with *A. esculentus* as paternal parent (26), multi cross combinations involving multiple wild species (40) and F_7s (3) were raised during Kharif-2021 along with 14 *A. esculentus* genotypes (7 released varieties and 7 germplasm accessions). All the cross combinations were morphologically characterized for two qualitative and six quantitative fruit characters. Majority of crosses exhibited an intermediate fruit morphology, however, the hispid hairiness on the capsules, stem and leaves and, the vigorous and perennial growth habit and continued flowering, and fruiting beyond four months, confirm dominance of wild characters in most of the crosses (Table 18.2, 18.3 & 18.4). Out of 102 crosses, the fruit morphology of three back cross progenies, Ruchi (*A. esculentus*) x AM24 (C2/50/Mizo34), Ruchi (*A. esculentus*) x AM-6 (C3/50/Mizo24), and Arka Anamika x 4(C2/50mizo34 x Parbhani Kranti), exhibited high morphological resemblance with the cultivated okra with linear narrow epicalyx segments of less than 4 mm width, confirming introgression from the cultivated okra to the amphidiploids (Fig. 18.3). Seed setting, an important trait for carrying forward the generation was normal in many of the crosses except in 28 crosses where seeds per capsule was counted to be less than 10. Both backcrossing and selfing were followed to advance the generation.

Fig 18.3: Introgression lines of okra amphidiploids with similar fruit morphology as that of cultivated okra

Table 18.2: Range of fruit characters in *Abelmoschus* amphidiploids

Character	Minimum	Maximum
Number of epicalyx segments	**4** AM-23 (C3/87/gr4), a third generation selfed progeny of a amphidiploid between *A.esculentus* x *A. angulosus* var. *grandiflorus*)	**10** Back cross progeny Ruchi x AM24 (C2/50/Mizo34) (BC_1)
Fruit length (cm)	**2.60** B-11 (*A. esculentus* x *A. tetraphyllus*) x *A. palianus* (plant exhibited the growth habit of *A. palianus* (spreading nature) in contrast to the erect growth habit)	**13.60** Ruchi x AM6 (C3/50/Mizo24), (morphological similarity with cultivated okra) (BC_1)
Fruit width (cm)	**1.50** B_5 [(*A. esculentus* x *A. angulosus* var. *grandiflorus*) x (*A. esculentus* x *A. pungens* var. *mizoramensis*)] X AM6 (C3/50/mizo24) (multi-cross combination)	**3.15** Ruchi x *A. tetraphyllus* (F_1)
No. of seeds per capsule	**4** C3-50 Mizo 34 x South Canara Local (BC_1)	**85** AM-13 (*A. moschatus* subsp. *tuberosus* x *A. moschatus*) (F_8)

Table 18.3: Frequency distribution for fruit color of *Abelmoschus* amphidiploids

Fruit color			
Character states	**Frequency**	**Character states**	**Frequency**
Dark green	2	Greenish purple	7
Dark green with whitish base	7	Light green	1
Dark green with creamish purple base	2	Light green with whitish base	31
Green	8	Light greenish with purple patches	6
Green with whitish base	36	Light purple with whitish base	2

Table 18.4: Fruit pubescence nature in of *Abelmoschus* amphidiploids

Fruit pubescence	Crosses/ Amphidiploids
Absent	Ruchi × AM6 (C3/50/Mizo24), C3-50 Mizo 27 x IC22232 (TCR-1696) and Arka Anamika x 4(C3/50mizo34 x Parbhani Kranti),
Hairs soft	F_7 progeny of *A. moschatus* subsp. *tuberosus* x *A. moschatus*, and two multi-cross combinations namely B_9 [(*A. esculentus* x *A.angulosus* var. *grandiflorus*) x (*A. esculentus* x *A. tetraphyllus*)] x C2/87/grand4, and B4 [(*A. esculentus* x *A. tetraphyllus*) x *A. palianus*] x Was15 (*A. esculentus* x *A. tetraphyllus*) amphidiploids

Cucumber (*Cucumis sativus*):

Preliminary characterization of 44 accessions with five check varieties of cucumber were undertaken during Kharif-2021. Observations were taken on seven quantitative and nine qualitative characters. The variability parameters for quantitative characters is presented in table 18.5. The fruit length, width and single fruit weight ranged from 10.60-24.10 cm, 4.17-6.43 cm and 116.0-401.67 g respectively. Fruit length was maximum in IC272881 and minimum in IC538913. Regarding the qualitative traits, fruit shape and pulp texture exhibited variability. Thirty-eight accessions exhibited elliptical elongate shape whereas cylindrical and oblong shapes were exhibited by five and one accessions respectively. IC527420 was found to be an early bearing accession by setting first female flower on the 4th node on 25 days after sowing.

Melon (*Cucumis melo*):

Nineteen accessions of *Cucumis melo* were characterized for five quantitative (single fruit weight (g), fruit length (cm), fruit width (cm), fruit circumference (cm), and flesh thickness (cm) and one qualitative trait (fruit skin colour). Single fruit weight ranged from 0.50 (SKN-9995) to 3.50 kg (IC468925). Six accessions (IC311663, SKN-10051,

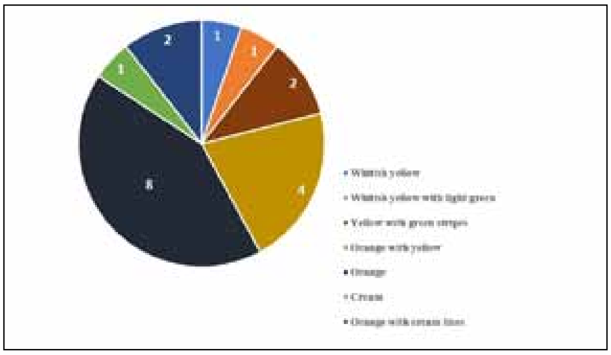

Fig 18.4: Variability in fruit skin colour in *Cucumis melo*

Table 18.5: Variability parameters of quantitative characters in cucumber

Character	Range	Mean	SD	CV (%)
Fruit Length (cm)	10.60-24.10	14.76	2.57	17.43
Fruit Circumference (cm)	12.93-20.07	15.92	1.69	10.62
Fruit Diameter (cm)	4.17-6.43	4.93	0.58	11.67
Single Fruit Weight (g)	116.0-401.67	207.71	49.81	23.98
Peduncle Length (cm)	1.43-4.75	2.78	0.77	27.63
Flesh Thickness (cm)	0.77-1.70	1.15	0.18	15.27

IC468925, IC446542, IC315763A, IC468990A) produced long fruits with length > than 30 cm and another five (SKN-9995, SKN-10035, IC315331, SKN-10024 and SKN-10023) with length less than 15 cm. Maximum fruit length was observed maximum in IC468925 (52.20 cm) among the accessions studied. Wide variability was observed in fruit skin colour which is depicted in Fig. 18.4.

Chinese spinach (*Amaranthus tricolor*): A total of 52 accessions comprising 47 *A. tricolor* var. *tricolor* and five *A. tricolor* var. *tristis* were characterized for five quantitative and six qualitative traits. Superior accessions with respect to leaf length was IC536718 (17.5 cm). Wide variability was observed for leaf lamina and petiole color, ranging from green, medium green, purplish green, red to magenta and leaf shape varying from ovate elongate, ovate, ovate oblong, with or without tip bifurcations, and leaf blotches (Fig. 18.5).

Taro (*Colacasia esculenta*):

A total of forty accessions of taro, out of which 16 of North Eastern Indian origin and remaining of A&N origin were characterized for 11 quantitative and 8 qualitative characters related to corm (Table 18.6). Two collections Chakma Taro (Mizoram) and a collection from Sastri Nagar, Great Nicobar were producing stolons/runners, which were consumed as vegetable in those regions. Ranchiguinea (a

Fig 18.5: Variability in leaf colour of chinese spinach germplasm

landrace from Andaman) and IC630948 from Nicobar Islands and S-9-2, a collection from Mizoram produced tubers with high mucilage content. Maximum plant spread was exhibited by a landrace '*Dudhguinea*' (140 cm) from A&N Islands whereas minimum by IC630948 (60 cm). Variability parameters recorded in the characters studied are presented in table 6. Fifteen accessions had their cormels spread throughout the mother corm, 5 accns. at the base only and from base up to middle in 10 accns. Nineteen were having acridity in the raw tuber and two accessions (IC639343 and 636543) exhibited light sweetness in raw tubers. Maximum value for mother corm weight and length were exhibited by IC630960 (390 g) and IC639343 (27.2 cm) respectively. JPJ/19-197 exhibited maximum values for both single cormel weight (43.75 g) and width (3.47 cm). However, IC636540 and JPJ-19/234 produced only mother corms. Twenty-eight of these (13 from North eastern states and remaining from A& N Islands) were characterised for nine quantitative above ground vegetative characters. Maximum plant span was exhibited by a landrace '*Dudhguinea*' (140 cm) from A&N Islands whereas minimum by IC630948 (60 cm).

Table 18.6: Variability parameters in 40 taro accessions characterized

Characters	Min	Max	Mean	SD	Variance (%)
Wt of mother corm (g)	30 (Chakma taro)	390 (IC630960)	119.82	77.53	64.71
Length of mother corm (cm)	1.55 (Telia)	27.26 (IC639343)	11.32	60.27	53.24
Width of mother corm (cm)	1.59 (Chakma taro)	7.40 (IC630944)	4.31	11.88	27.51
Cormel weight (g)	6.25 (IC630977)	43.75 (IC630943)	25.31	10.22	40.37
Cormel length (cm)	1.90 (IC630977)	74.91 (IC630944)	5.32	15.64	29.38
Cormel width (cm)	1.49 (IC636541)	3.46 (IC630943)	2.54	4.62	18.18

Curry-leaf (*Murraya koenigii*)

Eighteen curry leaf accessions maintained in the FGB were characterized for five quantitative and 13 qualitative characters. The length of the leaf was maximum in IC635972 (26.26 cm) while minimum in IC635980 (15.88 cm). Variability was also noted for the number of leaflets per leaf (17 - 22), and the length and width of terminal leaflets (2.94 – 7.76 cm and 1.45 – 3.76 cm, respectively). IC635979 exhibited closely packed leaves with a shorter internodal length (1.20 cm) whereas IC635978 showed close packing of leaflets within a leaf. Wide variability was observed for qualitative traits such as tender leaf colour (light green to purplish green to greenish-purple) and glossiness (4 accessions with matted) on the leaf surface, leaflet margin serration and general fragrance hence offering scope for detailed biochemical analysis (Fig. 18.6).

Fig 18.6: Variability in leaves of curry leaf germplasm

Jackfruit (*Artocarpus heterophyllus*):

Forty-five seedling-origin accessions of jackfruit germplasm in the FGB have been characterized for 35 fruit and seed descriptors (19-qualitative & 16 quantitative characters) developed by NBPGR. Variability in quantitative characters studied is presented in Table 18.7. Out of 45 acc., 35 belonged to '*varikka*' type (firm-fleshed fruits), seven (IC91779-3B, IC93388-2A, IC97625-

1B, IC97625-3A, IC97626-1A, N-6 and Stn/NL-6) to '*koozha*' type (soft-fleshed fibrous types) and three (IC91836-2A, IC92249-3A, and IC91808-3A) had intermediate flesh type. Early maturing typical landrace 'Thamarachakka' of Kerala, having small round fruits showcased during 'Vishu' festival, has witnessed three different fruit sizes in the germplasm collection. Good variability was exhibited in the qualitative characters, as all the character states were represented in 13 out of 19 studied characters. Two-thirds of accessions had ellipsoid fruit shape; about 90 per cent acc. had 'sweet' pulp taste; 'twisted' and 'rectangular'-shaped flakes dominated in the collection (Fig. 18.7). While 'light yellow' or 'yellow' pulp colours were predominant, local landrace 'Nedunkunnamvarikka' possessed attractive orangish-yellow flesh. IC91836-2A possessed a lightly tinted seed sac. Accession Stn/NL-5 exhibited 4 or 5 flakes originating from a common point, giving rise to a 'lotus' posture appearance. The majority of the accessions had easily separable seed coat from the kernel, which has significance in their use as kernel food.

A high coefficient of variability (>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 amenable for selection. The average TSS value is 25.34° Brix indicating collections were selectively made, keeping in view the fruit quality

Table 18.7: Variability parameters of fruit characters characters in jackfruit

#	Character	Min	Max	Mean	SD	CV (%)
1.	Fruit length (cm)	7.83 (IC91665-2A)	53.00 (Stn/NL-6)	36.13	9.67	26.77
2.	Fruit width (cm)	9.00 (IC91665-2A)	36.50 (IC91808-1B)	20.31	4.06	20.00
3.	Fruit weight (kg)	0.21 (IC91665-2A)	13.48 (IC92254-2B)	7.26	3.12	43.00
4.	Spine density (5 x 5 cm^2)	19.00 (IC91768-3A)	110.00 (IC93388-2A)	66.01	18.05	27.34
5.	Fruit circumference (cm)	26.83 (IC91665-2A)	85.50 (IC92249-3A)	67.52	10.63	15.74
6.	Wt. of fresh flakes with seed (g)	11.40 (IC91761-1A)	75.10 (Stn/NL-4)	27.59	14.40	52.18
7.	Wt. of fresh flakes without seed (g)	5.50 (IC96148-1B)	54.90 (Stn/NL-7)	18.46	10.90	59.05
8.	Flake length (mm)	41.01 (IC91761-1A)	83.47 (Stn/NL-7)	57.86	12.77	22.06
9.	Flake width (mm)	15.97 (IC91761-1A)	51.12 (Stn/NL-1)	33.01	9.10	27.56
10.	Rachis length (cm)	2.30 (IC91665-2A)	41.50 (Stn/NL-6)	25.21	8.01	31.78
11.	Rachis diam. (cm)	2.50 (IC91665-2A)	11.40 (IC92249-3A)	6.42	1.86	29.02
12.	TSS (°Brix)	18.50 (IC91779-3B)	30.30 (IC91761-1A)	25.34	4.75	18.76
13.	Seed length (mm)	21.74 (IC91665-2A)	44.87 (IC97627-2A)	35.08	4.45	12.67
14.	Seed width (mm)	13.35 (IC92249-3A)	27.15 (NL-4-2A)	19.90	3.16	15.89

Fig 18.7: Variability in flakes of jack fruit germplasm

aspects. Accessions namely IC91761-1A, IC97628-1A, IC91761-2A, V-504-2B and IC91766-2A among '*varikka*' types, IC97626-1A among '*koozha*' types, and IC91808-3A among 'intermediate' types are worth considering for promotion for table purpose.

Evaluation of wild species of banana collected from A&N Islands against pseudostem weevil (*Odoiporus longicollis* Oliver)

Germplasm of wild relatives of banana collected from A&N Islands along with landraces of Kerala and commercial cultivars were evaluated for resistance to banana stem weevil (*Odoiporus longicollis*) (Fig. 18.8). Two accessions (IC630992 and IC631126) of *Musa balbisiana* var. *andamanica* were found free from external as well as internal infestation. Longitudinally split opened pseudostem of *M. balbisiana* var. *andamanica* accessions did not reveal any feeding marks or life stages of the weevil. Nevertheless, severe infestation (> 40%) on pseudostem was recorded in *M. acuminata* (IC631154) with 14 infestation bore holes per plant and feeding patches of 34 - 177 cm in length often coalesce together. Similar degree of susceptibility was recorded in a cultivar, Karpuravalli (Table 18.8).

Musa balbisiana var. *andamanica* accessions were found to be the tallest among all the species with tightly arranged leaf sheaths in pseudostem with the girth of 104 - 117 cm at the collar level during bunching. Combination of pseudostem girth, compact arrangement leaf sheaths, presence of tough fibres, relatively more dry matter content (11%) in *M. balbisiana* var. *andamanica* (compared to 4-7 % in other accessions/landraces/cultivars) may be the possible mechanisms of preventing the adult female to lay the eggs or preventing grubs to feed.

Fig 18.8: Reaction of *Musa* species to pseudostem weevil (*Odoiporus longicollis*)

Table 18.8. Reaction of *Musa* wild species, landraces and cultivars to Pseudostem weevil

S. No.	*Musa* wild species/Land races/Cultivars *	Accession	Pseudostem infestation (%)	Reaction
1	*Musa balbisiana* var. *andamanica* (w)	IC630992 IC631126	Nil	Resistant
2	*M. kattuvazhana* (l) *M. inandamanensis* (w) Kathali (c) Njalipoovan (c)	IC623499 IC631163 - -	< 10	Moderately Resistant
3	Nendran (c) Cavendish (c) Chuneleiakunnan (l) Palayamkodan (c)	- - - -	10-40	Moderately Susceptible
4	*M. acuminata* (w) Karpuravalli (c)	IC631154 -	>40	Highly Susceptible

* w-wild, l-landrace; c-cultivar

Screening for resistance to bacterial wilt (*Ralstonia solanacearum*) in eggplant and its wild relatives

Total of 148 accessions belongs to *Solanum* species namely *S. melongena*, *S. torvum*, *S. incanum*, *S. melongena* var. *insanum*, *S. violaceum*, *S. sisymbriifolium*, *S. viarum*, *S. trilobatum* and *S. aethiopicum* were screened under artificial inoculation technique (root injury method). Lateral roots of 30-day-old seedlings in the field were trimmed and drenched with 10 ml of *R. solanacearum* culture suspension containing 7×10^8 cfu/ml. Symptoms of either partial or whole plant wilt started, a week after inoculation and continued till harvest. Out of 148 accessions, 14 accessions were free from any visible symptoms of wilting as well as negative to bacterial ooze test, whereas, 29 accessions were completely succumbed to *R. solanacearum*. Most of the resistant accessions found in the present study were belonging to *S. melongena* (IC255756, IC256708, IC636521, IC624237, IC53224, IC383695, IC421190, Arka Keshav) and its landraces (IC636524, IC641518, Vengeri brinjal) and few were belonging to *S. aethiopicum* (IC641515, IC618025) and *S. insanum* (IC599705).

Biochemical characterization

Greater yam:

Total anthocyanin content in fresh tubers of 11 accessions of Greater yam were estimated. *Karnataka Neela*, a land race collection from a custodian farmer exhibited 31.69 mg/100g (highest value) of total anthocyanin content which is significantly higher than the previous reports (22.7mg/100g).

Taro:

Six accessions exhibited purple colouration in the corm cortex and central portion, owing to the presence of anthocyanin, hence they were estimated for total anthocyanin content in the tuber. IC636544 and IC636540 of North Eastern origin taro collections exhibited higher values of 19.46 and 19.26 mg/ 100 g of sample respectively (Fig. 18.9).

Alpinia spp.

Biochemical characterisation of four species namely *Alpinia nigra*, *A. calcarata*, *A. galanga*

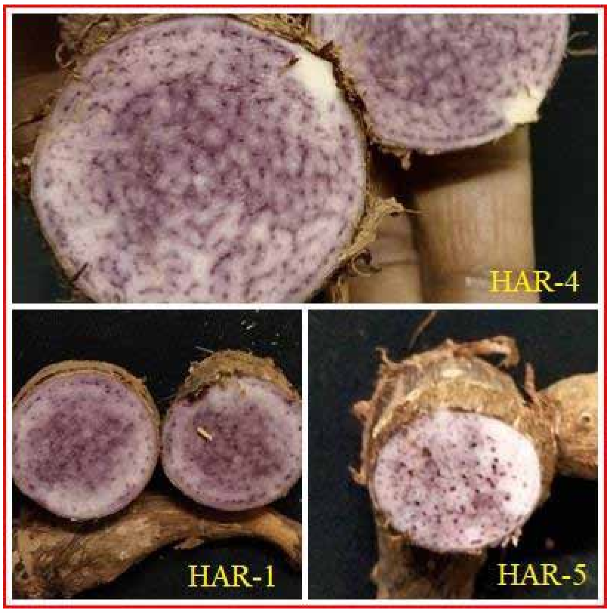

Fig 18.9: Anthocyanin rich taro collections from Northeast India

and *A. conchigera*) germplasm from the station at ICAR-IISR, Kozhikode revealed high content of volatile oil in *A. conchigera* (0.22%) followed by *A. calcarata* (0.2), *A. nigra* (0.1), and *A. galanga* (0.09). In addition, volatile oil chemo-profiling has been made for all four species.

Cucumber

Fruit samples of 12 accessions of cucumber comprising five orange fleshed accessions and three control varieties at ripe stage and, three accessions and one control variety at marketable stage were analyzed for total carotenoid content as presented in Table 18.9. The average carotenoid content at marketable stage ranged from 0.021 (JRPH/15-71) to 0.14 mg/100 g (IC257105) whereas at ripe stage it ranged from 0.099 (Himangi-white fleshed) to 1.393 mg/100 g (JB-11/155). It was found that the orange flesh cucumber germplasm had more than three times carotenoid content in comparison to white cucumber at ripe stage. Also, the average carotenoid content of ripe fruits were more than 10 times that at marketable stage. Carotenoid rich cucumber accessions can be incorporated in cucumber breeding programme to enhance the nutritive content of salad cucumber.

Table 18.9: Carotenoid content in cucumber accessions

S. No.	Accessions	Carotenoids (mg/100g)
	Physiological mature stage	
1	JB-12/185	0.221
2	JB-11/118	1.024
3	JRPH-15/71	0.483
4	JB-11/155	1.393
5	JRPH-15/56	0.43
	Average	**0.7102**
6	AAUC2	0.258
7	Himangi	0.099
8	Swarna Agethi	0.232
	Average	**0.19**
	Marketable stage	
9	JRPH-15/71	**0.021**
10	AAUC2	**0.02**
11	IC257105	**0.14**
12	KP/SC-1642	**0.057**
	Average	**0.059**

18.3 Taxonomic studies:

New Reports

- A new subspecies of *Momordica sahyadrica* (Cucurbitaceae) *Momordica sahyadrica* subsp. *anamalayana* KJ John, K Pradheep et Krishnaraj, a narrow endemic taxon, from Southern Western Ghats of Kerala, India was described from the station (Fig. 18.10). This new subspecies differs from the typical subspecies in having a slender stem, subsessile male flower pedicel, narrow male sepal, cupular corolla base with acuminate apex, greenish-yellow stigma and small fruits (14-18 g) with snout-like rostration and having a delicate growth habit with niche specificity, occupying the evergreen forest floor in the mid elevation ranges in the Anamalai Range of Western Ghats in Kerala, India.
- A new taxon, ***Trichosanthes dunniana*** H.Lév. subsp. ***clarkei*** K. Pradheep, was described from Sikkim Himalaya (Fig. 18.11). It differs from

Fig 18.10: *Momordica sahyadrica* subsp. *anamalayana* K.J. John, K Pradheep et Krishnaraj – newly described subspecies a. Habit; b – Male flower; c & d– Female flower; e – Immature Fruit

the typical taxon in having greenish bracts and calyces (vs. red in subsp. *dunniana*), longer pedicels of male flowers (4-7 mm vs. c. 2 mm in subsp. *dunniana*), shorter calyx lobes (5–6 mm versus c. 9 mm in subsp. *dunniana*) and white male as well as female flowers (vs. reddish in subsp. *dunniana*).

Fig 18.11: *Trichosanthes dunniana* H.Lév. subsp.*clarkei* K.Pradheep – newly described taxon. A. Fruiting branch; B. Female plant; C. Male plant

Misidentification of *Macrotyloma sargarhwalensis*

Correcting taxonomic misidentifications is vital in the conservation and use of wild relatives in crop breeding programmes. *Macrotyloma sargarhwalensis.* R.D.Gaur & L. R. Dangwal was described as a new species from Uttarakhand (India) in 1997. This species was considered a wild relative of the horse gram crop, therefore given so much thrust by agricultural scientists. Critical study of its protologue, type specimen, and field-grown plants of authentic germplasm (IC212722) indicated that this species is nothing but *Clitoria annua* J. Graham, and therefore synonymized with it (Fig. 18.12).

Fig 18.12: Original germplasm (IC212722) of *Macrotyloma sargarhwalensis* (inset: flowers and pods)

Mango-species-identification keys

A perusal of taxonomic literature indicated the presence of three unsolved species - *M. khasiana* (from Meghalaya), *M. acutigemma* (Sikkim), and *M. austroindica* (Tamil Nadu and Karnataka), which needs a taxonomic relook. Field studies had revealed that a species of a related genus, *Bouea oppositifolia*, was earlier wrongly identified/ kept as *M. andamanica* by agriculturists, and the virtual absence of *M. sylvatica* in Andaman, though reported, indicates possible misidentification. Keys for identification of Indian wild species in the field (using young flush, leaf, fruit, stone and seedling characteristics) were developed (Fig. 18.13).

Fig 18.13: Salient features of mango wild relatives in India

Solanum: Herbarium studies were made at the Botanical Survey of India, Kolkata (CAL) and Shillong (ASSAM) on all the *Solanum* specimens. Information on occurrence locality, habitat and taxonomic characters of 10 wild relatives of brinjal including endemic species, *S. multiflorum* was collected, besides studying variation in *S. violaceum* complex. Typical looking *S. insanum* accessions

S. No.	Trait	*S. insanum*	*S. incanum*
1.	Plant habit	Mostly straggling shrub, up to 0.8 m tall	Semi-erect branching shrub, up to 1.5 m tall
2.	Indumentum on young stems and leaves	Light to moderately stellate pubescent	Densely stellate pubescent, yellowish trichomes; young parts woolly
3.	Calyx lobe shape	Mostly (broad-) deltate	Narrowly deltate to rarely deltate
4.	Number of prickles/ calyx & their nature	0-15; spines medium	>25; spines robust, more pointed
5.	Fruit diameter (cm)	<2.5	2.5-3.5

were studied along with *S. incanum* (KP-2111), and based on shreds of evidence from the field, experimental and herbarium studies, it was found that these species can be distinguished by characters mentioned in the below table, besides habitat preference. However, other characteristics used to distinguish these two taxa such as the nature of leaf lobe apex (acute in *insanum*, rounded in *incanum*), leaf base (truncate in *insanum*, rounded to cordate in *incanum*), length of calyx and its lobe were found untenable in the present study.

Vigna: Perusal of recent taxonomic literature indicated an anomaly in the views of experts from India and the world. At the world level, *Vigna stipulacea* was merged with taxon from a totally different genus, *Pueraria montana* var. *lobata*. Besides, *Vigna umbellata* var. *gracilis* was synonymized with Indo-Chinese *V. gracilicaulis*, *V. hainiana* with *V. subramaniana*, and *V. trinervia* with *V. radiata*, *V. aridicola* with *V. aconitifolia*, and taxonomically recognized progenitors/wild forms of black gram (i.e., var. *silvestris*) and adzuki bean (i.e., var. *nipponensis*) were merged with crop taxa themselves. Apart from it, taxa described from outside India such as *Phaseolus novoguineensis*, *P. scaberulus* and *V. opisotricha* were merged with the strictly Indian endemic *V. radiata* var. *setulosa*. All these indicate the need for consulting protologue, critical examination of type specimen, the study of taxonomic history and expertise in nomenclatural rules.

An experimental study of germplasm (20 acc.) labelled as *V. trinervia* and *V. bourneae* from the Western Ghats and A&N Islands indicated that the key characteristics used to distinguish both the taxa such as the size of standard petal and the stem hair length are untenable. Also, V-shaped specks on the upper surface of the leaves were found taxonomically insignificant. However, there exists some variation in the colour of leaves and seeds, and the intensity of hairiness and stem pigmentation.

18.4 germplasm conservation and regeneration

A total of 9832 accessions comprising cereals (3123), millets (85), oilseed (48), pulses (3040), vegetables (2486) and crop wild relatives (1050) were conserved in the MTS facility of the station. In the field gene bank, currently 1928 accessions are maintained including 399 of tropical fruits, 644 of spice crops, 198 of tuber crops, 244 of medicinal plants, 285 of crop wild relatives and 158 of other economic plants.

For long term storage, 623 samples consisting of collected (270 collected samples) and multiplied (353 samples) germplasm were deposited at NGB, which comprises cowpea (40), cucumber (31), green gram (18), wild okra (16), brinjal (13), melon (12), foxtail millet (8), finger millet (7), black gram (6), gingelly (5), Chinese spinach (4), lablab (4), sorghum (4), chillies (3), ash gourd (2), *Citrus medica* (1) and *Citrus aurantiifolia* (1).

One accession each of *Musa kattuvazhana*, *Musa acuminata*, *Musa hirta*, *Citrus medica* and *Citrus aurantiifolia* we re sent for cryo-conservation.

Germplasm Exchange

Supply to user agencies: Under Material Transfer Agreement (MTA), 6221 accessions of germplasm of various crops/ species were supplied to 47 user agencies, comprising 13 ICAR institutes (4884 accs.), 29 State Agricultural Universities (1201 accs.) and 5 Other Agencies (136 accs.). One accession each of 35 species of various economically important species of A&N origin to FC&RI, Mettuppalayam, TN for conservation in their FGB

Germplasm receipt: A total of 200 germplasm in various crops comprising drumstick, sesame, *Guizotia* and wild sesame was received.

Externally funded projects:

A. Generating Genomic Resources for facilitating genetic enhancement on selective *Vigna* species and Horse gram:

a. Large scale evaluation of genetic resources of horse gram

A total of 2144 accessions of horse gram germplasm evaluated during (2020-21) was evaluated for the second time in augmented design with 7 check varieties (AK 21, AK 38, HGGP, PHG 9, DPPI 2278, PAIYUR 1, BIRSA KULTHI) in 23 blocks. The genotypes were assessed based on 19 morphological traits (8 quantitative and 11 qualitative traits). The variability parameters for yield contributing traits and superior accessions are given in Table 18.10 :

Evaluation of core sets comprising 400 accessions of greengram and 300 of horsegram are in progress **(Fig. 18.15)**.

B. Collection, conservation, taxonomy, diversity, cytology, molecular

Characterization and Nutritional analysis of *Momordica subangulata* Blume subsp. *subangulata* and other edible species of *Momordica* L. from Northeast India

Exploration and collection: Augmented 45 collections of teasel gourd of Northeastern origin and 13 of novel synthetic species of *Momordica* (*M.* × *suboica* Bharathi) with potential as a new vegetable crop. Augmented two collections of *Momordica subangulata* subsp. *subangulata* from Nagaland for multiplication and developing ex-situ regeneration protocol using in-vitro methods.

Characterization of Teasel gourd germplasm: Characterized 20 accessions collected from various parts of Tripura, Assam and Mizoram for fruit characters. The fruit weight ranged from 27.58 (JB/11-239) to 110g (JB/11-166A), fruit length from 5.33 (CHTG-7) to 8.92cm (Arka Bharat), fruit width from 3.20 (JB/11-78A) to 5.33cm (JB/11-166A), fruit circumference from 11.33 (JB/11-78A) to 18cm (JB/11-166A) and flesh thickness from 0.2(JB/11-138) to 0.6cm (JB/11-166A). Results showed that JB/11-166A was showing significantly higher values for all the economic fruit characters studied except for fruit length. Variability in fruits of teasel gourd germplasm is depicted in Fig. 18.16.

Widening the genetic base of Teasel gourd (*M. subangulata* subsp. *renigera*): To overcome the requirement of hand pollination in teasel gourd

Table 18.10: Superior accessions of horsegram for yield contributing traits

	Days to 50 per cent flowering	Pod length (cm)	No of seeds per pod	Seed yield per plant (g)	100 seed weight (g)
Max	82	8.2	6.25	27.76	5.96
Mean	48.3	4.95	4.6	8.76	3.4
Minimum	23	2.88	1.5	1.02	1.03
Superior check	Birsa Kulthi (37 days)	HGGP (5.37)	HGGP (4.9)	Paiyur (8.9g)	Paiyur(3.54g)
Superior accessions	IC353815 IC361650 IC22809 IC22805 IC139446	IC426493 IC202598 IC45748 IC22800 IC26140 IC71783 IC71817	IC22800 IC202598 IC71783 IC45748 IC1978	IC23492A IC44013 IC68590 IC23443 IC43508	IC342684 IC71792 IC145314A IC33072 IC417809
CV%	10.83	9.6	8.35	48.42	9.8
SE(d)	7.4	0.67	0.54	5.99	0..47

Fig 18.15: Field view and seed diversity depiction of greengram coreset

outside its home range, an attempt was made to transfer the natural insect pollination traits and cue mechanism of related *M. dioica sahyadrica* (both 2n=28), to the teasel gourd genome (4n=58), thus combining high vegetative propagation efficiency, bigger fruit size, prolificacy, extended harvest period and entomophily. Earlier attempts on interspecific hybridization resulted in developing F_{1s} (4n x 2n= 3n) with ill-developed fruits. Hence the dioecious pollen parents; *M. dioica* and *M. sahyadrica* were subjected to tetraploidization by treating tuber sprouts with 1% colchicine at 15 minutes interval from 7 am to 11 am on the growth primordia at two leaf stage. Bulged collar region of survived plants was taken as an indication of polyploidization and such plants were used as pollinizers for teasel gourd.

There was reduction in fruit size and seed number per fruits (11 to 35g; 4.67 to 15.33 seeds in *M. subangulata* subsp. *renigera* x *M. dioica* and 20 to 40g; 10 to 19 seeds in *M. subangulata* susp. *renigera* x *M. sahyadrica*) compared to the maternal parent (60 to 75g; 28 to 40 seeds), which may be attributed to the xenia effect of pollinizer parent. In addition to fertile *M.* × *suboica* Bharathi, male flowers were also used for back crossing, which yielded normal sized fruits (75 to 90g).

C. Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery

Sub-project 6; Component 1: Wide hybridization and Genetic Enhancement

Herbarium study (about 250 specimens) in Botanical Survey of India at Kolkata (CAL) and Shillong (ASSAM) resulted in updating

Fig. 18.16: Variability in fruits of teasel gourd germplasm

information on species distributional range and their habitat, intraspecific variation in species besides correcting misidentifications. However, hardly any sheet representing wild forms/ populations of sesame bore the name of either *S. malabaricum* or *S. mulayanum*. Out of 46 earlier attempted crosses, seeds of F_1 progenies of 38 wide crosses (*S. indicum* × *S. malabaricum*-12; *S. indicum*

Fig 18.17: Sterile F_1 hybrid of *S. indicum* x *S. prostratum* having potential as ornamental bedding plant

× *S. mulayanum*-11; *S. indicum* × *S. laciniatum*-4; *S. indicum* × *S. radiatum*-2; *S. malabaricum* × *S. indicum*-9) were raised in the field. All the F_1 hybrids involving *S. laciniatum* as a male parent were sterile, therefore amphidiploidization attempts to make fertile progenies are on the way. In the majority of the crosses, F_1 seed colour exhibited maternal inheritance, however, in crosses TMV-7 × IC557247, IC557245 × VRI-1, and IC623409 × VRI-1, seed colour of the pollen parent was expressed. In addition, 46 wide crosses (including some reciprocals), were non-attempted/unsuccessful (*S. indicum* × *S. alatum* – 8; *S. indicum* × *S. prostratum* – 8; *S. indicum* × *S. laciniatum* – 13; *S. indicum* × *S. radiatum* – 17) were attempted, and out of them, got successful fruit set in 38 crosses (Fig. 18.17).

Fig. 18.18. Phyllody and associated symptoms on a month-old crop of Sesame (a & b) and during maturity (c) at NBPGR-RS, Thrissur

Screening of *Sesamum indicum* and its related species for resistance to phyllody

Total of 228 accessions belongs to *Sesamum indicum* (65), *S. malabaricum* (37), *S. mulayanum* (40), *S. radiatum* (20) and inter specific crosses (66) were evaluated against phyllody under field conditions. Phyllody and its associated symptoms were appeared on nearly 30 days old plants in few accessions and maximum incidence (about 70%) occurred at harvest. Accessions namely IC277411, IC280376, IC312565, IC397212, IC409051 and IC436744 of *S. indicum*, IC623402 of *S. radiatum* and IC199437-5, IC199437-12 and IC199438 of inter-specific crosses were found free from phyllody and associated symptoms **(Fig. 18.18)**.

Fig. 18.19: Showcasing the okra amphidiploids to plant breeders' of Kerala Agrl. University, Thrissur, Kerala

Projects:

Research Programme: Plant Genetic Resources Management in Southern India including Goa and Andaman & Nicobar Islands.

Programme Leader:M Latha., Principal Scientist & Officer in charge

Research programme (Code, Title, Programme leader, CoPI)

PGR/ DGE-BUR-THR-01.01: Plant Genetic Resources Management of field crops and their wild relatives M Latha, Joseph John K., K. Pradheep, PP Thirumalaisamy, Suma A, S Mani and A Indiradevi

PGR/ DGE-BUR-THR-01.02: Plant Genetic Resources Management of spices, fruit crops and their wild relatives, medicinal and other economic plants K. Pradheep, Joseph John K., PP Thirumalaisamy, Suma A., S. Mani, and A Indiradevi

PGR/ DGE-BUR-THR-01.03: Plant Genetic Resources Management of vegetables, tropical tubers and their wild relatives Suma A., Joseph John K,M Latha, K. Pradheep, PP Thirumalaisamy, S Mani, and A Indiradevi

Externally funded projects:

Scheme Code: 40003 Project Code: 1010668: Generating Genomic Resources for facilitating genetic enhancement on selective Vigna species and Horsegram Dr M latha (Co-PI)

Scheme code: 97810 Project Code: 1011838 : Collection, Conservation, Taxonomy, Diversity, Cytology, Molecular Characterization and Nutritional analysis of Momordica subangulata Blume subsp. subangulata and other edible species of Momordica L. from Northeast India Dr. Joseph John K (PI) Dr Suma A (Co-PI)

Scheme Code: 40003 Project Code : 1012162: Mainstreaming of Sesame germplasm for productivity enhancement through genomics assisted core development and trait discovery Dr K Pradheep PI) Dr Suma A (Co-PI)

TRAININGS AND CAPACITY BUILDING

19

Summary: In 2021, the institute was involved in organizing 13 trainings / workshops / awareness programs in the headquarters and regional stations. Various scientific staff attended 32 training programs. The technical and administrative staff attended 8 and 5 trainings, respectively. All scientists of the Bureau and 04 technical staff participated in various Seminars/ Conferences/ Symposia/Workshops/meetings.

19.1 Trainings/workshops/visits/fairs organized in 2021

S. No.	Title of programme	Duration in 2021	Venue
1.	Training course on "Management of fruit genetic resources"	Feb. 1-2	ICAR- NBPGR, New Delhi, in collaboration with ICAR-AICRP on Fruits and ICAR-IIHR, Bengaluru (virtual)
2.	Training cum exposure visit on cultivation kiwi and its nursery management for farmer group of Pauri Garhwal	Feb. 8-10	NBPGR RS Bhowali
3.	Exposure visit- cum-training under UNEP-GEF for farmer group of Almora	Feb. 22	NBPGR RS Bhowali
4.	Awareness cum-Agro biodiversity conservation fair under Tribal Sub Plan.	March 17	Munsyari, Pithoragarh (UK)
5.	A plant genetic resources conservation awareness workshop cum-diversity fair organized by Division of Plant Collection and Germplasm Exploration	March 24	Dungari village, Dehradun, Uttarakhand
6.	A workshop cum awareness programme under tribal sub-plan on 'conservation of plant genetic resources for health and nutritional security' was organized with the local support from Gram Panchayat, Somwar Kheda and Jeevan Vikas Sanstha, Paratwada.	March 27	Tribal Vil: Malkapur, Tal: Chikhaldara, Dist: Amravati, Maharashtra State by ICAR-NBPGR, Regional Station, Akola
7.	Workshop cum awareness programme organized under Scheduled Caste Sub-Plan on "Conservation of plant genetic resources for health and nutritional security"	March 30	Village Goregaon (Kh), Tal: Akola, Dist: Akola, Maharashtra
8.	National workshop on 'Follow-up action on Delhi declaration on agrobiodiversity management'	Aug. 10	ICAR- NBPGR, New Delhi
9.	Training programme on 'Biosecurity and biosafety: policies, diagnostics, phytosanitary treatments and issues'	Sept. 15-24	Division of Plant Quarantine, ICAR-NBPGR
10.	Awareness cum agro biodiversity fair under tribal sub plan.	Sept. 16	Gamshali, Chamoli (UK)
11.	Plant genetic resources conservation awareness workshop cum biodiversity fair	Oct. 5	Karra block of Khunti district of Jharkhand byICAR-NBPGR Regional Station, Ranchi

12.	National consultation on 'Plant-based local food systems for health and nutrition'	Oct. 22	ICAR- NBPGR, New Delhi (virtual)
13.	Awareness cum agro-biodiversity fair under tribal sub plan.	Nov. 18	Leelam, Munsyari, Pithoragarh (UK)

19.2 Trainings undertaken during 2021

Name of employee	Title of training programme	Duration in 2021	Place
Scientific Staff			
Kamala Venkateswaran	Generic Online Training Course in Cyber Security	Jan. 05	MeitY, New Delhi
Ruchi Bansal	Analysis of Experimental Data	Jan 17-22	ICAR-NAARM, Hyderabad
Vijay Singh Meena	Non-conventional approaches for genetic improvement of perennial horticultural crops	Jan. 17- Feb. 06	ICAR-IARI, New Delhi
SP Ahlawat, M Latha, Gowthami R, Mamta Singh, P Pranusha	Enhancing research skills and refinement of technology by a scientist (Online)	Jan. 18-20	ICAR-IIHR, Bengaluru
Mohar Singh	General management programme for scientists	Jan. 18-29	ASCI, Hyderabad
N Sivaraj	Generic online training course in cyber security	Jan. 21	MeitY, New Delhi
Suma A	Refresher course on 'Prequels to plant breeding by design & prediction'	Jan. 28- Feb. 18	UAS, Bengaluru
L Saravanan P Pranusha B Bhaskar K M Rai	Management of Fruit Genetic Resources (Online)	Feb. 01-02	NBPGR, New Delhi
Puran Chandra Ravi Kishore Pamarthi	Biodiversity conservation (Online)	Feb. 22-26	Wildlife Institute of India, Dehradun
S Nivedhitha	Health and mental well being of ICAR staff for enhancing proficiency (Online)	Feb. 25-27	ICAR-IIWBR, Karnal
Sandhya Gupta	People & forest interface (Online)	Feb. 8-9	Central Academy for State Forest Service, Dehradun
S Nivedhitha DP Semwal Soyimchiten S.	Geo-informatics in agriculture using open-source data and analysis platforms (Online)	Mar. 1-5	ICAR-IARI, New Delhi
Veena Gupta	Leadership development for women scientists (Online)	March 8-10	ICAR-NAARM, Hyderabad
Ruchi Bansal	Participated in Training on Data Visualization using R	March 9-11	ICAR-NAARM, Hyderabad
Vandana Tyagi	Generic online training in cyber security (Online)	Apr. 29	MeitY, New Delhi

MC Singh	Training workshop for Liaison Officers (Online)	May 20-21	ISTM, New Delhi
Veena Gupta	Quality management system and internal auditor training course as per ISO 20387:2018 (Online)	May 28-30	Quality & Accreditation Institute, New Delhi
Jameel Akhtar Zakaullah Khan	MDP on leadership development (a pre-RMP programme) (Online)	Jun.14-25	ICAR-NAARM, Hyderabad
Julius Uchoi L Saravanan	Plant genetic resources management and utilization (Online)	Jul. 19-Aug. 01	ICAR-NBPGR, New Delhi
All Scientist of NBPGR	Management and utilization of plant genetic resources (Online)	Jul. 6	ICAR-NBPGR, New Delhi
Anuradha Agrawal	Accreditation of Biobanks (ISO 20387)-Biotechnology-Biobanking-General Requirements for Biobanking'	Aug. 10-12	Asia Pacific Accreditation Cooperation, South Turramurra, NSW (Australia)
Mamta Singh	Bioinformatics (Online)	Aug. 17-21	RASA Life Science Informatics
Bhaskar Bajaru	Biosecurity and biosafety: policies, diagnostics, phytosanitory treatments and issues (Online)	Sept. 15-24	ICAR-NBPGR, New Delhi
SR Pandravada	Soilless terrace gardening	Sept. 28	ICAR-IIHR, Bengaluru
Sangita Bansal, MC Yadav, Susheel Kumar Raina	Transcriptomic data analysis (Online)	Sept. 28-30	ICAR-IASRI, New Delhi
KP Mohapatra, Jyoti Kumari, Kuldeep Tripathi, Vikender Kaur, Rashmi Yadav, Ruchi Bansal	Analysis of multi-location experiments (Online)	Oct. 28-30	ICAR-NAARM, Hyderabad
Monika Singh	Inter lab comparison, proficiency testing and evaluation of scores (Online)	Nov. 22-23	National Institute of Training for Standardization, BIS, NOIDA
V Celia Chalam	International Training Programme on Bulk Sampling, handling and documentation in the Context of Transboundary Movement of Living Modified Organisms (LMOs)	Nov. 26	Biotech Consortium India Ltd., New Delhi,
Pavan Kumar Malav Ravi Kishore Pamarthi	Basics of plant taxonomy and herbarium management (Online)	Dec. 1-31	Central National Herbarium, BSI, Kolkata
Shephalika Amrapali	Statistical designs and analytical method for multifactor experiments	Dec. 8-17	ICAR-CMFRI, Kochi
Bharat Gawade Pardeep Kumar	SNP mining, GWAS and genomic selection	Dec. 16-21	ICAR-IASRI, New Delhi
Technical Staff			
Smita Lenka Jain	Skill development in maintenance of soil health for better crop ecosystems (Online)	Jan. 21-23	ICAR-IIHR, Bengaluru

Rajeev Gambhir Vijay Mandal	10th Generic Online Training of Government Personnel of Central Government Ministries/ Departments in Cyber Security	March 25	Central Government Ministries/ Departments in Cyber Security
Ankur Tomar	Programming of web & mobile applications using low-code platforms (Online)	Jul. 07-12	ICAR-NAARM, Hyderabad
Manish Tomar	Webinar on 14th batch generic online training course in cyber security	July 09	MeitY, Government of India
Shivangi Mathur, Ankur Tomar, Manish Tomar	E-governance applications in icar for technical staff (Online)	Sep. 6-10	ICAR-IASRI, New Delhi
Vijay Mandal	Communication skills for supervisory officer (Online)	Sep. 30-Oct. 01	ISTM, New Delhi
Akansha Bajpai	Statistical techniques for data analysis in agriculture (Online)	Oct. 4-13	ICAR-IASRI, New Delhi
Ankur Tomar, Shivangi Mathur, Manish Tomar	Advances in web and mobile application development (online)	Dec. 6-10	ICAR-NAARM, Hyderabad
Administrative Staff			
Avdhesh Kumar Sanjay Dangwal	Administrative and financial management	Jun. 24-26	Online
Amrita Negi, Avdhesh Kumar, Sanjoo Verma	Reservation in service (Online)	Jun. 28-30	ICAR-NAARM, Hyderabad
Sh. Avdhesh Kumar, Sanjoo Verma	RTI Act, 2005 (Online)	Jul. 15-16	ICAR-NAARM, Hyderabad
Prabal Das Gupta	Administrative and financial Management	Sep. 21-25	ICAR-NAARM, Hyderabad
PK Jain	Digital workplace: Essentials for non-IT executives	Dec. 13-17	NPC, New Delhi
SSS			
Dasrath Singh	Skill upgradation	Jul. 5-12	ICAR-NBPGR, Jodhpur Centre

19.3 Capacity building

19.3.1 Deputation abroad- Nil

19.3 Participation in Seminars/ Conferences/ Symposia/Workshops/meetings

Name of scientist	Title of Seminars/ Webinars/ Conferences/ Symposia/ Workshops/ meetings	Duration in 2021	Place
Anitha Kodaru, B Parameswari, Bhaskar Bajaru	National webinar series on Recent Molecular Approaches for Plant Disease Diagnosis-II	Jan. 5	SV Agricultural College, ANGRAU, Tirupati, Virtual
V Celia Chalam	National Webinar on 'Recent Molecular Approaches for Plant Disease Diagnosis-II'	Jan. 5	Virtual
PK Malav, S Nivedhitha, Kamala Venkateswaran	Webinar On International Code of Nomenclature (ICN) For Plants	Jan. 06	BSI, Deccan Regional Centre, Hyderabad
B Parameswari	Virtual Symposium – 2020 on Advances in Phytopathology	Jan. 6-7	Virtual

V Celia Chalam	Zone Virtual symposium on 'Advances in Phytopathology'	Jan. 7	Virtual
Kamala Venkateswaran	Webinar on marketing of agricultural commodities-challenges and opportunities	Jan. 12- 14	ICAR-NDRI, Karnal, Virtual
Mamta Singh	International webinar on 'Production of androgenic haploids and doubled haploids in banana'	Jan. 15	Virtual
SK Yadav, Soyimchiten	Webinar on Enhancing Research skills and refinement of technology by a Scientist	Jan. 18-20	ICAR-IIHR, Bengaluru
Kamala Venkateswaran	Webinar on Research Priorities for Indian seed sector	Jan. 23	Hyderabad, Virtual
SR Pandravada, N Sivaraj	National Webinar on Emerging aspects of taxonomy and biodiversity	Feb. 3	Hyderabad, Virtual
B Parameswari	Webinar on Next Generation Sequencing for Deciphering Host-Pathogen Interactions	Feb. 4-5	IPS–Bionivid Virtual
RK Pamarthi	National Web Conference on Sustaining Pulse Production for Self Sufficiency and Nutritional Security	Feb. 9-11	ISPRD, IIPR, Kanpur
Dinesh Chand, Sunil Gomashe	International Conference on Pulses Research (ICPR-2022)	Feb. 10	Virtual
Puran Chandra, Pragya	FAO sponsored international expert panel fruit and vegetable genetic diversity: the status and challenges of conservation, exchange and use	Feb 16	FAO, Rome Virtual
B Parameswari	Webinar on Gene Editing Research in Agriculture: Key Initiatives in India	Feb. 17	Virtual
V Celia Chalam	CGIAR IYPH Webinar 2: Germplasm health in preventing transboundary spread of pests and pathogens.	Feb. 17	CGIAR, Virtual
V Celia Chalam	Webinar on Introduction to High-Throughput Sequencing, American Phytopathological Society.	Feb. 17	USA, Virtual
N Sivaraj	Webinar on Access and Benefit Sharing: The journey so far and challenges ahead	Feb. 24	National Biodiversity Authority and UNDP, Virtual
Puran Chandra	Webinar on Linkages of van panchayats with institutions of community participation and panchayati raj institutions	Feb. 25	TERI, New Delhi
L Saravanan	National Webinar on Impact of Climate Change and Invasive Alien Species on Agriculture	Feb. 26	Virtual
N Sivaraj, Bhaskar Bajaru	Dragon fruit germplasm field day	Feb. 27	Sangareddy, Telangana
RS Rathi, RK Pamarthi, PK Malav, S Nivedhitha, V Celia Chalam, Kavita Gupta	Brainstorming meeting on Digital Sequence Information (DSI) and Germplasm Sharing	March 1	ISPGR, New Delhi Virtual

Vandana Tyagi, SK Yadav	International Roundtable on achieving global food security through instrumentalities of plant variety and other related disciplines (patent, trade secret, ABS and regulatory framework)	March 5-6	DPIIT-IPR CHAIR &CIPRA, National Law School of India University, Bangalore
V Celia Chalam	Webinar on HTS for Plant Certification.	March 10	APS, USA, Virtual
SK Yadav, P Pranusha	Hindi workshop on Statistical genetics and its application in agriculture	March 18-20	ICAR-IASRI , New Delhi Virtual
Puran Chandra	Webinar on Event on Linkages of Biodiversity Management Committees (BMCS) with Institutions of Community Participation and Panchayati Raj	March 19	TERI, New Delhi
V Celia Chalam, Kavita Gupta, Jameel Akhtar, Pardeep Kumar, Raj Kiran, Pooja Kumari, B Parameswari, KS Hooda	IPS National e-Conference on Plant Health and Food Security: Challenges and Opportunities.	March 25-27	IPS and ICAR-IARI, New Delhi, Virtual
S Nivedhitha	1st International Multi-Stakeholder Symposium on Plant Genetic Resources for Food and Agriculture, Technical Consultation on *in situ* Conservation and on-farm Management of PGRFA	March 29–30	FAO, Crop Trust & ITPGRFA
Ruchi Bansal	International Symposium on Advances in Plant Biotechnology and Genome Editing & 42nd Meeting of Plant Tissue Culture Association	April 8-10	Virtual
V Celia Chalam	International Advances in Plant Virology 2021	April 13-14	Association of Applied Biologists, UK, Virtual
SR Pandravada	Webinar on Guidelines for selection and management of the Biodiversity Heritage Sites	April 17	ICAR-NBPGR, New Delhi, Virtual
Anitha Kodaru, V Celia Chalam, L Saravanan, Prasanna Holajjer, Bhaskar Bajaru	Webinar on 'Is gene editing a Myth or Reality? CRISPER CAS 9 Applications in Agriculture'	April 22	PPAI, Hyderabad Virtual
V Celia Chalam	National Webinar on Genome Editing for Food, Nutrition and Environmental Sustainability	April 28	Shivaji College, Delhi,
Dinesh Chand, Sunil Gomashe, Sandeep Kumar	XXXI Group Meet *Kharif* 2020, All India Coordinated Research Network on Potential Crops	May 1	NBPGR, New Delhi Virtual
V Celia Chalam	National e-Conference on Recent Trends in Plant Pathology	May 4	ANGRAU, Hyderabad Virtual
Jameel Akhtar, Raj Kiran	National e-Conference-2021 on 'Recent trends in Plant Pathology	May 4	INSOPP, Ludhiana Virtual
Jameel Akhtar	National Symposium on 'Plant Health Management Beyond 2020'	May 5-6	Nauni, Solan, HP

RS Rathi, KC Bhatt, DP Semwal	Declamation on 'Indigenous Plant Wealth for Food, Nutrition and Health security'	**May 21**	ICAR-IARI
All scientists of NBPGR	Webinar on Agrobiodiversity and food systems for sustainable nutrition and health	May 22	ICAR-NBPGR, New Delhi, Virtual
Ishwar Singh	Web seminar on 'World Environment Day'	June 5	CCS HAU Hisar Virtual
L Saravanan, B Parameswari	International conference on Sugarcane Research: Sugarcane for Sugar and Beyond (Canecon2021)	June 19-22	ICAR-SBI, Coimbatore, Virtual
V Celia Chalam	Gene Drive Webinar Series No.2 Could Gene Drive Approached be used to Protect Nature and Recover Biodiversity Loss	June 24	ISAAA, USA, Virtual
RK Pamarthi, K Tripathi	International Symposium on Sustainable Intensification of Integrated Crop Live stock Farming System for Enhancing Productivity and Improving small holders livelihood	June 24-25	The University of Melbourne, Parkville, Australia, Virtual
Pratibha Brahmi, Vandana Tyagi	International Expert Panel - Cryopreservation: A long-term strategy for hard-to-conserve PGRFA collections in a post-COVID world	June 25	Secretariat of the International Treaty for PGRFA and the Global Crop Diversity Trust
L Saravanan	International webinar on Desert locust, *Schistocera gregaria* (Forskal): International Scenario and a potential threat to India	July 2	NIPHM, Hyderabad, Virtual
Dinesh Chand, Sunil Gomashe, DP Semwal, KC Bhatt, RS Rathi, Puran Chandra, Soyimchiten, RK Pamarthi, PK Malav, S Nivedhitha, SK Raina, Sheikh M Sultan, SR Pandravada, N Sivaraj	Virtual workshop on 'Planning and Management of CWR and RET Species of PGR Importance in India'	July 5	ICAR- NBPGR, New Delhi and BSI, Kolkata Virtual
PK Malav	Virtual meeting on Agro Biodiversity Index	July 7	Alliance Bioversity-CIAT
Vandana Tyagi	Webinar on Agrobiodiversity for Food Security	July 16	ICAR-CTCRI, Kasargod, Virtual
Sunil Gomashe	International Webinar on "Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone"	July 17	SKRAU, Bikaner, Virtual
Vikender Kaur, Sunil Gomashe	Web Conference on 'Innovative and Current Advances in Agriculture and Allied Sciences'	July 19-21	Meerut, UP, Virtual
Anitha Kodaru	Bi-annual subcommittee meeting of National Network of Plant Health Experts	July 22	NIPHM, Hyderabad, Virtual
KS Hooda	International Day for Biological Diversity 2021	July 22	Ministry of Environment, Forest and Climate Change, GOI

SR Pandravada	Webinar on Emerging AgriTech towards transforming Indian Agriculture	July 23	ICAR- IIOPR, Pedavegi, Virtual
V Celia Chalam	International Webinar on Monitoring and Early Warning of Plant Pest and Disease Epidemics in Response to Climate Change.	July 27-28	FFTC-BAPHIQ-TARI, Taiwan, Virtual
SR Pandravada	National webinar on Ecosystem for sustainable Farmers Producer Organization	July 30	ICAR-RCER, Patna, Bihar, Virtual
Jameel Akhtar	29th Annual Group Meeting of 'AICRP on rapeseed-mustard'	Aug. 4-6	ICAR-DRMR, Bharatpur, Virtual
RK Pamarthi, S. Nivedhitha, Raj Kiran	5th International Conference on Advances in Agriculture, Environmental and Biosciences for Sustainable Development (AAEBSSD-2021)	Aug. 5-7	Rampur, UP, Virtual
B Parameswari	28th Annual General Body meeting of National Academy of Agricultural Sciences, New Delhi	Aug. 9	NAAS, New Delhi, Virtual
Dinesh Chand, Sunil Gomashe, B Parameswari	National Workshop on " Follow-up Action on 'Delhi Declaration on Agrobiodiversity management'	Aug. 10	ICAR-NBPGR, New Delhi, Virtual
P Pranusha	Webinar on Abiotic Stress Management in Agriculture	Aug. 10	CSAUAT, Kanpur, Virtual
N Sivaraj	Webinar on Integrated farming systems for sustainable livelihood and nutritional security	Aug. 12	Virtual
B Parameswari	Webinar on Quarantine procedures for the national and international exchange of plant materials	Aug. 12	ICAR-SBI Regional Centre, Kannur, Virtual
V Celia Chalam Jameel Akhtar, BH Gawade, Pardeep Kumar	International e-Conference on Postharvest Disease Management and Value Addition of Horticultural Crops.	Aug. 18-20	ICAR-IARI, New Delhi, Virtual
L Saravanan, B Parameswari, Prasanna Holajjer, Bhaskar Bajaru	Webinar on Global exchange of crop germplasm: Phytosanitary regulations and procedures with reference to India	Aug. 21	Indian Institute of Maize Research, Ludhiana, Virtual
Mamta Singh	International Webinar "Progress and Prospects in Genomics, Genetics, and Breeding for Biotic Stresses in Plants"	Aug. 22	Plantgenomia, Virtual
Jyoti Kumari	60th All India Wheat and Barley Research Workers'	Aug. 23-24	Virtual
Anitha Kodaru	Webinar on Harnessing the benefits of modern agricultural biotechnology in the Asia-Pacific Region-Challenges and way forward	Aug. 24	ICAR, New Delhi, Virtual
Dinesh Chand, Sunil Gomashe	XXVI Meeting of ICAR Regional Committee No. VII	Aug. 25	Virtual
Puran Chandra	International seminar on 'Pomegranate: Ancient fruit in modern horticulture'	Aug. 25-27	Virtual
Prasanna Holajjer	Webinar on 'Phytosanitary strategies for food security and market access of fruits and vegetables'	Aug. 26	NIPHM, Hyderabad, Virtual
N Sivaraj	Webinar on Medicinal Plants: Leads for Drug Discovery	Aug. 31	ICAR-DMAPR, Anand, Virtual

Prasanna Holajjer	Webinar on Nematode – A Hidden Enemy of Crops	Sept. 2	Bayer Crop Sciences, Virtual
Soyimchiten	National webinar on Nutritional Security in India: Issues and Way Forward	Sept. 4	ICAR-Research Complex for Eastern Region, Patna, Virtual
SK Yadav, Soyimchiten	National Conference (online) on Oil Palm- A right choice towards self-sufficiency in edible oil production	Sept. 6	ICAR-IIOPR, Pedavegi, Virtual
V Celia Chalam	National e-Seminar on Recent Advances in Plant Disease Management.	Sept. 25	Hyderabad, Telangana Virtual
SK Yadav, Vikender Kaur	International webinar on Alternate cropping systems for climate change and resource conservation	Sept. 29 to Oct. 1	ICAR-IIFSR, Meerut, Virtual
Ishwar Singh, N Sivaraj	National Conference on 'Integrated Farming Systems: A Tool for Enhancing Income and Nutritional Security'	Oct. 5-7	ICAR-RCER, Patna, Virtual
Vartika Srivastava	International Conference on 'Future Challenges & Prospects in Plant Breeding'	Oct. 6-7	Coimbatore, TN
Ishwar Singh	Webinar on 'Agro-Environmental Ethics'	Oct. 07	NDRI, Karnal
N Sivaraj, SR Pandravada	Webinar on Working Models to maximize the use of Genetic Diversity in Crop Improvement Programmes	Oct. 16	ICAR-NBPGR, New Delhi, Virtual
Z Khan, Jameel Akhtar, Raj Kiran, SK Yadav	3rd International Conference on "Global Initiative in Agricultural, Forestry and Applied Sciences for Food Security, Environmental Safety and Sustainable Development (GIAFAS-2021)	Oct. 17-18	SGRR University, Dehradun, Uttarakhand
Archana P. Raina, SR Pandravada	National Consultation on 'Plant-based Local Food Systems for Health and Nutrition'	Oct. 22	New Delhi
Anitha Kodaru, B Parameswari, L Saravanan, Prasanna Holajjer, Bhaskar Bajaru	Webinar on Novel approaches for simplified detection of plant viruses and virus like pathogens	Oct. 22	Plant Protection Association of India, Hyderabad, Virtual
SR Pandravada	Webinar on CGIAR's engagement in the post-UN food systems summit	Oct. 25	ICAR-NAHEP, New Delhi, Virtual
SK Yadav, Vikender Kaur	International webinar on Fighting the hunger using smart technology	Oct. 26	ICAR-IIOPR, Pedavegi, Virtual
All the scientists of NBPGR	Interaction meeting of ICAR Scientists with Secretary DARE & DG ICAR	Oct. 28	ICAR, New Delhi, Virtual
BH Gawade, Prasanna Holajjer	National seminar on 'The facets of innovation and development of plant nematology'	Oct. 29-30	Nematological Society of India, New Delhi, Virtual
V Celia Chalam, SR Pandravada	Global Conference on 'Green Development of Seed Industries'	Nov. 4-5	FAO, Rome, Italy, Virtual
V Celia Chalam	One day awareness workshop on 'Importance of Quarantine Measures in Import of Planting Material'	Nov. 12	Solan, HP

Archana P. Raina , K Tripathi, Dinesh Chand, Sunil Gomashe, Pratibha Brahmi, Vandana Tyagi, SK Yadav, Pragya, Mamta Singh, Rashmi Yadav, Anitha Kodaru, V Kamala, SR Pandravada, N Sivaraj, B Parameswari, Prasanna Holajjer, P Pranusha, Bhaskar Bajaru, Sheikh M. Sultan, Vikender Kaur, Ruchi Bansal, BH Gawade, K C Bhatt, RS Rathi, RK Pamarthi, PK Malav, S. Nivedhitha, V Celia Chalam, Kavita Gupta, Jameel Akhtar, Pardeep Kumar, Raj Kiran, Bharat Raj Meena	2nd International Agrobiodiversity Conference (IAC)	Nov. 15-18	Alliance of BI & CIAT, CGIAR and MoFA & IC, Italy, Virtual
V Celia Chalam	APSA virtual technical session 2021, Asia and Pacific Seed Association	Nov. 22-24	Singapore, Virtual
Ishwar Singh, Mool Chand Singh	5th International Agronomy Congress	Nov. 23-27	Indian Society of Agronomy at PJTSAU, Hyderabad
Anitha Kodaru L Saravanan, B Parameswari, Prasanna Holajjer, Bhaskar Bajaru, V Celia Chalam, Kavita Gupta	Webinar on Space Entomology: Its Significance in Astronaut's World	Nov. 29	PPAI, Hyderabad, Virtual
MC Singh	Workshop for Liaison Officer SC-ST)	Nov. 29-30	ISTM, New Delhi
V Celia Chalam	International Conference on Global Perspectives in Crop Protection for Food Security (GPCP 2021).	Dec. 8-10	Coimbatore, Tamil Nadu
Bharat Raj Meena SK Yadav	International Conference on 'Vegetable Research and Innovations for Nutrition, Entrepreneurship and Environment (ICVEG-21)'	Dec. 14-16	ICAR-IIVR, Varanasi Virtual
V Celia Chalam Jameel Akhtar	IPS Delhi Zone Virtual Symposium on Plant Diseases: Impact on Food Security	Dec. 17-18	ICAR-IARI, New Delhi, Virtual

KM Rai	Webinar on Agro-biodiversity conservation and use for climate resilience and livelihood improvement on small holding farmer.	Dec. 23	VPKAS Almora, Virtual
Jameel Akhtar	National Workshop on 'Modern Interventions in Environmental Management'.	Dec. 30	ICAR-IIAB, Ranchi, Virtual

GENERAL INFORMATION

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Summary: In total 125 scientific, 72 technical, 42 administrative/finance and 51 supporting staff personnel were in position at ICAR-NBPGR including Regional Stations, as on 31st December. During the year 16 promotions, 06 transfers and 18 retirements were effected across all categories. The scientific staffs were bestowed with 12 awards. Dissemination of research outputs were in the form of peer reviewed research articles (154), books (09) and book chapters/manual chapters (19). As a part of outreach activities, the institute organized 03 field days and 14 PGR awareness cum biodiversity fair programs.

20.1 Institute management committee (IMC)

The Director, ICAR-NBPGR, Pusa Campus, New Delhi-110012	Chairman
The Director (Agri.), Delhi Government 5/9 under Hill Road, Delhi-110054	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)-160055, Punjab	Member
Head, Plant Breeding, Punjab Agricultural University, Ferozepur Rd, Ludhiana, Punjab 141027	Member
Shri Mukesh Mann, Village Alipore, Narela, Delhi, Ph-9810012222	Member
Shri Sanjay Maruti Patil, BAIF Office, Amrai Campus, Jauhar, District-Palghar, Maharashtra, Ph-9623931855	Member
Dr. RC Bhattacharya, Principal Scientist, ICAR- NIPB, LBS Centre, Pusa Campus, New Delhi-110012	Member
Dr. BS Dwivedi, Head, Division of Soil Sciences and Agril. Chemistry, ICAR-IARI, New Delhi-110012	Member
Dr. Ratan Tiwari, Principal Scientist, ICAR-IIWBR, Gahoon Vihar, Karnal, Haryana 132001	Member
Dr. PK Singh, Principal Scientist, ICAR-NBAGR, Makrampur, GT Road Bye Pass, Karnal, Karnal, Haryana 132001	Member
ADG (Seeds), ICAR, Krishi Bhawan, New Delhi-110001	Member
Comptroller, ICAR-IARI, Pusa Campus, New Delhi-110012	Member
Chief Admn. Officer (SG), ICAR-NBPGR, New Delhi-110012	Member Secretary

20.2 Research advisory committee (RAC)

23rd meeting of RAC of ICAR-NBPGR, New Delhi was held through video conferencing on 29- 30th September, 2021 under the chairmanship of Dr PL Gautam. Other members of the RAC; Dr. M.R. Dinesh, Dr. Paramjit Singh, Dr. Ramesh Venkata Sonti, Dr KS Varaprasad, Dr SK Barik, Dr JS Chauhan, Dr DK Yadava, 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.

Name and Address	
Dr. PL Gautam, Ex. Chairman, PPV&FRA, New Delhi	Chairman
Dr. MR 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 Faculty Indian Institute of Science, Education and Research (IISER)	**Member**
Dr. KS Varaprasad, Former Director, ICAR-IIOR, Hyderabad	**Member**
Dr. SK Barik, Director, CSIR-National Botanical Research Institute	**Member**
Dr. JS Chauhan, Former- Assistant Director General (Seed) ICAR, New Delhi	**Member**
Dr. JR 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 DK Yadava, Assistant Director General (Seed) ICAR, Krishi Bhawan, New Delhi	**Member**
Sh. Mukesh Maan, Village-Alipore, Narela, New Delhi	**Member**
Sh. Sanjay Maruti Patil, BAIF Officer, Amrai Campus, Jauhar, District- Palghar, Maharashtra	**Member**
Dr. Ashok Kumar, Head, Division of Germplasm Evaluation ICAR-NBPGR, New Delhi	**Member Secretary**

20.3 Institute research council (IRC)

The 32nd Institute Research Council (IRC) meeting was held under the Chairmanship of Dr Kuldeep Singh, Director, ICAR- NBPGR with Dr. Sushil Pandey as Member secretary from July 14- 17, 2021. 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 differentcategories: Technical Staff: Sh Satya Prakash (Secretary, Staff Side) and Sh Braham Prakash (TO); Administrative staff: Mr Yogesh Kumar (Assistant) and Vijaylakshmi Sharma (AAO); 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 SrAO.

20.5 Prioritization monitoring and evaluation (PME) cell

PME cell coordinated all scientific activities such as project proposals (13), manuscripts (71)/ abstracts (164); training (04)/ fellowship proposals (01), etc. as per the ICAR guidelines. It also coordinated professional attachment training for ARS scientists 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 six-monthly (target and achievements), half-yearly (progress report of scientists), other agenda items and ATRs for Director's conferenceand 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 asand when required for the council/any other agencies.

PME Cell

Dr Kavita Gupta, Nodal officer

Dr S Rajkumar, Co-nodal officer

Dr MK Rana, Member

Dr Sandeep Kumar, Member

Dr Jyoti Kumari, Member

Dr Padmavati Gore Ganpat,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 (T-3)

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) andpayroll (information related to transfer and joiningof employees) were supported through FMS-MIS.

HRD Activities

Annual Training Plan (ATP) of all the staffmembers of the Bureau for the year 2021-22 was prepared based on the training needs assessmentand submitted to the Council. During the reporting period, all scientists and nine technical staff have attended different training programmes and the same is being updated regularly in the ICAR-ERP System as per Council's guidelines. The informationon HRD activities were compiled in the form of six-monthly report, annual report, impact assessmentproforma etc.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 acentralized data repository system of ICAR consisting of technology, data generated through experiments/ surveys/observational studies, geo-spatial data, publications, learning resources, etc.Safe transfer of raw experimental data in electronicform was ensured on transfer and superannuationof scientists working at ICAR-NBPGR.

20.6 Personnel

The list of staff at NBPGR is provided herewith. It is not a documentary proof of seniority.

(i) Scientific Staff in position as on 31st December 2021

S. No.	Name	Designation	Discipline
1	Dr Kuldeep Singh	Director	Genetics & Plant Breeding
PLANT EXPLORATION & GERMPLASM COLLECTION DIVISION			
2	Dr Sudhir Pal Ahlawat	Head	Plant Breeding
3	Dr Anjula Pandey	Principal Scientist	Economic Botany
4	Dr KC Bhatt	Principal Scientist	Economic Botany
5	Dr Dinesh Prasad Semwal	Principal Scientist	Economic Botany
6	Dr Ranbir Singh Rathi	Principal Scientist	Economic Botany
7	Sh Soyimchiten	Scientist	Horticulture (Fruit science)
8	Ms Nivedhitha	Scientist	Economic Botany & PGR
9	Sh Pavan Kumar Malav	Scientist	Economic Botany & PGR
10	Sh Ravi Kishor Pamarthi	Scientist	Economic Botany & PGR
11	Dr Puran Chand	Scientist	Agroforestry
AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT			
12	Dr Sunil Archak	National Fellow & Incharge, Principal Scientist	Biotechnology
13	Madhu Bala Priyadrashi	Senior Scientist (SS)	Computer Application

S. No.	Name	Designation	Discipline
UU & UEP			
14	Dr SK Kaushik	Principal Scientist	Genetics & Plant Breeding
15	Dr Vinay Mahajan	Principal Scientist	Genetics & Plant Breeding
16	Dr Hanuman Lal Raigar	Principal Scientist	Agril. Statistics
GERMPLASM EXCHANGE AND POLICY UNIT			
17	Dr Pratibha Brahmi	Principal Scientist & Incharge	Economic Botany
18	Dr Vandana Tyagi	Principal Scientist	Economic Botany
19	Dr SK Yadav	Principal Scientist	Horticulture
20	Dr Pragya	Principal Scientist	Horticulture
GERMPLASM EVALUATION DIVISION			
21	Dr Ashok Kumar	Principal Scientist & Head (Act.)	Plant Breeding
22	Dr. KK Gangopadhyay	Principal Scientist	Horticulture
23	Dr Archana P. Raina	Principal Scientist	Biochemistry (Plant Science)
24	Dr Rakesh Bhardwaj	Principal Scientist	Biochemistry
25	Dr Sandeep Kumar	Principal Scientist	Biochemistry
26	Dr Jyoti Kumari	Principal Scientist	Plant Breeding
27	Dr KP Mohapatra	Principal Scientist	Agroforestry
28	Dr Rashmi Yadav	Principal Scientist	Agronomy
29	Dr Ishwar Singh	Principal Scientist	Agronomy
30	Dr Vinod Kumar Sharma	Principal Scientist	Plant Breeding
31	Dr Raj Kumar Gautam	Principal Scientist	Plant Breeding
32	Dr KS Hooda	Principal Scientist	Plant Pathology
33	Dr Rakesh Srivastava	Sr Scientist	Horticulture
34	Dr Vikender Kaur	Scientist	Economic Botany
35	Dr Gayacharan	Scientist	Agril. Biotechnology
36	Dr Ruchi Bansal	Scientist	Plant Physiology
37	Dr Kuldeep Tripathi	Scientist	Economic Botany & PGR
38	Dr Vijay Singh Meena	Scientist	Horticulture (Fruit science)
39	Dr Mamta Singh	Scientist	Genetics &Plant Breeding
40	Dr Nand Lal Meena	Scientist	Biochemistry
41	Dr Sapna	Scientist	Biochemistry

GERMPLASM CONSERVATION DIVISION

S. No.	Name	Designation	Discipline
42	Dr Veena Gupta	Principal Scientist & Head (Act.)	Economic Botany
43	Dr Neeta Singh	Principal Scientist	Plant Physiology
44	Dr J Radhamani	Principal Scientist	Plant Physiology
45	Dr Anjali Kak Koul	Principal Scientist	Economic Botany
46	Dr Chitra Devi Pandey	Principal Scientist	Seed Science &Technology
47	Dr Sushil Pandey	Principal Scientist	Seed Science &Technology

S. No.	Name	Designation	Discipline
48	Dr Sherry Rachel Jacob	Senior Scientist	Seed Science & Technology
49	Dr Vimala Devi	Senior Scientist	Genetics & Plant Breeding
50	Sh J Aravind	Scientist	Plant Genetics
51	Dr Padmavati G Gore	Scientist	Economic Botany & PGR
52	Dr Harish GD	Scientist	Genetics & Plant Breeding
53	Dr Badal Singh	Scientist	Economic Botany & PGR

PLANT QUARANTINE DIVISION

54	Dr V Celia Chalam	Principal Scientist	Plant Pathology
55	Dr кavita Gupta	Principal Scientist	Agril. Entomology
56	Dr Moolchand Singh	Principal Scientist	Agronomy
57	Dr Zakaullah Khan	Principal Scientist	Nematology
58	Dr Jameel Akhtar	Principal Scientist	Plant Pathology
59	Dr Surendra Pal Singh	Principal Scientist	Agril. Entomology
60	Dr Boopathi T	Senior Scientist	Agriculture Entomology
61	Dr Bharat Hanamant Gawade	Scientist	Plant Nematology
62	Dr Pradeep Kumar	Scientist	Agril. Biotechnology
63	Mrs Raj Kiran	Scientist	Plant Pathology
64	Ms Pooja Kumari	Scientist	Plant Pathology
65	Sh Bharat Raj Meena	Scientist	Plant Pathology

TISSUE CULTURE AND CRYOPRESERVATION UNIT

66	Dr Anuradha Agrawal	Principal Scientist & Head (Act.)	Economic Botany
67	Dr Rekha Chaudhury	Principal Scientist	Economic Botany
68	Dr Sangita Bansal	Principal Scientist	Agriculture Biotechnology
69	Dr Ruchira Pandey	Principal Scientist	Economic Botany
70	Dr Neelam Sharma	Principal Scientist	Economic Botany
71	Dr Sandhya Gupta	Principal Scientist	Economic Botany
72	Dr Vartika Srivastava	Scientist	Fruit Science
73	Dr Gowthami R	Scientist	Genetics &Plant Breeding
74	Dr Era Vaidya Malhotra	Scientist	Agriculture Biotechnology
75	Dr Subhash chander	Scientist	Economic Botany & PGR

DIVISION OF GENOMIC RESOURCES

S. No.	Name	Designation	Discipline
76	Dr Gurinderjit Randhawa	Principal Scientist & Head (Act.)	Plant Physiology
77	Dr Soma Sunder Marla	Principal Scientist	Biotechnology
78	Dr MC Yadav	Principal Scientist	Genetics/Cytogenetics
79	Dr Mukesh Kumar Rana	Principal Scientist	Plant Breeding
80	Dr Rakesh Singh	Principal Scientist	Biotechnology
81	Dr Ambika Baldev Gaikwad	Principal Scientist	Biotechnology

S. No.	Name	Designation	Discipline
82	Dr Lalit Arya	Principal Scientist	Plant Biochemistry
83	Dr Manjusha Verma	Principal Scientist	Plant Biochemistry
84	Dr Sundeep Kumar	Principal Scientist	Biotechnology
85	Dr Rajesh Kumar	Principal Scientist	Plant Biotechnology
86	Dr Amit Kumar Singh	Senior Scientist	Biotechnology
87	Dr R Parimalan	Senior Scientist	Biotechnology
88	Dr S Rajkumar	Senior Scientist	Genetics/Cytogenetics
89	Dr Yashin Jeshima K	Scientist	Genetics
90	Ms./Sheel Yadav	Scientist	Biotechnology- Plant Science
91	Dr Monika Singh	Scientist	Agril. Biotechnology
92	Dr Wankhede Dhammaprakash Pandhari	Scientist	Plant Genetics

NBPGR, REGIONAL STATION, HYDERABAD

93	Dr Anitha Kodaru	Principal Scientist & Incharge	Plant Pathology
94	Dr SR Pandrawada	Principal Scientist	Economic Botany
95	Dr Kamla Venkateswaran	Principal Scientist	Economic Botany
96	Dr Natarajan Sivaraj	Principal Scientist	Economic Botany
97	Dr Parameswari Balasubramanium	Senior Scientist	Plant Pathology
98	Dr P Pranusha	Scientist	Plant Genetics
99	Dr Prasanna Holajjer	Scientist	Nematology
100	Dr Bhaskar Bajaru	Scientist	Plant Pathology

NBPGR, REGIONAL STATION, AKOLA

101	Dr Dinesh Chand	Principal Scientist	Economic Botany & PGR
102	Dr Sunil Sriram Gomashe	Senior Scientist	Genetics &Plant Breeding

NBPGR, REGIONAL STATION, BHOWALI

103	Dr Mamta Arya	Scientist & OIC	Plant Genetics
104	Dr Krishna Madhav Rai	Scientist	Fruit Science

NBPGR, REGIONAL STATION, CUTTACK

105	Dr Diptiranjan Pani	Principal Scientist	Economic Botany
106	Dr RC Mishra	Principal Scientist	Economic Botany

NBPGR, REGIONAL STATION, SHIMLA

107	Dr Mohar Singh	Principal Scientist	Plant Breeding
108	Dr Rahul Chandora	Scientist	Economic Botany & PGR
109	Dr Narendra Negi	Scientist	Fruit Sciences

NBPGR, REGIONAL STATION, THRISSUR

110	Dr Joseph John K	Principal Scientist	Economic Botany

S. No.	Name	Designation	Discipline
111	Dr M Latha	Principal Scientist	Plant Breeding
112	Dr K Pradheep	Principal Scientist	Economic Botany
113	Dr Thrimalaisamy PP	Senior Scientist	Plant Pathology
114	Suma A	Scientist	Economic Botany

NBPGR, REGIONAL STATION, SRINAGAR

115	Dr Sheikh Mohd Sultan	Principal Scientist	Economic Botany
116	Dr Susheel Kumar Raina	Senior Scientist	Genetics &Plant Breeding

NBPGR, REGIONAL STATION, JODHPUR

117	Dr Kartar Singh	Scientist	Plant Pathology
118	Dr Neelam Shekhawat	Scientist	Genetics &Plant Breeding

NBPGR, REGIONAL STATION, RANCHI

119	Dr Shashi Bhushan Choudhury	Senior Scientist	Genetics &Plant Breeding
120	Dr Shephalika Amrapali	Scientist	Economic Botany & PGR
121	Dr Reshmi Raj KR	Scientist	Genetics &Plant Breeding

NBPGR, REGIONAL STATION, SHILLONG

122	Dr Julius Uchoi	Scientist	Horticulture-Fruit Science
123	Dr Subarana Hajong	Scientist	Economic Botany & PGR

On deputation

124	Dr RK Tyagi	Principal Scientist	Economic Botany
125	Dr JC Rana	Principal Scientist	Genetics &Plant Breeding

(ii) Technical staff in position as on 31st December 2021

Division of Plant Exploration & Germplasm Collection

S.No.	Name	Designation
1	Dr NS Panwar	Chief Technical Officer
2	Smt Rita Gupta	Senior Technical Officer
3	Sh Omprakash Dhariwal	Technical Officer
4	Sh SK Sharma	Technical Officer

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

S. No.	Name	Designation	Discipline
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
19	Sh Narendra Pal		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**

Division of Germplasm Coneservation

27	Dr AD Sharma		Chief Technical Officer
28	Sh Rajvir Singh		Assistant Chief Technical Officer
29	Smt Smita Lenka Jain		Assistant Chief Technical Officer
30	Sh Satya Prakash Sharma		Technical Officer
31	Smt Nirmala Dabral		Technical Officer
32	Anjali		Senior Technical Assistant
33	Sh Lal Singh		Technical Assistant

Tissue Culture and Cryopreservation Unit

34	Sh Devender Kumar Nerwal		Assistant Chief Technical Officer
35	Sh Anangpal Singh		Assistant Chief Technical Officer
36	Sh Dharam Pal Singh Meena		Senior Technical Officer
37	Sh Ramesh Chandra		Technical Officer
38	Sh Suresh Chandra Mali		Technical Assistant

Agricultural Knowledge Management Unit

39	Sh Rajiv Gambhir		Chief Technical Officer
40	Sh VK Mandal		Technical Assistant
41	Shivangi Mathur		Technical Assistant

S. No.	Name	Designation	Discipline
42	Smt Sangita Tanwar		Assistant Chief Technical Officer
43	Sh Om Prakash		Technical Officer

Director Technical Cell

44	Sh Abhay Sharma		Technical Officer
45	Sh AK Sharma		Senior Technical Assistant

Vehicle Cell

46	Sh Brahm 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 Ravinder Kumar		Technical Assistant (Driver)
52	Sh Khuswinder Kumar		Senior Technician (Driver)

Regional Station, Akola

53	Sh Rakesh Lather		Technical Assistant

Regional Station, Bhowali

54	Sh PS Mehta		Assistant Chief Technical Officer
55	Sh Mohan Ram		Senior Technical Assistant (Driver)
56	Sh Gopal Singh		Technical Assistant (Driver)
57	Sh Anuj Kumar Sharma		Technician

Regional Station, Hyderabad

58	Sh Babu Abraham		Assistant Chief Technical Officer
59	Sh R Gunashekhran		Technical Officer
60	Sh MAA Khan		Senior Technical Assistant (Driver)
61	Sh MV Reddy		Technical Assistant (Driver)

Regional Station, Jodhpur

62	Sh Bhatta Ram		Technical Officer
63	Sh Dharam Raj Meena		Technical Assistant
64	Mrs Chanchal Gaina		Technical Assistant

Base Centre, Ranchi

65	Sh AK Gupta		Senior Technical Officer
66	Sh Ashwini Kumar		Technical Assistant
67	Sh Narendra Ram		Technical Officer (Driver)

Regional Station, Shimla

68	Sh Dayal Singh		Senior Technical Assistant
69	Sh Ram Chander		Senior Technical Assistant

Regional Station, Thrissur

S. No.	Name	Designation	Discipline
70	Sh S Mani		Assistant Chief Technical Officer
71	Sh R Ashokan Nair		Assistant Chief Technical Officer
72	Smt A Indra Devi		Assistant Chief Technical Officer

(iii) Administrative Staff in Position as on 31st December 2021

S.No.	Name	Designation

Establishment Section

1	Sh Abhishek Srivastava	Senior Administrative Officer
2	Sh UC Sharma	Administrative officer
3	Smt Poonam Batra	Personal Assistant
4	Smt Sangeeta Gambhir	Assistant Administrative Officer
5	Smt Savitri Devi	Assistant
6	Sh Yogesh Kumar Gupta	Assistant
7	Sh KC Kundu	Assistant
8	Sh Arvind Kumar	Assistant
9	Sh Sandeep Gaur	Assistant (on Lien)
10	Ms Sanjoo Verma	Assistant
11	Sh Hemant Ankur	Assistant
12	Sh Dev Kumar	UDC
13	Sh Umesh Kumar	LDC

Accounts Section

14	Smt Yashoda Rani	Assistant Administrative Officer
15	Sh Mahavir Singh Yadav	Assistant
16	Smt Madhu Chawla	Assistant

Stores

17	Smt Poonam Singh	Administrative Officer
18	Sh Dinesh Sharma	Assistant

Purchase

19	Sh Avdhesh Kumar	Assistant Administrative Officer
20	Sh Sanjay Dangwal	Assistant

Audit Section

21	Sh KK Sharma	Senior Finance & Account Officer
22	Sh Mahesh Kumar	Finance & Account Officer
23	Sh Surender Kumar	Assistant Administrative Officer
24	Smt Bharti Sharma	Assistant
25	Sh Prabal Das Gupta	Assistant

Pension & Records

S. No.	Name	Designation	Discipline
26	Smt Amrita Negi		Assistant Administrative Officer

Director's Cell

27	Smt Kanchan Khurana		Personal Secretary

Prof. PGR & GCD

28	Sh Ganga Nand		Personal Secretary

Division of Plant Exploration & Germplasm Collection

29	Smt Urmila Singh		Personal Assistant

Division of Germplasm Evaluation

30	Smt Neelam Khatri		Personal Assistant

Hindi Unit

31	Sh Ashutosh Kumar Tiwari		Assistant Director (Official languages)

Security

32	Sh UC Sati		Security Officer

Regional Station, Akola

33	Sh Purushottam Dhoke		Assistant
34	Smt Smita D Karale		UDC

Regional Station, Bhowali

35	Sh NS Patwal		Assistant Administrative Officer

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		UDC

Regional Station, Jodhpur

40	Smt Leela Sharma		Assistant

Regional Station, Shimla

41	Smt Pratibha Bhatt		Assistant Administrative Officer

Regional Station, Shillong

42	Smt Lakshmilian Kharnary		Assistant

(iv) Skilled Supporting Staff in Position as on 31st December 2021

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 Kush Kumar
9	Sh Brahm Dev Paswan
10	Sh Ram Kalit Rai
11	Sh Yatish Chandra
12	Smt Rukmani
13	Sh Suresh Ram
14	Sh Om Prakash
Division of Genomic Resources	
15	Smt Agya Devi
16	Sh Ramesh Chand
Tissue Culture and Cryopreservation Unit	
17	Sh Chandeshwar Rai
18	Sh Nand Kishor
19	Smt Geeta Devi
Agricultural Knowledge Management Unit	
20	Sh Lalu Rai
AICRN-PC	
21	Sh Mahadev Maurya
Library	
22	Sh Umesh Kumar
Dispatch Section	
23	Sh Anant Swaroop
Accounts Section	
24	Sh Sanjeev Paswan
Audit Section	
25	Sh Sunil Kumar
26	Sh Yogesh Kumar
Establishment	
27	Sh Roshan Lal
Experimental Farm, Issapur	
28	Sh Dhir Singh
29	Sh Mahabir Singh
Regional Station, Akola	
30	Sh RC More
31	Sh RP Barsee
32	Sh AD Godlinga
33	Sh MB Nikose
Regional Station, Bhowali	
34	Sh Anand Kumar
35	Sh GC Arya
36	Smt Tulsi Devi
Base Centre, Cuttack	
37	Sh Sarangdhar Barik
Regional Station, Hyderabad	
38	Mohd. Mazhar Pasha
39	Sh M Shankar
40	Sh E Satyanarayan
41	Sh MB Keshhwa Raju
42	Sh M Srinivas
Regional Station, Jodhpur	
43	Sh DS Rajpurohit
Base Centre, Ranchi	
44	Sh Vijay Kumar
Regional Station, Shimla	
45	Sh Paras Ram
46	Sh Rohit

47	Sh Sukhdev
48	Sh Dalip Singh
49	Sh Inder Singh

Regional Station, Shillong

50	Sh AK Deka

Regional Station, Thrissur

51	Sh MK Prakaseen

20.7 Staff transferred /Superannuated/ New Appointments/Promotions

20.7.1 Appointments/Joining

Dr L. Saravanan, Senior Scientist from Regional Station Hyderabad joined on Jan. 20, 2021

Dr SK Malik, Principal Scientist, joined on March 01, 2021

Dr Harish GD Scientist from Regional Station Shillong joined on Sept. 01, 2021

Dr Badal Singh, Scientist from Regional Station Shimla joined on Oct. 1,2021

Dr Pankaj Kumar Kannaujia, Scientist, joined NBPGR on Nov. 22,2021

Sh Pradyumna Kumar Jain as Chief Admn. Officer (Sr. Grade) on Aug. 28, 2021

Sh Prashant Sharma as Comptroller on Oct. 07, 2021

Sh Pawan Kumar Gupta, Sr FAO on Oct. 14, 2021

Sh Prasen jit, as AO on Nov. 16 ,2021

Sh Sushil Kumar as AO on Dec. 24, 2021

Sh Gordhan Gena joined as T-3 on Apr. 12, 2021

Sh Manish Tomar joined as T-3 on Jan. 01, 2021

Sh Ankur Tomar joined as T-3 on Feb. 01, 2021

20.7.2 Retirements

Dr Neelam Sharma, (Pr. Scientist) at NBPGR superannuated on Mar. 31, 2021

Dr Soma Sundar Marla, (Pr. Scientist) at NBPGR superannuated on Mar. 31, 2021

Dr. R.K. Tyagi, (Pr. Scientist) at NBPGR superannuated on July, 31, 2021

Dr J Radhamani, (Pr. Scientist) at NBPGR superannuated on Nov. 30, 2021

Dr V Kamala Venkateswaran (Pr. Scientist) at RS, Hyderabad superannuated on Nov. 30, 2021

Sh. Narander Pal (Technical Officer) at NBPGR superannuated on Apr. 30, 2021

Sh R. Gunashekaran (Technical Officer) at RS, Hyderabad superannuated on Apr. 30, 2021

Sh Babu Abraham (Assistant Chief Technical Officer) at RS, Hyderabad superannuated on May. 31, 2021

Mohamad Abas Ali (Technical Assistant) superannuated on July. 31, 2021

Sh. Ravinder Kumar (Technical Assistant Driver) at NBPGR superannuated (VRS) on Aug. 01, 2021

Sh Ashok Kumar Gupta (Senior Technical Officer) at Base Centre Ranchi superannuated on Aug. 31, 2021

Sh Shashi Kant Sharma (Technical Officer) at NBPGR superannuated on Aug. 31, 2021

Sh Pooran Singh Mehta (Assistant Chief Technical Officer) at RS, Bhowali superannuated on Dec. 31, 2021

Sh. Mohan Ram, Senior Technical Assistant (Driver) at RS, Bhowali superannuated on Dec. 31, 2021

Smt Poonam Batra (Personal Assistant) at NBPGR superannuated (VRS) on Feb. 05, 2021

Smt Bharti Sharma (Assistant) at NBPGR superannuated on March. 31, 2021

Smt Savitri Devi (Assistant) at NBPGR superannuated on Nov. 30, 2021

20.7.3 Promotions

Dr. Shashi Bhushan Choudhury, Sr Scientist Bhowali promoted to Level 12 (RPG 8000)

Smt Bharti Sharma, Assistant promoted to the post of AAO w.e.f. 30.03.2021

Smt. Savitri Devi Assistant promoted to the post of AAO w.e.f 01.04.2021

Smt Poonam Singh, AO promoted to the post of Sr.AO, ICAR-NBPGR

Sh Kush Kumar Bhargava, SSS promoted to the post of LDC w.e.f 2.08.2021

Sh Anant Swaroop, SSS promoted to the post of LDC w.e.f 12.08.2021

Sh Sunil Kumar, SSS promoted to the post of LDC w.e.f 16.08.2021

Smt Urmila, PA promoted to the post of PS

Smt Neelam Khatri, PA promoted to the post of PS

Sh MS Yadav, Assitant promoted to the post of AAO w.e.f 26.10.2021

Smt Sanjoo Verma Assitant promoted to the post of AAO w.e.f 6.12. 2021

Sh. P. Suleiman UDC promoted to the post of Assistant w.e.f 6.12.2021

Sh MB Keshav Raju, SSS promoted to T-1 w.e.f 31.12.2021

Sh Sukh Dev SSS promoted to T-1 w.e.f 31.12.2021

Sh Inder Singh SSS promoted to T-1 w.e.f 31.12.2021

Sh Grish Chand Arya SSS promoted to T-1 w.e.f 31.12.2021

20.7.4 Transfers

Dr SC Dubey, Pr Scientist & Head (Act.) transferred to ICAR Hqrs as ADG (PPB) w.e.f. 30.01.2021

Dr SP Singh, Pr Scientist transferred to ICAR-NCIPM w.e.f. 28.01.2021

Sh KK Sharma, Sr FAO to IASRI w.e.f. 25.09.2021

Sh Abhishek Srivastava, SrAO to IASRI w.e.f. 30.09.2021

Sh UC Sharma, AO to CIRG w.e.f. 10.11.2021

Sh Mahesh Kumar, FAO to CIRG 29.12.2021

20.7.5 Left ICAR

Sh Hemant Ankur, Assistant w.e.f. 20.11.2021

20.7.5 Death

Dr Vinay Mahajan, Pr Scientist Expired on 3.04.2021

Dr S Vimala Devi, Pr Scientist Expired on 01.06.2021

Sh Devender Narwal Expired on 26/04/2021

Sh Arvind Kumar, Assistant Expired on 17.12.2021

20.8 Awards / Honours/Prizes/invited lectures during 2021

- Dr Jyoti received Harbhajan Singh Memorial Award by Indian Society of Genetics and Plant Breeding, New Delhi.
- Dr Kuldeep Tripathi conferred with Dr R.S. Paroda Young Scientist Award for the year 2020 from ISPGR, New Delhi.
- Ms. Sapna received "Young Scientist Award" in the International Conference on "Research Initiatives for Agricultural Biotechnology and Allied Sciences (ICRIABAS-2020)" on 24-25 April'2021 organized by New Age Mobilization Society in collaboration with IIMT University, held at Meerut.
- Dr MC Singh was awarded Fellow, Indian Society of Genetics & Plant Breeding.
- Bharat H. Gawade received Best Oral Presentation Award for paper presented on 'Managing the threats of plant nematodes during international exchange of vegetative propagules of horticultural crops' in International e-Conference on "Postharvest Disease Managementand Value Addition of Horticultural Crops" 2021 during August 18-20, 2021at ICAR-IARI, New Delhi organized by Indian Phytopathological Society, New Delhi in virtual mode.
- Pardeep Kumar was awarded 'Best Oral Presentation Award' for presentation entitled 'Status of seed-borne fungi in indigenous solanaceous vegetable germplasm in India' by P Kumar, J Akhtar, R Kiran, BR Meena, Sadhana, V Gupta, S Pandey, SC Dubey and VC Chalam during International e-Conference on 'Postharvest disease management and value addition of horticultural crops' organized by the Department of Plant Pathology, ICAR-IARI, New Delhi, on August 18 -20, 2021
- Pooja Kumari received Oral Presentation Award on "Molecular characterization of monopartite bhendi yellow vein mosaic virus infecting wild okra (*Abelmoschus moschatus* ssp. *moschatus*) in India". In 3rd International Conference on Global Initiatives in Agricultural, Forestry and Applied Sciences for Food Security,

Environmental Safety and Sustainable Development (GIAFAS-2021)"organised by Agricultural & Environmental Technology Development Society (AETDS) at Shri Guru Ram Rai University, Dehradun, Uttarakhand, India, held on October 17-18, 2021 by virtual mode.

- Pooja Kumari received Young Scientist Award in Plant Pathology on the occasion of 5th International Web Conference on "Advances in Agriculture, Environmental and Biosciences for Sustainable Development (AAEBSD-2021)"organised by Agro Environmental Development Society (AEDS) Majhra Ghat, Rampur, Uttar Pradesh, India on August 5-7,2021.
- Raj Kiran was awarded with "Young Scientist Award in Plant Pathology-2021" during International Conference (Virtual) on "Advances in Agriculture, Environmental and Biosciences for Sustainable Development (AAEBSD-2021)" organisedby Agro Environmental Development Society (AEDS) Rampur, Uttar Pradesh from August 05-07, 2021.
- Dr B. Parameswari received best oral presentation award in Central Zone Virtual Symposium – 2020 on Advances in Phytopathology held from 06-07 January 2021 by Y.S.R Horticultural University, Venkataramannagudem, Andhra Pradesh.
- Dr. L Saravanan received Best Oral Presentation Award- Scientist Category in Golden Jubilee International Conference: Global perspectives in crop protection for food security held during 08-10 December at Tamil Nadu Agricultural University, Coimbatore.
- Dr B Parameswari, Senior Scientist awarded with best oral presentation first prize (as co-author: Grassy shoot disease caused by Ca. *Phytoplasma sacchari*, a major biotic stress and physiological intervene in sugarcane cultivation") in International Plant Physiology Virtual Symposium (2021) conducted by ICAR-SBI Coimbatore.

Publications

Research papers

Bansal S, K Sharma, V Gautam, AA Lone, EV Malhotra, S Kumar and R Singh (2021) A comprehensive review of *Bunium persicum*: a valuable medicinal spice. *Food Reviews International.* https://doi.org/10.1080/87559129.2021.1929305

Ghosh D, CR Chethan, S Chander, B Kumar, RP Dubey, HS Bisen, SK Parey and PK Singh (2021) Conservational tillage and weed management practices enhance farmers income and system productivity of rice–wheat cropping system in central India. *Agricultural Research* 1-9.

Gowthami R, N Sharma, KK Gangopadhyay, S Rajkumar, P Pathania and A Agrawal (2021) Cryopreservation of pollen of *Abelmoschus moschatus* medik. subsp. *moschatus* as an aid to overcome asynchronous flowering for wide hybridization with cultivated okra [*A. esculentus* (l.) Moench]. *CryoLetters* 42(4): 233 – 244.

Gowthami R, N Sharma, R Pandey and A Agrawal (2021) A model for integrated approach to germplasm conservation of Asian lotus (*Nelumbo nucifera Gaertn*.). *Genet Resour Crop Evol* 68: 1269–1282.

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Bansal S, MK Sharma and A Kumar (2021) High frequency *in vitro* somatic embryogenesis in black cumin (*Bunium persicum* boiss b. fedtsch). In: *Souvenir of International web conference entitled 4th Global meet on science and technology for staying healthy and feeding evergrowing population worldwide,* September 12-13, 2021. pp. 153.

Bansal S, N Sharma, V Srivastava, E V Malhotra, D K Nerwal and S C Mali (2021) *In Vitro* Conservation and Cryopreservation of Tuber Crops Germplasm at ICAR-NBPGR. In: *Abstract eBook of International symposium on Advances in Plant Biotechnology and Genome Editing (APBGE-2021),* ICAR-IIAB, Ranchi during April 8-10, 2021. pp. 168.

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Malhotra EV, R Jain, R Aminedi (2021) Genome-wide identification and functional characterization of herbivory induced microRNAs in *Cajanus cajan* and *Cajanus scarabaeoides*. In: *E abstract book of International symposium on Advances in Plant Biotechnology and Genome Editing (APBGE-2021),* ICAR-Indian Institute of Agricultural Biotechnology, Ranchi and Plant Tissue Culture Association-India (PTCA-I), April 8-10, 2021, pp. 108-109

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Srivastava V, A Agrawal, RV Kilasrao, M Singh, V Kaur and D Wankhede (2021) Interspecific hybridization between *Linum usitatissimum* (2n=30) x *Linum grandiflorum* (2n=16): An attempt to create variability by utilizing crop wild relative of flax. *In: the International conference on Future Challenges and Prospects of Plant Breeding,* 6-7 Oct., 2021, pp. 62.

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Oral Presentation/ Invited lectures

Agrawal A (2021) Plant Tissue Culture and Cryopreservation. In: SAGE Summer School Virtual Training Program "Entrepreneurship development using tissue culture technology through commercial production of quality plants in demand", SAGE School of Agriculture Sciences, SAGE University, Bhopal, Madhya Pradesh, 24 May - 18 June, 2021.

Agrawal A and Srivastava V (2021) Do or die attitude of recalcitrant seeds: An enigma. Invited Speaker, Online lecture series on "Seed Sustainability", Dept of Seed Science and Technology, KAU, Kerala, Dec 4, 2021.

Agrawal A (2021) Principal, methods and prospects of in vitro conservation and cryopreservation of horticultural crops. Invited Speaker, National Virtual Training Program on 'Conservation, Management and Utilization of Horticultural Genetic Resources for Livelihood and Nutritional Security', ICAR-IIHR, Bengaluru, Nov. 25, 2021.

Agrawal A (2021) Principles of In Vitro Conservation and Cryopreservation of PGR. In: Training Manual of Virtual Training Programme on "Plant Genetic Resources Management and Utilization", July 19 - August 1, 2021. ICAR-National Bureau of Plant Genetic Resources, New Delhi.

Agrawal A and R Gowthami (2021) In vitro conservation and cryopreservation of PGR. Oral presentation in Virtual Training on 'Management and Utilization of Plant Genetic Resources, ICAR-NBPGR, July 6, 2021.

Agrawal A (2021) Use of Biotechnology in Plant Conservation. Invited Speaker in One-day lecture Series on "Science and Technology for Sustainable Development with Women Empowerment", organized by Oxford College of Science, Bangalore

University and Indian Science Congress Association, Bangalore Chapter, Oct. 1, 2021

Agrawal A (2021) Indian Gene Bank and Germplasm Conservation. Invited Resource Person, in the UGC sponsored 3rd Refresher Course in Biotechnology, UGC – Human Resource Development Centre, University of Calicut, Calicut, Kerala, Sept 25, 2021.

Agrawal A, S Gupta, N Sharma, S Bansal, V Srivastava, EV Malhotra, S Chander, R Gowthami, K Singh (2021) Biotechnological applications for plant germplasm conservation at ICAR-National Bureau of Plant Genetic Resources, India's recent achievements In : Thammasiri, K., Kongsawadworakul, P. & Swangpol, S. C. (Eds). Book of Abstracts: The IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (Physiological, Biochemical, Embryological, Genetic and Legal Aspects) (Biotech 2021). Faculty of Science, Mahidol University, Bangkok, Thailand: Department of Plant Science, Faculty of Science, Mahidol University, July 12-13, 2021.

Bansal S, N Sharma, V Srivastava, E V Malhotra, D K Nerwal and S C Mali (2021) *In Vitro* Conservation and Cryopreservation of Tuber Crops Germplasm at ICAR-NBPGR In: International symposium on Advances in Plant Biotechnology and Genome Editing (APBGE-2021), ICAR-IIAB, Ranchi during April 8-10, 2021.

Chander S (2021) Studies on nutritional status of different *Chenopodium* accessions. In International Conference on Advances in Agriculture, Environmental and Biosciences for Sustainable Development organized by Agro Environmental Development Society during August 05-07, 2021.

Gupta S(2021) Cryopreservation and assessment of genetic stability of cryopreserved *Fragaria* spp. using SSR markers' in the IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation Physiological, Biochemical, Embryological, Genetic and Legal Aspects (Biotech 21) (online), organized by Faculty of Science, Mahidol University, Bangkok, Thailand, July 12, 2021.

Gupta S (2021) *In vitro* propagation and conservation of *Artocarpus lakoocha* Roxb.: An underutilized fruit of India' in the IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation Physiological, Biochemical, Embryological, Genetic and Legal Aspects (Biotech 21) (online), organized by Faculty of Science, Mahidol University, Bangkok, Thailand, July, 13, 2021.

Gupta S (2021) *Ex situ* conservation of pear (*Pyrus* spp.) genetic resources at ICAR-NBPGR, INDIA in '2nd International Agrobiodiversity Congress' held online from 15-18 Nov. 2021.

Gupta S (2021) Plant Biotechnology for sustainable Agriculture. In: Webinar organized by Society for Plant Research, August 17, 2021.

Gupta S (2021) Role of Plant tissue culture in germplasm conservation of fruit plants of arid zone. In: Training programme entitled 'Adavances in Plant Tissue Culture and its application in Agriculture' under NAHEP, Swami Keshvanand Rajashtan Agriculture University, Bikaner, Feb 27, 2021.

Malik SK (2021) Citrus Germplasm Collection, Characterization and Conservation: Practical Considerations. In: Sensitization workshop of DBT project "Collection, Conservation and Morpho-Phenological Characterization of Citrus Germplasm of North East Region".

Malik SK (2021) Prioritization, Inventorization and Germplasm Collection of Wild-Minor Fruits from PAs in India. In: Workshop on "Planning and Management of CWR and RET Species of PGR Importance in India", ICAR-NBPGR, New Delhi and BSI, Kolkata, 5th July 2021.

Malik SK (2021) Conserving diversity of underutilized fruits for health and nutrition through community participation: a dynamic approach. In: Indian Horticultural Congress-2021 Kanpur, Uttar Pradesh, 18-21 Nov., 2021.

Malik SK (2021) Management of Genetic Resources for Fruits. In: Horticulture Research Station, Kahikuchi, Assam Agricultural University, Guwahati under the banner "AAU Lecture Series" on 8 Oct., 2021.

Courses taught/students guided

Dr Anuradha Agrawal, Era Vaidya Malhotra and Gowthami R. took online classes in course of 2nd semester of the year 2020-21, PGR 505: Germplasm management using *in vitro* and cryopreservation techniques (2L +1P), as Faculty in Division of PGR, Indian Agricultural Research Institute (IARI)

Dr. Anuradha Agrawal guided one PhD student (Shivani Singh) as Co-Chairperson, from Amity Institute of Biotechnology, Amity Uniersity, NOIDA for the thesis entitled "Seed Conservation Biology of Wild Species of Indian *Musa* and Development of Cryopreservation Protocols" submitted July 2021.

Dr Anuradha Agrawal guided one PhD student (Chaw Su Su Htwe) as Chairperson, from PG School, IARI, for thesis entitled "Transcriptomes changes during cryopreservation stages of banana meristems".

Dr Era Vaidya Malhotra took online classes in course of PGR 503 - Principles and Methods of Germplasm Conservation as Faculty in Division of PGR, IARI.

Dr Gowthami R. guided one MSc (Genetics and Plant breeding) student (Yazhini P) as Co-Chairperson, from Agricultural College and Research Institute, Madurai, TNAU, Coimbatore for the thesis entitled "Studies on *in vitro* propagation of *Hemidesmus indicus* (L.) R. Br. ex Schult."

Dr Sandhya Gupta, Sangita Bansal and Vartika Srivastava took online classes in course of 1st semester of the year 2020-21: PGR602: *In Vitro* Conservation and Cryopreservation (2L+ 1P) as Faculty in Division of PGR, IARI

Dr Sandhya Gupta guided one MSc (PGR) student (Mr. Praveen G) as Chairperson, from PG School, IARI, for thesis entitled "Cryopreservation of *Fragaria vesca* L. and virus elimination through cryotherapy"..

Dr. Subhash Chander took offline and online classes in course of 1st Semester during 2021-22: PGR-611 (2+0): Plant Genetic Resources, Conservation and Utilization as a faculty of Plant Genetic Resources in IARI, New Delhi.

Dr. Vartika Srivastava took online classes in course of 2nd semester of the year 2020-21, FSC 509: Propagation Biotechnology in Fruit and Plantation Crops (2L +1P), as Faculty in Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute (IARI)

Dr. Vartika Srivastava took online classes in ourse of 1st semester of the year 2020-21: FSC-505: Propagation and Nursery Management for Fruit Crops (2L +1P), as Faculty in Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute (IARI)

Dr. Vartika Srivastava guided one M.Sc. student (Bhupendra Sagore) as member of the advisory committee, from Fruits and Horticultural Technology, IARI, New Delhi for his thesis work on "Shortening the breeding cycle in Papaya using various growth regulators and embryo culture"

Other Recognitions

- Dr. Anitha Kodaru, Principal Scientist and Officer-In-Charge was recognized as ISPGR fellow (2020) by Indian Society of Plant Genetic Resources, New Delhi.
- Dr N Sivaraj, Principal Scientist deputed as member by ASRB to conduct departmental promotion committee meeting at Indian Institute of Millets Research, Hyderabad on 24.09.2021.
- Dr N Sivaraj was elected as *South Zone Councillor* for the Indian Society of Plant Genetic Resources (ISPGR) through the election.
- Dr. L Saravanan was awarded with Fellow of Society of Tropical Agriculture from The Society of Tropical Agriculture, New Delhi.
- Dr L Saravanan, Senior Scientist selected as Chief Editor, Indian Journal of Plant Protection.
- Dr B. Parameswari, Senior Scientist nominated as Editorial Board Member of Indian Journal of Microbiology Research for the year 2021.
- Dr B. Parameswari, Senior Scientist nominated as distinguished member of World society of Virology

- Dr B Parameswari, Senior Scientist elected as General Secretary of Plant Protection Association of India, Hyderabad.
- Dr. B Parameswari conferred with Agricultural Scientist award 2020-21 from Vasantharaj David Foundation, Chennai.
- Dr Prasanna Holajjer, Scientist, selected as Councilor (Central Zone) of Executive Committee of Nematological Society of India, New Delhi.
- Dr Prasanna Holajjer, Scientist, appointed as Associate Editor, Indian Journal of Plant Protection.
- Dr Prasanna Holajjer, Scientist recognized as a fellow of Society for Biocontrol Advancement, Bengaluru, India.
- Dr Bhaskar Bajaru, Scientist, elected as Treasurer, Plant Protection Association of India, Hyderabad.

Invited Lectures

1. Dr Kuldeep Tripathi delivered lecture 'Principles of Germplasm Characterization and Evaluation' in a Virtual Training Program on "Management of Fruit Genetic Resources", during Feb. 1-2, 2021 for AICRP scientists in SAUs.
2. Dr Kuldeep Tripathi delivered lecture "Techniques of descriptor recording" in Virtual Training Programme on "Plant Genetic Resources Management and Utilization" during July 19 to August 1, 2021.
3. Dr K S Hooda delivered lecture on 'Indian Plant Quarantine System' at Department of Plant Pathology, PAU, Ludhiana for Tutorial Classes for SC students on 13.05.2021 (Virtual)
4. Dr K S Hooda delivered lecture on 'Plant Biosecurity - The Way Forward' at Department of Plant Pathology, PAU, Ludhiana for Tutorial Classes for SC students on 13.05.2021 (Virtual)
5. Dr Ishwar Singh, Principal Scientist delivered a lecture on 'Good Agricultural Practices for sugarcane and sugarcane-based cropping systems' in a two-week ICAR (HRM Division) sponsored training programme on "*Good Agricultural Practices (GAPs) for higher productivity, profitability and resource-use efficiency) for the technical staff of ICAR Institutes.*" held during August 2-16, 2021 in the Division of Agronomy, IARI, New Delhi in online mode.
6. Dr Ishwar Singh, Principal Scientist delivered a lecture on Cultivation of mustard and wheat to the farmers in a *Farmers-Scientists Meet* organized at Issapur Farm, NBPGR on September 28, 2021
7. Dr Ishwar Singh, Principal Scientist delivered lecture on utilization of dairy waste, kitchen waste, farm waste and crop residues for preparation of FYM, Compost, Vermicompost & Vermiwash and incito decomposition of crop residues to the farmers on the occasion of *Special National Swachhata Campaign on 'Waste to Wealth'* at Issapur Farm, NBPGR on October 12, 2021
8. Dr Ishwar Singh, Principal Scientist delivered a talk on utilization of kitchen, yard and Farm waste to the participating farmers during celebration of *Kisan Diwas* at Issapur Farm, NBPGR on December 23, 2021.

Best article awards:

1. Received the best article award for the e-publication- Jayshri N Papade, Sunil S Gomashe, KN Ganapathy and Dinesh Chand (2021) Niger: A Potential Crop with High Nutritional Value and Biotechnological Approaches for its Improvement. *Agriculture and Food: E-Newsletter*. **3(6)**: 639-642
2. Received the best article award for the e-publication- Krishnananda P Ingle, Sunil S Gomashe, Yukta A Sarap and Dinesh Chand (2021) Safflower (*Carthamus tinctorius* L.): Phenology, Ecology, Distribution and Molecular Approaches for crop improvement. *Agrigate eMagazine* **3**: 31-38.

20.8 Honours/Recognition

Dr Subhash Chander, Scientist, TCCU, ICAR-NBPGR, New Delhi, received "Young Scientist Award" from Agro Environmental Development

Society during the '5th International Conference on Advances in Agriculture, Environmental and Biosciences for Sustainable Development', August 5-7, 2021.

Best paper/poster/oral presentation

Drs Sangita Bansal, Mr Manoj K Sharma and Mr Amit Kumar received Best Poster Award for paper entitled "High frequency *in vitro* somatic embryogenesis in black cumin (*Bunium persicum* boiss b. fedtsch)" during International web conference entitled '4th Global meet on science and technology for staying healthy and feeding evergrowing population worldwide', September 12-13, 2021.

20.9 Publication list:

20.9.1 Research Articles

20.9.1 Research Articles

Arya L, RK Narayanan, A Kak, CD 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.

Aski MS, N Rai, VRP Reddy, Gayacharan, HK Dikshit, GP Mishra, D Singh and R Schafleitner (2021) Assessment of root phenotypes in mungbean mini-core collection (MMC) from the World Vegetable Center (AVRDC) Taiwan. *PloS one* **16(3):** e0247810.

Bansal R, S Priya, HK Dikshit, SR Jacob, M Rao, RS Bana, J Kumari, K Tripathi, A Kumar, S Kumar and KHM Siddique (2021) Growth and Antioxidant Responses in Iron-Biofortified Lentil under Cadmium Stress. *Toxics* **9(8):** 182.

Bansal R, S Priya, HK Dikshit, SR Jacob, M Rao, RS Bana, J Kumari, K Tripathi, A Kumar and S Kumar (2021) Growth and antioxidant responses in iron-biofortified lentil under cadmium stress. *Toxics* **9:** 182.

Bansal S, K Sharma, V Gautam, AA Lone, EV Malhotra, S Kumar and R Singh (2021) A Comprehensive Review of *Buniumpersicum*: A Valuable Medicinal Spice, *Food Rev. Int.* DOI: 10.1080/87559129.2021.1929305.

Bansal S, K Sharma, V Gautam, AA Lone, EV Malhotra, S Kumar and R Singh (2021) A comprehensive review of *Bunium persicum*: a valuable medicinal spice. *Food Reviews International.* https://doi.org/10.1080/87559129.2021.1929305

Bhardwaj V, SK Kaushik, BP Singh, S Sharma, ML Dalamu, S Sood, R Singh, V Patil, A Srivastava, V Kumar, A Bairwa, EP Venkatasalam, C Challam and SK Chakrabarti (2021) Kufri Karan - first multiple diseases resistant, high yielding potato variety for cultivation in hills and plateaux of India. *Potato J.* **47**: 97-106.

Bhaskar B, RSJ Devi, SV Kumar, CPD Rajan and MS Prasad (2021) Assessment of molecular variability among rice leaf and neck blast isolates of *Pyriculariaoryzae* using MGM and RAPD markers. *Indian J. Plant Prot.* **49(3):** 166-172.

Bhaskar B, RSJ Devi, SV Kumar, CPD Rajan and MS Prasad (2021) Evaluation of combination spray schedules of Tricyclazole and *Pseudomonas fluorescens* against blast disease of rice. *ORYZA-An International Journal of Rice* **58(3):** 419-426.

Bhaskar KA, A Al-Hashimi, M Meena, VS Meena, S Langyan, M Shrivastava, RZ Sayyed, HA El-Enshasy, BMA Al-munqedhi and R Singh (2021) Conservation agricultural practices for minimizing ammonia volatilization and maximizing wheat productivity. Environ. Sci. Pollut. Res. Int. **29(7):** 9792-9804.

Bhatt KC, PK Malav, PG Gore, K Tripathi, RS Rathi, UL Tiwari and SP Ahlawat (2021) A note on distribution and potential of Japanese wild adzuki bean [*Vigna angularis* var. *nipponensis* (Ohwi) Ohwi and H. Ohashi] in India. *Genet. Resour. Crop Evol.* **68:** 2157-2166.

Brahmi P, V.Choudhary and V Tyagi (2021) An overview of framework and case studies related to ABS in plant genetic resources. *Indian J Pl. Genet Reso*. **34(1):** 25-34.

Chandra PB, KS Hooda, TI Anuradha, S Kumar, V Sujatha and G Bhavani (2021) Screening of genotypes for multiple disease resistance in maize in Peddapuram, Andhra Pradesh, India. *Plant Arch.* **21:** 2210-2214.

Channapa M, S Sharma, D Kulshreshtha, K Singh, SC Bhardwaj, S Murugasamy, A Sindhu, VK Vikash. and R Aggarwal (2021) Transcriptome profiling anddifferential gene expression analysis provides insights into *Lr*24-based resistancein wheat against *Puccinia triticina*. *3 Biotech* **11:** 455.

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Fig 20.3: Cowpea field day organized at ARS, Badnapur, Maharashtra

Fig 20.5. Padmashri Rahibai Soma Popere visited ICAR-NBPGR Stall in Tribal Fair at Dharni, Maharashtra

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Fig. 20.7 PGR awareness programme under TSP at Adilabad, Telangana

Fig.20.8. PGR awareness programme under SCSP at Chintaguda, Rangareddy, district Telangana

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Fig 20.12: PGR/Farmer Rights Awareness Camp organized at remote and hilly border village of Zamboor Pattan Uri in District Baramulla

Fig 20.13: Plant Genetic Resources Awareness Camp was organized by ICAR-NBPGR RS Srinagar at village Garkon District Kargil in remote Aryan Valley of Ladakh

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20.9.2 Book

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20.9.4 : Chapters in training manuals, proceedings, review articles, technical articles, technical bulletins etc.

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20.10: Organization of germplasm field days / diversity days

Germplasm Diversity Day: ICAR-NBPGR organized Germplasm Diversity Day at ICAR-NBPGR Farm, Issapur, New Delhi on February 20, 2021. Around 10,000 germplasm accessions of different field crops were shown to the crop experts of ICAR-IARI, ICAR-IIPR, ICAR-IIWBR, ICAR-CSSRI, BISA, PAU and ICAR-NBPGR. Dr Ashok Kumar, Head, Division of Germplasm Evaluation, ICAR-NBPGR, welcomed Dr TR Sharma, DDG (Crop Sciences), ICAR and participants. He outlined the germplasm activities being carried out at Issapur Farm and informed about the large scale characterization of germplasm through different projects. Dr TR Sharma, DDG (CS), ICAR, Chief Guest of the function, stressed upon utilization of crop wild relatives (CWRs) and landraces in Indian breeding programme and establishing collaborative linkages with crop based institutes for better utilization of the germplasm. He interacted with concerned scientists and participants and appreciated the efforts of ICAR-NBPGR for large scale germplasm characterization and establishing the Field Gene Bank of minor fruits and multi-purpose tree species of subtropical and semi-arid region.

Pulses & Oilseeds Experts Visit: ICAR-NBPGR organized "Pulses & Oilseeds Experts Visit" on March 4, 2021 at ICAR-NBPGR for the benefit of scientists working on these crops. A total of 4,578 germplasm accessions comprised of linseed (2,668), fababean nurseies (95) chickpea (325) and grasspea (183) were grown for characterization and preliminary evaluation. Likewise, Indian Lentil Core-set (170 accessions) were grown for agronomic evaluation. In addition, the trait specific germplasm of rapeseed mustard and fababean nurseries were grown for validation and selection, respectively. Dr TR Sharma, DDG (CS) was chief guest of function. Dr Sanjeev Gupta, ADG (Oilseeds & Pulses) and Dr A Sarker, Coordinator, ICARDA, South Asia & China Programme graced the occasion.

RS Akola organized field day on Cowpea: Cowpea field day was organized at ARS, Badnapur, Maharashtra on October 14, 2021. Hon. Dr. Trilochan Mohapatra, Director General, ICAR, New, Delhi along with with other Dignitaries were visted the field day.

20.11 PGR awareness, MGMG and TSP:

Activities on On-farm Conservation and Coastal Bio-shield plantation

- An "On-farm conservation programme on Mango" was conducted on 9th Aug, 2021 at Mango City Kollengode, Palakkad Dist in which 22 farmers attended and 107 grafts in 20 traditional poly embryonic mango cultivars collected from Kannapuram-Mango Heritage village, Kannur were supplied to 20 farmers for conservation and further use (Fig. 18.14). In addition, 69 of mango grafts were supplied to 'Devaranyakam' an afforestation initiative by Thanakulam, Kalarkode, Alappuzha.
- Technical guidance and seedlings of Andaman bullet wood (*Manilkara littoralis*) were supplied to Social Forestry Department, Thrissur Division, Kerala Forest Department as part of the establishment of the coastal bio-shield plantation. Also undertaken a floristic survey of sixteen sites on the West coast in Thrissur District for identifying suitable species for raising a bio-shield plantation promoted by the Social Forestry Department.
- 50 polybag seedlings of Andaman bullet wood were supplied to M/s Dheevara Trust, Purakkad Alappuzha, Kerala for coastal bio-shield planting.

RS Akola organized tribal farmers fair organized

A Workshop cum Awareness programme under Tribal Sub-Plan on "Conservation of Plant Genetic Resources for Health and Nutritional Security" was organized at tribal Village- Malkapur, Tal: Chikhaldara, Dist: Amravati, Maharashtra State on 27th March 2021. It was organized with the local support from Gram Panchayat, Somwar Kheda and Jeevan Vikas Sanstha, Paratwada. A total of 165 participants comprising tribal farmers and organizers were part of the programme (Fig. 20.4).

RS Akola participated in Tribal Fair organized by KVK, Ghatkhed, Amravati and VNMAU, Parbhani at Vil: Lawada, Tal: Dharni Dist: Amravati on 11th December 2021. It was graced by the Shrimati Yashomatitai Thakur, Hon'ble Minister, Women and Child Development, Shri. Omprakash Kadu, Minister of State, Education, Government of Maharashtra. Dr. Ashok Dhawan, Honble Vice Chancellor, VNMAU, Parbhani, Dr. V. M. Bhale, Dr. PDKV, Akola. Padmshri Rahi Bai Popere and Padmshri Dr. Ravindra Kolhe. The programme was attended by about 600 tribal women and men farmers from the Dharni tribal block. All the dignitaries appreciated the efforts being made by ICAR-NBPGR in conservation of the Agro-biodiversity of the region **(Fig. 20.5).**

RS Akola organized workshop cum awareness programme organized under Scheduled Caste Sub-Plan under Schedule Caste Sub-Plan a workshop cum awareness programme on "Conservation of Plant Genetic Resources for Health and Nutritional Security" at village Goregaon (Kh), Tal: Akola, Dist: Akola, Maharashtra State on 30th March 2021. It was organized with the local support from Gram Panchayat, Goregaon (Kh) and Anand Buddha Vihar Samiti, Goregaon (Kh). A total of 125 participants comprising farmers and organizers were part of the programme. Women farmers also participated proactively in the event (Fig. 20.6).

RS Hyderabad organized **Awareness on Agri-biodiversity cum Farmers' Benefit Delivery Programme under TSP** Keeping in view the erosion of Agri-biodiversity especially in the tribal areas of Adilabad District, NBPGR RS, Hyderabad in collaboration with Horticultural Research Station, Adilabad, Sri Konda Laxman Telangana State Horticultural University, Telangana, organized an Awareness on Agri-biodiversity cum Farmers' Benefit Delivery Programme on 9th March, 2021 at Adilabad under the Tribal Sub Project to bring in awareness to the tribal farmers regarding the need and necessity of conservation of Agri-biodiversity especially for livelihood and nutritional security. About 100 tribal farmers from tribal pockets Lachchampur-B, Rayaguda, Chintakarra, Mallapur, Kondapur and Gulabthanda participated in the one day programme. Different implement kits useful to the tribal farmers were distributed by NBPGR RS, Hyderabad.

Grass root level Awareness Programme on Agri-biodiversity conservation cum Farmer Benefit delivery at Chintaguda under SC Sub Project: ICAR-NBPGR, RS Hyderabad organized a Biodiversity fair cum Grassroot

level Awareness Programme on Crop Genetic Resources conservation on 25th March 2021 at Chintaguda (Ranga Reddy district) under the SC-Sub Project to promote and encourage cultivation and conservation of Agri-biodiversity by the SC farmers, farm tool kits consisting of a Sprayer and a Tarpaulin sheet are distributed to suitable beneficiaries. About 100 SC farmers participated in the programme. 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.

Awareness programme on Agri-biodiversity Conservation cum Biodiversity Fair at Krishi Vigyan Kendra (KVK) Pandirimamidi under Tribal Sub Plan: Awareness programme on Agri-biodiversity conservation cum Biodiversity Fair was organised by ICAR-NBPGR Regional Station, Hyderabad at Krishi Vigyan Kendra, Pandirimamidi, DR YSR Horticultural University, East Godavari District, Andhra Pradesh State on 09 November 2021. The programme was organised under Tribal Sub Plan in collaboration with KVK, Pandirimamidi, DR YSRHU to bring in awareness to the tribal farmers regarding the need and necessity of conservation of agri-biodiversity, keeping in view the erosion of agri-biodiversity especially in the tribal areas of East Godavari District. A total of 110 tribal farmers from the following villages viz., Addategala, Chinturu, Maredumilli, Kakavada, Rampachodavaram, Y. Ramavaram, and Vetukuru.

Agrobiodiversity Awareness Program: ICAR-NBPGR, RS Hyderabad conducted an Agrobiodiversity awareness program for a farmer co-operative group from Warangal, Telangana on 12th October, 2021. National Institute for Plant Health Management, Hyderabad facilitated the farmers mobilization. Dr. Anitha Kodaru, Principal Scientist & Officer-In-Charge briefed about the Institute mandate and various activities of the station. Dr. N Sivaraj, Principal Scientist presented the importance of conservation of Agrobiodiversity and its benefits to forming community. Dr. Celia Chalam Vasimalla, Head, Division of Plant Quarantine, NBPGR, New Delhi interacted with the farmers about importance of Agrobiodiversity. Diversity of cereals, pulses and millets were displayed for the benefit of farmers.

PGR awareness Workshop cum Biodiversity Fair: ICAR-NBPGR RS Ranchi organized one day 'Plant Genetic Resources Conservation Awareness Workshop cum Biodiversity Fair' was on 5th October, 2021 in Karra block of Khunti district of Jharkhand.

Farmers training: ICAR-NBPGR RS Ranchi organized three days farmers training on 'Plant Genetic Resources Management for improved livelihood opportunities' from 23rd to 25th March 2021 at Tisri block, Giridih, Jharkhand under SCSP scheme.

PGR awareness programme under TSP

ICAR-NBPGR RS Srinagar organized three programmes under TSP in collaboration with KVK, Research Stations of SKUAST-K and ICAR-

1. 30th March, 2021 at village Laam Tral, District Pulwama (J&K) in collaboration with KVK Malangpur SKUAST (K) Pulwama and ICAR-IGFRI RS Srinagar.
2. 8th April, 2021 at remote border village of Zamboor Pattan Uri, District Baramulla (J&K) in collaboration with ICAR-IGFRI RS Srinagar.
3. 5th September, 2021 at remote Aryan village of Garkon Batalik, District Kargil (Ladakh) in collaboration with Mountain Agriculture Research & Extension (MARES) Station, SKUAST-K, Kargil Ladakh.

A total of 410 farmers including 132 women participated in these programmes. Farmer kits of small agricultural implements and seed packets of Rajmash landrace and field pea were distributed among the farmers on these occasions. At village of Garkon Batalik, District Kargil (Ladakh) during the programme farmers displayed crop diversity maintained in their fields which was assessed on spot by a committee and cash prizes were awarded to the best three displays. First cash prize was given to Ms. Dawa Angmo, second to Mr. Tashi Ksmber and third to two participants namely Ms. Stanzin Fatopa and Ms. Tashi Yangsbit for some wonderful displays of crop diversity.

Biodiversity fair cum PGR awareness camp: ICAR-NBPGR RS Shillong organized Biodiversity fair cum PGR awareness camp in collaboration with KVK, Dima Hasao, Assam under TSP on 22nd October, 2021. 100 farmers from Miyungkhro village under Harangajao block belonging to Dimasa tribal community participated the awareness programme and exhibited the various multi crops species. They were distributed with knap sack sprayers (Fig 20.14).

ICAR-NBPGR RS Shimla organized one-day farmer's awareness camps on "Biodiversity and PGR awareness" organized by ICAR-NBPGR, Shimla on 17/04/21 at Bagi Panchayat, District Shimla under Scheduled Cast Sub Plan. A total of 202 farmers from various villages of Bagi panchayat attended the camp. The prime aim of this workshop was to bring awareness among the farming community regarding the benefits of plant genetic resources including crop landraces which are being maintained by them (**Fig.9**).

ICAR-NBPGR RS Jodhpur organized two awareness programme cum workshop on conservation of Plant Genetic Resources for nutritional and livelihood security of tribal farming community under Tribal Sub Plan at KVK Hindaun City, Karauli on 20th March, 2021 and at KVK Pali on 9th March 2021. The main purpose of these events was to educate the farmers about the importance of conservation of landraces/ local cultivars and protection of endangered species of crops of that area, so that the conservation of this priceless treasure can be done by the farmers for the farmers and ultimately for the country.

Organization of PGR awareness programme under Schedule Caste Sub Plan: An awareness programme cum workshop on conservation of Plant Genetic Resources for nutritional and livelihood security of tribal farming community was successfully organized under Schedule Caste Sub Plan at ICAR-NBPGR RS Jodhpur on 20th December 2021 for the farmers of Jodhpur district.

Organization of Farmers training programme under Schedule Caste Sub Plan: A three days training for the farmers of Jodhpur district was organized from 05th to 07th October, 2021 at ICAR-NBPGR Regional Station Jodhpur on "Plant Genetic Resources Management for improved livelihood opportunities". Total 50 farmers participated in the training. The training was especially targeted for Farmers to perform good practices of effective conservation and use of PGR.

ICAR-NBPGR RS Thrissur was organized PGR Awareness programme at RS Thrissur. Nineteen students of Dept. of Botany, St. Mary's College, Thrissur, 2 from Dept. of Fruit Science and 14 from Dept. of Plant Breeding and Genetics, CoA, Vellanikkara visited on 17th December 2021 and 18th December 2021, respectively and they were enlighted with the various activities of PGR management of the station.

ICAR-NBPGR RS Thrissur organized a farmer conservator's meet on Taro and Greater yam on 10th February 2021. Twenty eight volunteer farmers were distributed landraces of Taro and Greater yam for on-farm conservation.

Popularization of Teasel gourd – A new potential economic plant by RS Thrissur: A training programme and seed distribution of teasel gourd was held on 23rd February, 2021 and male and female plants of teasel gourd were supplied to 28 progressive farmers.

On-farm conservation programme on Mango: ICAR-NBPGR RS Thrissur conducted an "On-farm conservation programme on Mango" at Mango City Kollengode, Palakkad Dist in which 22 farmers attended and 107 grafts in 20 traditional poly embryonic mango cultivars collected from Kannapuram- Mango Heritage village, Kannur were supplied to 20 farmers for conservation and further use.

20.15 Swachhata Pakhwada, Vigilance awareness week, Parthenium Day, Indian Constitution Day, International Yoga Day celebrations, Hindi Pakhwada etc.

Special National Swachhata Campaign on 'Waste to Wealth": ICAR-NBPGR organized organized a *Kisan Gosthi* at Issapur and Dr Ishwar Singh, Principal Scientist delivered lecture on utilization of dairy waste, kitchen waste, farm waste and crop residues for preparation of FYM, Compost, Vermicompost &Vermiwash and in cito decomposition of crop residues to the farmers of village Issapur on the occasion of Special National Swachhata Campaign on 'Waste to Wealth'

ICAR-RS, Hyderabad celebrated the special national swachhata campaign on 13th Oct 2021 with hands-on learning by staff on the maintenance and upkeep of greenhouse with the help of the Farm Manager, Mr M Venkataramana Reddy. On this accession, videos of "Waste to Wealth" *viz.*, Improved Composting Techniques and Quality Compost from Kitchen Waste were played to the farmers who were visited the station for Agrobiodiversity awareness programme.

Celebration of International day of Yoga: Director and staff members of the ICAR-National Bureau of Plant Genetic Resources observed International Yoga Day on 21st June 2021. Yoga enthusiasts practiced various postures of yoga and pranayama under the tutelage of Dr Ishwar Singh, Principal Scientist.Participants practiced yoga in the Biodiversity Garden maintained at the Bureau. Yoga enables achieving unison with inner self and here it was also in unison with the nature. Director, Dr Kuldeep Singh encouraged everyone to practice yoga daily to maintain good physical and mental health particularly in the times of Covid19 pandemic.

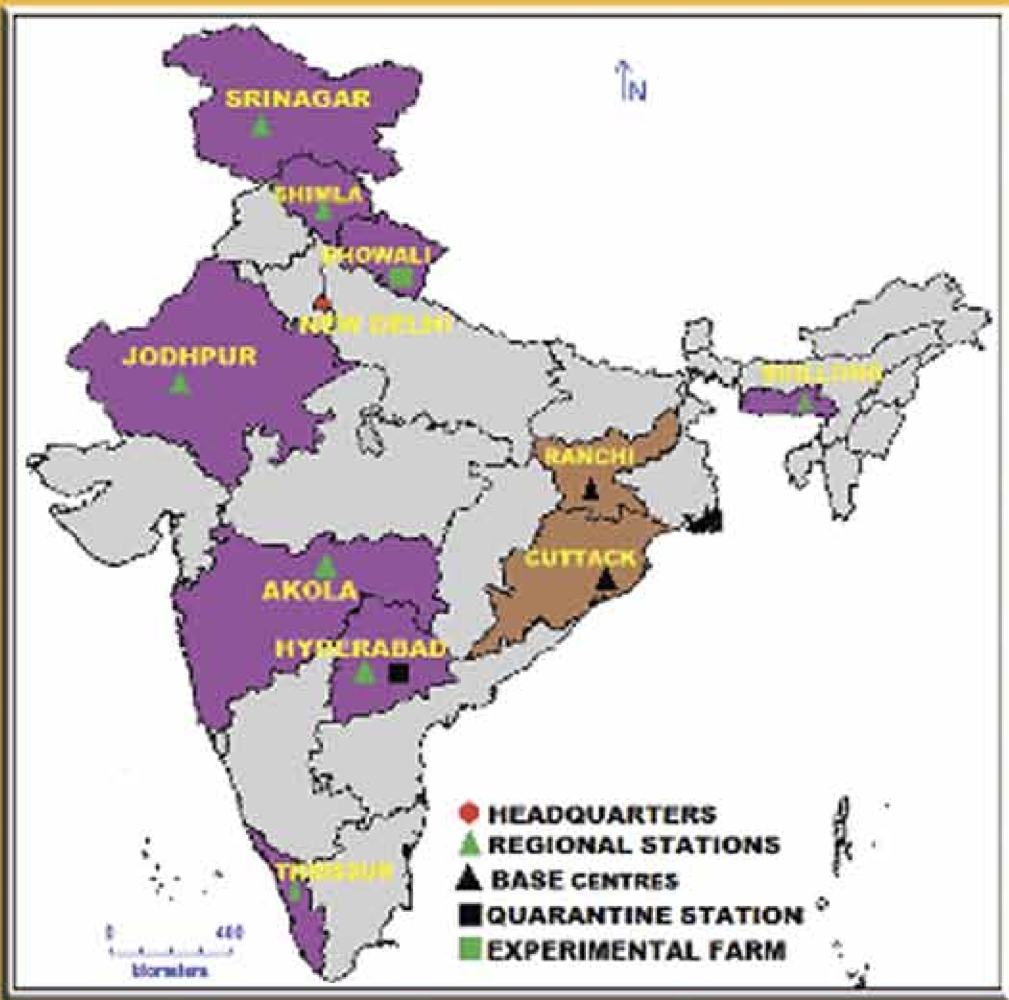
Parthenium Day: Parthenium Awareness Week is organized every year since 2004 to make farmers and general public aware about the menace of Parthenium, which is responsible for causing health problems in human beings and animals, besides deteriorating environment, loss of productivity and biodiversity. As part of the organisation of 'Parthenium Awareness Week' from August 16-22, 2021, RS, Hyderabad organised Parthenium Awareness Programme on 19th August, 2021. All the staff at the station discussed and shared the experiences with Parthenium and its ill effects as an obnoxious weed. With great zeal and enthusiasm all the staff engaged in uprooting the parthenium plants including those in vegetative state from the bunds and cropping area in a bid to make 10 acre farm Parthenium free.

Hindi Pakhwada: Hindi Pakhwada was celebrated at the RS Hyderabad during 14th September to 30th September, 2021. During programme on 25th Sept 2021, Dr. Mahesh Kumar (Hindi Nodal Officer, IIMR) highlighted the history of Hindi language and its importance in official communication. All the staff members were participated in the different competition conducted on the occasion of **Hindi Pakhwada.**

Hindi Saptah Celebration was organized by ICAR-NBPGR RS Thrissur online via zoom platform on 15th Sept. 2021, with the active participation of all staff members, SRFs, Project Assistants etc. Dr JV Prasad, Director (Acting), ICAR-ATARI, Hyderabad was the Chief Guets and Dr. Flamine Xavier, Asst Professor, Dept. of Vegetable Science, KAU delivered a talk on "***Rashtriya Poshan Mah***" in Hindi.

Vigilance Awareness Week: ICAR-NBPGR, RS Hyderabad conducted vigilance awareness programme on 26th October 2021. Dr. Anitha Kodaru, Principal Scientist & Officer-In-Charge, administered integrity pledge in Hindi and English to all the Staff at the station. She highlighted the importance of transparency, accountability and corruption free environment for achieving the better growth.

Observation of Constitution day: Constitution Day observed at the station on 26th November, 2021. All the staff participated in the pledge taking ceremony led by Dr Anitha Kodaru, Officer-in-Charge, Regional Station, Hyderabad.



Annual Report

Agrisearch with a human touch